

## An introduction to species concepts and speciation of fishes

Renea A Ruffing, Patrick M Kocovsky & Jay R Stauffer Jr

The Pennsylvania State University, Ferguson Building, University Park, PA 16802, USA

### Abstract

More than 22 different species concepts have been proposed. The concepts in general reflect the philosophical outlook, particular expertise, and the groups on which the authors are working. The full-length papers in this special issue dedicated to species concepts relative to fishes are based on presentations by the authors at the 2001 annual meeting of the American Society of Ichthyologists and Herpetologists at University Park, Pennsylvania, USA and generated much discussion on the topic of what constitutes a species.

### Correspondence:

Renea A. Ruffing,  
The Pennsylvania  
State University,  
Ferguson Building,  
University Park, PA  
16802, USA  
Tel.: +1 814 865 1132  
E-mail: rar155@psu.  
edu

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Humans apply names to objects for communication and information retrieval in the ever-changing environment in which we live. The most primordial communities of people are known to give particular names to groups of animals in order to identify them (Mayr and Ashlock 1991). Many times these names coincide closely with species designated by taxonomists (Gould 1979; Wilson 1992). In ancient Greece, the concept of species and even variation within species were recognized, although species were considered static in nature (Mayr 1963). Thus, the concept of species has long influenced the way in which humans view the diversity of life. The idea, however, of what constitutes a species has fluctuated greatly throughout the course of time (Mayr 1963).

In the early part of the twentieth century, the evolutionary synthesis brought together several scientific disciplines to try to arrive at a unified theory of evolution (Mayr and Provine 1980). A re-evaluation of the meaning of the term species in an evolutionary perspective was an important aspect of the synthesis (Davis 1996). Despite the claim that during this

synthesis 'naturalists solved the great species problem' (Mayr and Provine 1980), no true consensus of what defines the species category arose. Mayden (1997) described 22 species concepts in use in the biological community, illustrating that there is still much debate over what it is to be a species.

These different views of what constitutes a species have caused much confusion and debate in the field of ichthyology. The criteria that designate a 'good' species to cyprinid taxonomists may not be the same as those of salmonid researchers (Behnke 1972). It has been suggested that taxonomists working on temperate species are much less likely to grant species status to reproductively isolated sympatric forms than are researchers of African cichlids (Kottelat 1997; Turner 1999). Turner (1999) suggests that this may be related to a reluctance to grant species status to forms, which are likely to have arisen, by sympatric speciation, which many workers find implausible. Many fisheries biologists are content with designating populations of fishes as Evolutionary Significant Units (Waples 1995) or subspecies without being too

concerned about determining the taxonomic level of the particular populations with which they are working (Behnke 1972).

There are several reasons why there is such a large disparity in what constitutes a full species in the field of ichthyology. In effect, there may be a failure to recognize the importance of considering how one thinks about fish species and speciation. Nelson (1999) reported that most valid extant species of fishes have been described without a species concept being stated by the researcher. Political forces generate pressure as to whether or not species are recognized as valid. There are also differences with regards to whether species are viewed as individuals in an ontological sense or as categories (Stauffer and McKaye 2001). That so many species concepts are in use today may contribute to the problem.

In general, our view is similar to that of Mayden and Wiley (e.g. Wiley 1978; Mayden 1997; Ghiselin 2002; Mayden 2002; Wiley 2002). We view species as individuals in an ontological sense within the philosophical framework of the evolutionary species concept (ESC, Simpson 1951; Wiley 1978). Because the ESC is not operational (Mayden 1997), the practising taxonomist must choose one or more of the other existing species concepts (Mayden 1997) that supports his or her hypothesis of an evolutionary species to serve as surrogates.

The papers in this special issue dedicated to species concepts and speciation in fishes are based on presentations by the authors at a special symposium on the same topic at the 2001 annual meeting of the American Society of Ichthyologists and Herpetologists (ASIH, Pennsylvania State University, PA, USA). The idea for the symposium came about from comments exchanged following a presentation entitled 'The naming of cichlids' by Jay R. Stauffer and Kenneth R. McKaye at the previous year's annual meeting of ASIH (La Paz, Baja California Sur, Mexico). In their presentation, Stauffer and McKaye argued that species were in fact ontological individuals (*sensu* Ghiselin 1997). They further agreed with Mayden (1997) that the only species concept that provides taxonomists with a theoretical basis for describing all species is the ESC (Simpson 1951; Wiley 1978). Stauffer and McKaye (2001) suggested that although the biological species concept of Mayr (1996) is operational in many instances, it cannot be used to directly diagnose allopatric populations. For allopatric populations, Stauffer and McKaye (2001) also advocated the use of unique phenotypes that delimit lineages to recognize evolutionary species. Although these ideas

were not altogether new, they generated much discussion on the topic of what constitutes a species in fish biology and fisheries, hence the idea for the symposium and this special edition.

In this edition, there are five review papers written by symposium participants and two 'points of view' articles. Michael T. Ghiselin, a malacologist and philosopher of science, leads off with a discussion of philosophical and biological views of species. He clearly defines the differences between species as a category and species as individuals. He extends his discussion to cover various species concepts and their applicability. E. O. Wiley is an evolutionary biologist specializing in North American fishes. Wiley examines how ichthyologists view species and suggests that allopatric speciation predominated among freshwater species of North America. He also expands on the idea that species are individuals and suggests that the evolutionary species concept best exemplifies the way we think about fishes. Richard Mayden also works on North American fishes. He discusses the role of species, as individuals under the ESC, in relation to the preservation of biodiversity. George Barlow is an ethologist and ichthyologist who has worked on many groups of fishes. He suggests that behaviour and products of behaviour could and should be used as an indicator of species status in fishes under the biological species concept. Jay Stauffer, Ken McKaye and Ad Konings specialize in cichlid fishes. They propose a species definition for Lake Malawi cichlids based on the evolutionary species concept, but also include criteria from the biological and morphological species concepts. They also discuss the role of behaviour in cichlid fishes and suggest that it should play a prominent role in the delineation of cichlid species.

George Turner and Daniel Pauly contribute Point of View articles that augment the contributions from symposium participants. Turner offers cautionary examples that support a view of species and speciation in fishes which contrasts with those of most of the other authors. Pauly presents the historical perspective of 'the Master', discussing Darwin's work in ichthyology and how Darwin thought about species and the process of speciation.

Although many researchers believe that the topic of what constitutes a species has been 'beaten to death', there has yet to be consensus on the topic of species in fish biology and fisheries (and in general for that matter). If a species concept that accurately represents the diversity of life is the 'Holy Grail' of systematic biology (Wilson 1992), we believe that the

quest for it must continue particularly since it is crucial to the study of biodiversity (Wilson 1992).

The purpose of the symposium upon which this volume is based was to bring together theoreticians and practitioners to present their views on the process and the study of species and species concepts from philosophical, historical, and applied perspectives. Our objective was to present information that may allow all biologists to better grasp the idea of species concepts and to reinforce in their minds the importance of considering species concepts in their research, be it systematics, ecology, or natural history.

We hope the readers of this volume will find new insight into and a better understanding of issues surrounding the species problem particularly in regards to fishes.

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