

## What are the costs of bad taxonomic practices: and what is *Madracis mirabilis*?

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**Abstract.** The variety of information available today for identification of biological species should allow repeatable and verifiable recognition of the same species by many investigators. However, if good taxonomic practices are not employed, this is not the case. The cost of producing data, which cannot be referred to a described species, is explored here for studies that cite the names *Madracis mirabilis* (Duchassaing and Michelotti 1860) or “*Madracis mirabilis sensu Wells 1973*”. We estimate that in half of such studies published since 1967, specimens named as *M. mirabilis* are not referable to any single species. As such, data from these studies cannot be applied in any analyses that have species-level implications – including studies of diversity, physiology, reproduction, biogeography, ecology and evolution. A rough estimate of the dollar costs of producing these compromised data is just under \$4 million dollars. A few basic steps toward improved taxonomic procedures are 1) reference to original materials, including type specimens, original descriptions and study-specific reference materials; 2) a working knowledge and understanding of the international code of zoological nomenclature; 3) maintenance of reference specimens and of records of identification methods and observations; and 4) documenting identification methods within publications.

**Keywords:** *Madracis auretenra*, *Madracis myriaster*, *Madracis mirabilis*, type specimens, taxonomic code

### Introduction

The recent description of a new, but commonly encountered, Caribbean scleractinian coral species, *Madracis auretenra* (Locke, Weil and Coates 2007), raises, again, the high costs of embedded, poor, taxonomic practices. For about 40 years this species has been regularly misnamed as *Madracis mirabilis* (Duchassaing and Michelotti 1860). Mistakes in identification happen, but the errors in evidence here result mostly from using poor taxonomic procedures and represent an unjustifiable waste of expensive, limited, resources. Undertaking only a few, simple procedures would almost guarantee better taxonomy.

For many years *M. auretenra* has been misnamed as *M. mirabilis*. Subsequent to a comprehensive revision by Cairns (1979) of deep-water scleractinians of the Caribbean, some authors named their specimens as “*M. mirabilis sensu Wells 1973*” (Wells 1973), which Cairns clearly indicated was not the same species as *M. mirabilis* (Duchassaing and Michelotti 1860). *M. auretenra* is shown in Fig. 1. It is a shallower water species, which has zooxanthellae; and it has the apt common name, yellow-pencil coral.

*Madracis mirabilis*, shown in Fig. 2 is a subjective junior synonym for *Madracis myriaster* (Milne-Edwards and Haime 1849) and *M. myriaster* is a Western Atlantic, deep-water species that does not have zooxanthellae. Type material of *M. mirabilis*

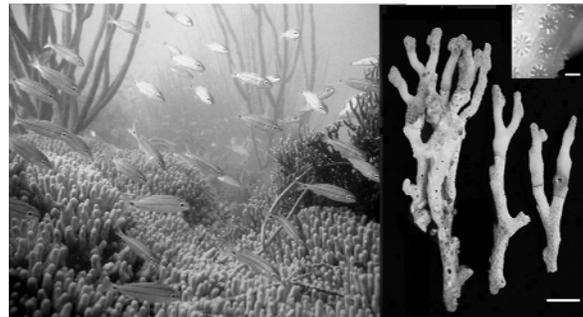


Figure 1: *Madracis auretenra* at Shelly Bay Shoal, Bermuda (left) and holotype (right), from Media Luna SW, Puerto Rico (scale 2 cm), with a close up of the spiny coenosteum (scale 1 mm) (Locke et al. 2007; reproduced courtesy of the Proceedings of the Biological Society of Washington). This species has been misnamed *M. mirabilis* for many years.

and in vivo specimens of *M. myriaster* are shown in Fig. 2. A thoroughly researched synonymy for *M. myriaster* up to 1979 is provided by Cairns (1979); a number of other authors, both before Cairns and more recently, recognized the morphological identity of *M. mirabilis* to *M. myriaster*.

In this paper we present the results of our attempts to discover the identity of specimens that have been named as *M. mirabilis* or as “*M. mirabilis sensu Wells*” in papers published since 1967. In particular we wanted to know whether these specimens were or were not *M. auretenra*. We also made a rough

estimate of a dollar value for the research effort that might be considered wasted, if no species identity can be resolved. Finally, four simple procedures toward better standards and outcomes of taxonomic practices are provided.

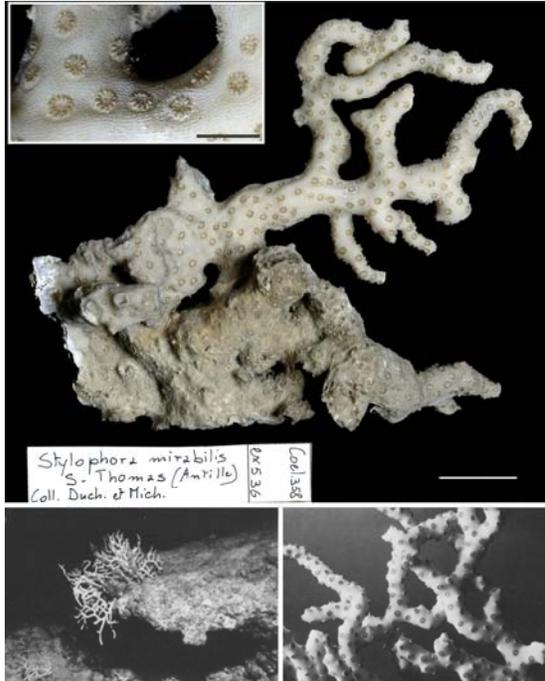


Figure 2. This is *M. mirabilis*; the name is a junior synonym for *M. myriaster*. Type material of *M. mirabilis* from the Zoological Museum of Turin (top) (scale 2 cm). The inset provides a close up of the striate coenosteum (scale 1 cm). Living material of *M. myriaster* from 196 m depth, Castle Roads, Bermuda (Fricke and Meischner 1985).

## Methods

Computerized literature searches and visual searches of literature cited sections of relevant publications were made to locate primary references published since 1969 using the species name *M. mirabilis* (Table 1). The first or principal authors of the publications were contacted by electronic mail to see whether they could confirm the identity of their study material as *M. auretenra*, *M. myriaster* or another species, by looking for the distinguishing morphological features that became apparent once *M. auretenra* had been described (Locke et al. 2007). Authors were also asked the source of their current information about their specimens: memory, photographs, reference specimens, or another source.

To estimate a tangible cost of data that are unusable due to incorrect and unrecoverable identifications, we considered the dollar value of time and other resources we have spent describing *M. auretenra*, disseminating that information, and trying to resolve which earlier studies were relevant to *M. auretenra* (Table 2). Then we applied this value to the studies

that produced such data. In particular, data that could not be cited in a review of the biology of the new, but very well-studied species, *M. auretenra*, were considered unusable.

## Results

The cumulative results of literature searches, queries and responses are shown in Table 1.

Table 1. Use of *Madracis mirabilis* or “*M. mirabilis* (sensu Wells 1973)” since 1967

Number* of PUBLICATIONS (type 1) naming <i>M. mirabilis</i> as a study species (*does not include many regional species lists)	146
PUBLICATIONS (type 2) since July 2007 (post publication of <i>M. auretenra</i> ) naming <i>M. mirabilis</i> (in journals: Coral Reefs, Molecular Ecology Notes, Marine Biotechnology, Marine Biology; and in Coral Reefs of the USA)	6+
<b>Presentations at ICRS 11 naming <i>M. mirabilis</i></b>	<b>3+</b>
Number of different first authors of the PUBLICATIONS (type 1, only)	88
Number of investigators to whom <i>M. auretenra</i> paper (Locke et al 2007) was distributed (includes some secondary authors)	60
Number of PUBLICATIONS (type 1, only) for which species identities have been verified as <i>M. auretenra</i>	60 (41.1%)
Number of PUBLICATIONS (type 1, only) not verified (1. no reply from authors [46 authors], 2. authors could not verify identity [2 authors], or 3. no current contact information for authors [38 publications])	86 (58.9%)
<b>Validation resources reported by responding authors</b>	
Reference specimens	
Photographs of specimens	
Written details of specimens	
Personal recollection of specimen details	
Field site revisited	

The number of publications naming *M. mirabilis* that we have found, so far, for the period 1967 to July 2007 is 146. More than ten have been published since 2007, including in some prominent publications (such as the journal Coral Reefs, in the new volume “Coral Reefs of the USA” [Riegl and Dodge 2008]), and in the 11<sup>th</sup> International Coral Reef Symposium abstracts. The 60 publications for which a species identity could be verified included many in which substantial taxonomic information was included, such as close-up photographs of the corallites and coenosteum or detailed descriptions of those structures, or some clear indication by the author(s) that they were not studying *M. mirabilis* (= *M. myriaster*). Eighty-six of the published studies (Table 1) remain doubtful with regard to a species identity. There were three primary reasons why the identity of the specimens could not be or were not verified by the authors of the papers (in descending order of numbers of incidences): no current contact information for the

authors; no response from authors (perhaps because the contact information found was not current); and the authors had no materials or detailed recollections from which they could verify the identity of their specimens.

We prompted authors to indicate the category of resource that they used to verify their morphological species identifications and found that they were mostly as we had expected - reference specimens, good quality photographs, personal, unpublished, descriptions of material, and other personal recollections; however, some authors were also able to revisit their study sites and make new observations of the specimens.

Our evaluation of the time we committed to our studies is shown in Table 2. This is based on actual costs, salaries and in-kind contributions to the project; overhead was both charged against some of the funding for this project and provided as an in-kind contribution, but it is all indicated as overhead.

Table 2. Cost estimate for the *M. auretenra* research project

Expense category		Value USD
Direct costs	Student stipend @ 21,000/yr*3yr	63,000
	Faculty salary @.10*90,000/yr*3yr	27,000
	Materials and supplies	5,000
	Field work (travel, fuel)	5,000
	Publications	700
	Meeting costs	2,000
Total direct costs		102,700
Overhead	(.30)	30,810
In kind contributions	Lab and field services	5,000
Total costs		138,510

Our expenses related to the publication of the new species *M. auretenra* and to our attempts to widely disseminate information and to affect a correction to the ongoing misidentification of *M. mirabilis* were near \$140,000 USD.

### Discussion

Data, derived from specimens for which a morphological identity cannot be confirmed, cannot be used in comparative analyses with species-level implications – including studies of: reef ecology, coral physiology, biochemistry, palaeobiology, environmental degradation and global climate change (see Winston 1999 for specific examples). Even if species identity (‘getting the name right’) is not essential to developing an hypothesis, it still can be very significant whether data from a single species or from a conflated taxon is considered (Weil and Knowlton 1994; Winston 1999). In the case of “*M. mirabilis sensu Wells*” no description existed for the

misnamed “species” prior to 2007 so that authors had very little to refer to as far as producing a consistent identification among different studies. Therefore, it would be hard to justify any assumption that all authors were working on the same, and just one, morphological species.

We know that data from 86 studies, which might be relevant to *M. auretenra*, cannot be included in a review of the biology of that well-studied, widespread, and common species; in fact, at this point those data could not be included in such a study of any coral species. However, the same data may be applicable to very general questions about coral reef ecology and biology. Thus, conservatively, we suggest that only a third of the data produced in those studies has extremely limited value. If we consider that the cost of our studies is in a similar range to the studies we cited and apply a current cost to research over the whole period of the publications we consider, then we would be looking at a total expenditure of about \$3,970,620 for data with limited to no value.

This is equivalent to about 57 years of salary for one taxonomic research scientist, with an averaged income through their career of \$70,000 per year. This is more than one entire career or equivalent to 30 years salary, a relatively long career, accompanied by an annual research budget of \$62,000.

Employing poor taxonomic practices is having significant, long-term, negative impacts on the entire field of coral reef research; both through the negation of data and hypotheses that are used to justify research and conservation protocols and through, simply, wasting large amounts of time and money.

We recommend four easy steps towards better taxonomy, which have been noted in a number of publications on taxonomic procedures, for example, see Winston (1999).

#### 1. Establishing identity:

- consult original descriptions – electronic copies of original materials are readily provided by most institutions
- consult with taxonomic experts - question and understand their identification criteria
- consult type material - types for many Caribbean corals are deposited at the Smithsonian, or other major reference museums in the United States, such as the Peabody at Yale, and at major European museums; they often will lend material or will send good quality images free of charge

#### 2. Understanding naming practices – consult the International Code of Zoological Nomenclature.

It is available online at:

<http://www.iczn.org/iczn/index.jsp>

#### 3. Maintaining reference materials

4. Documenting identification methods – record primary and secondary references, comparative methods (material examined), and authorities consulted

The kinds of data available for the identification of scleractinian corals go well beyond the structural features that were the original basis of distinguishing many species. However, no matter what kind or how many data are applied to the question of taxonomic identity, if good taxonomic practices are not applied then good results are not expected.

A review of the biology of the very well-studied coral *M. auretenra* is in preparation. If you have participated in or know of a study that is relevant, please contact J.M. Locke at <janml Locke@yahoo.com>.

#### Acknowledgment

Hans Fricke, Dieter Meischner and Springer and Business Media for use of in situ *M. myriaster* figures from Marine Biology 1985; National Science Foundation Grant # EPS-0223152 (JML); Bermuda Department of Conservation Services and Canadian Associates of the Bermuda Institute of Ocean Sciences for funding and logistic support.

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