



Helping Solve the “Other” Taxonomic Impediment: Completing the *Eight Steps to Total Enlightenment and Taxonomic Nirvana*

NEAL L. EVENHUIS

Department of Natural Sciences, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817, USA;
email: neale@bishopmuseum.org

“To discover is to draw the veil. It is not to run into something and keep it to oneself. It is to push back the frontier of infinity and to pass the news on to posterity.”

—Mauricio Obregón

Background

Simply put: despite over ten years of recognizing the problem and giving it a catchy phrase, we still lack the taxonomic expertise to effectively describe the remaining biodiversity on earth. How can we enjoy and protect something if we don’t know it is out there to enjoy and protect?

The Conference of the Parties to the Convention on Biodiversity (COP) at their meeting in Jakarta in 1995 echoed the warnings of previous committees organized around the world to outline the problems we face in the future of taxonomy. The perception by the COP of a lack of taxonomists to handle the enormous task identifying and naming the biodiversity we have yet to describe on this earth led the IUBS/Diversitas to term this lack of expertise as the “taxonomic impediment”¹. Elaine Hoagland (1996) highlighted the term in her white paper on the subject for the COP. Her paper precipitated an overwhelming chorus of “I second that” by fellow taxonomists as well as in their subsequent discussions that fine-tuned proclamations of the need and the methods by which we could solve the problem.

Two years previous to Hoagland’s report, the U.S. National Science Foundation (NSF) created the PEET program (Partnerships for Enhancing Expertise in Taxonomy) to enhance and increase taxonomic expertise in areas where it is deemed by colleagues and NSF review panels to be sorely lacking. Nine years later, NSF proudly declared “Taxonomic Impediment Overcome” (Rodman & Cody, 2003). The article’s headline may have been a bit more embellishment than reality, but nevertheless, the effort by NSF in creating the PEET program—and also at about the same time the Biotic Surveys and Inventories Program (BS&I) (meant to foster broadscale collecting and discovery of species throughout the world) cannot be understated. They were both major leaps forward in showing the world that governments could in fact get behind taxonomy and support increasing the expertise that was lacking in that discipline and critical steps to helping solve that problem.

While even the most recent editorials on the taxonomic impediment and their respective responses (e.g., Wheeler *et al.*, 2004; Lyal & Wietzmann, 2004; Martin, 2004; Geeta *et al.* 2004; Causey *et al.*, 2004; Young, 2004; Carvalho *et al.*, 2005) may argue the details, they clearly all agree with each other that we still lack taxonomic expertise to adequately describe the biodiversity on this planet. However, they all have apparently missed another “taxonomic impediment”: one that darkens the potential successes made by NSF funding and other advances. Namely, that some of the existing taxonomists are not doing much or even any taxonomy. Numerous reasons exist for this unfortunate dilemma (see Summary below). Some that are inherently

1. Earlier uses of the phrase “taxonomic impediment” (e.g., Taylor, 1976; Ramsay, 1986; McIntyre *et al.*, 1992) are for aspects of taxonomic poverty other than lack of taxonomic expertise.

common in collaborative survey work are outlined here with examples from a recently-funded NSF BS&I terrestrial arthropod survey in Fiji. That discussion is supplemented with a step-by-step process that explains the process of taxonomy and the sociological pros and cons to each step; and, if followed correctly by all taxonomists, will ultimately solve this “other” impediment.

“Cool. Gimme a free trip to Fiji”

Caveat: The Fiji BS&I Survey is very successful and it is only because it is that I can safely write this article warning of some of the pitfalls that may befall someone who tries to organize such a collaborative survey.

Among the many tasks in formulating a logical process and project design to the initial NSF Fiji Terrestrial Arthropod Survey (termed henceforth as “Fiji project”) was creating an essential team of experts who would be critical to the success of the project by identifying taxa in their specialty group(s) [= target group(s)] and describing new species that was resulting from the massive Malaise trapping program that was already in place on many of the islands scattered throughout the Fiji Archipelago. To supplement and enhance the identification and description of those selected biodiverse elements in Fiji, team members were asked to participate in all-expenses-paid collecting trips to Fiji to personally collect their target group by whatever specialized method they deemed most appropriate and to help train in-country students and parataxonomists, the latter who were employed in collecting, sorting, and identifying the specimens collected primarily by Malaise traps and leaf-litter catches.

A certain amount of trust was put into each participant that they would indeed take the time out of their busy schedules and volunteer their efforts toward fulfilling the objectives of the grant and describe the biodiverse taxa they stated existed in Fiji. For the most part, this trust was reciprocated by diligent reporting of the identifications of material they were being sent and in submissions of their manuscripts to the journal series created and dedicated to the Fiji project: *Fiji Arthropods*. But this diligence was not always the case. All team members were told they could participate in a trip to Fiji under the condition that they would submit before or soon afterwards a manuscript describing any new taxa discovered. Unfortunately in some cases, no such paper ever was forthcoming.

Table 1 shows the list of the target taxa of the Fiji project, the known number of species prior to the inception of the project, the estimated new taxa that would be found in Fiji, and how many new species were published or in press/in preparation since the Fiji project began. The names of specialists and their target taxa are not included but the numbers are real. Identifying those who did not meet their original expectations of the project by name or taxon is not the purpose of this paper. It is to illuminate the problem and offer a solution to it.

After not getting the number of manuscripts I had hoped for from some team members or even progress reports from them of what taxa had been identified by them, I began to think that the only reason some participants signed on to the project was merely to get a free trip to Fiji, soak up some sun, go collecting, go back to their labs with their booty, and reminisce with digital pictures and collected specimens of the pleasant 10–14 days they had amongst the warm climes and friendly people of that South Pacific island nation. This, of course, would not only be disingenuous to the project, but also to science. And especially to NSF and the republic of Fiji since the Biotic Surveys and Inventories program was created to conduct broadscale collecting, foster descriptions of new taxa, and require vouchering of specimens in the home nation. BS&I projects are essentially taxonomic capacity-building programs and they also assist with building infrastructure in-country where needed. Since the finances of the Fiji Government were such that they looked forward to and strongly encouraged outside funding to help such programs as ours in their country, our obligations and responsibility to the island nation of Fiji were immense.

TABLE 1. Original and Added* Target Taxa for the Fiji project.

Taxon Group**	Known Spp.	Estimated New	Described new or (In Press/in Prep)	Notes
A	40+	>15	0(0)	
B	10+	>10	2(3)	
C	5+	>20	0(0)	
D	5+	>10	4(2)	
E	40+	>10	0(0)	
F	50+	>10	0(1)	
G	50+	>50	0(0)	
H	20+	>50	10(15)	
I	20+	>50	3(0)	n. spp. described by a non-NSF participant
J	50+	>20	4(3)	
K	50+	>50	0(5)	
L	1	>10	3(8)	
M	20+	>50	0(0)	
N	1	>20	3(10)	
O	1	>50	0(0)	
P	20+	>20	0(1)	
Q	10+	>10	0(0)	
R	<5	>10	0(0)	
S	0	1	0(0)	
T	<5	>10	0(0)	
U	<5	4	4	all new spp. described

* added after project was funded but worked on by original NSF participants

** may be families, orders, or classes; 17 different taxonomists signed on to work on these 21 taxa (some working on more than one taxon group)

But all the participants in the Fiji project are good-natured and honest colleagues who were chosen not only for their expertise with their taxon, but because they showed a genuine interest in the Fijian arthropod fauna. What then could be the reason for their inactivity of some in publishing? Brian Brown [also an organizer of a NSF-funded BS&I survey: in Colombia] (2005) opined in his analysis that the lack of resources for Diptera taxonomists may have been the reason for so few papers on Neotropical Diptera being published despite the Malaise trap catches of his study and a few others showing the greatest diversity in insects being with the Diptera specimens collected. A paper written over 50 years ago (Hedgpeth *et al.*, 1953) essentially said the same thing. Apparently not much has changed. I agree that there is indeed be a lack of proper resources for taxonomists in some institutions and this has had a significant impact on the taxonomic productivity of many researchers, but this is not the only reason for so few papers being published.

In speaking with NSF staff and organizers of other BS&I surveys I found that the inactivity in publishing was found not only in our Fiji project but seemed to be an inherent factor in virtually every collaborative survey effort that had publications of new taxa as one of the expectations. If one agreed to do the work when signing up for a survey project, an organizer would expect that person to come through with the promised goods. However, this would not always be the case.

There was apparently a common symptom that pervaded a number of taxonomists preventing them from being productive in the publishing arena. Given this assumption, it would then seem that if true and affecting a significant number of taxonomists, it would have a resulting negative impact on taxonomic production in

describing new species. Were employers and taxpayers then funding taxonomists to do only part of the job? Was the NSF-PEET program funding students to be trained in actually describing organisms or were they being trained to only go through a portion of the taxonomic process and then get stuck part way through?

Let's examine the Fiji project participant's productivity (or lack thereof in certain cases) and then follow along as I offer possible reasons for this inactivity and a step-by-step process that if followed by all taxonomists, will solve this problem.

The "Dog-Ate-My-Homework" Excuse and Other Syndromes

Factors to consider

Examination of Table 1 above shows a marked amount of inactivity by some project participants in describing the estimated new species. There are a number of factors that contributed to some of the inactivity, but not all of the inactivity. In prodding and querying team members on when they expected I might eventually see a submitted paper, they offered a number of excuses: some reasonable, but others verging on pathetic and reminiscent of childhood excuses to their teachers for not turning in homework. It became obvious that publishing was a chore and not a priority for these latter cases. For them it was like having to eat your vegetables as a kid: Some kids ate them at the beginning so that the bad taste would not be the last taste in their mouth; while others opted to wait until the end because it the most horrible part of the meal and easiest to put it off as long as possible. I was apparently experiencing the latter school of thought on vegetable eating.

1. Reduction of project term

The Fiji project was originally proposed to NSF for three years. The grant was approved by NSF but the funding was reduced by about 30% from what we had originally proposed. It was decided that the best approach to still conduct the project with the reduced funding would be to reduce the term of the project from three years to two years. Although we met the project goals of a complete checklist, bibliography, database, and training of in-country students in those two years, the cutting back of one year from a three-year survey project ultimately had an impact on the process of identification, description, and publication of new species. Yet, this cutback apparently impacted only some, because others were obviously not impacted at all and were able to publish quite effectively.

The publication process usually involves a number of months of review, editing, and printing before publication. Knowing this and that we had a one-year reduction in time, it was decided to create a peer-reviewed journal series dedicated to the project and edited and reviewed in the same expedited manner as *Zootaxa*. This allowed a remarkable successful publication of 6 issues of *Fiji Arthropods* wherein were published 22 papers by 15 authors describing 62 new species from Fiji and related regions in just two years; whereas only a fraction of these papers and resulting new taxa might have seen publication under a more "normal" journal process.

2. Unforeseen obligations

When signing on to the Fiji project, one must assume that those participants agreeing to collaborate all had every desire to contribute to the project in as full a capacity as their time allowed. However, in the time between submittal of the proposal and the notice of award from NSF (about 5-6 months), some of the participants discovered that they had other grant obligations, family obligations, large book projects, or sabbaticals that took them away from the Fiji project. In most cases, these absences from the project were for a few months to a year, but not the full two years. Thus, one would still expect at least a portion of the original estimated expectations from these participants.

The Real Reasons

Of the original 19 participants who agreed to collaborate on the project, I analyzed the publication output of five who I categorized as having little or no excuse for not publishing in order to ascertain if there was a pattern in their lack of productivity. I searched *Zoological Record* for the years 1997 to 2006 inclusive to find their relative taxonomic productivity in the last 10 years. The results are presented in Table 2. Authorship of papers was recorded only if they were senior or sole author of a taxonomic paper to reduce any possibility of giving undue credit to someone for possibly attaching their name onto someone else's taxonomic work. There was only one junior-authored taxonomic paper found for these five people, and was ultimately of little impact to the overall analysis.

TABLE 2. Ten-year taxonomic productivity of 5 original Fiji project participants from 1997–2006.

Scientist	Papers published	New Taxa published
A	0	0
B	0	0
C	1	6
D	2	1
E	1	0
totals	4	7

The results of the analysis in Table 2 show essentially an average of less than half of one paper per ten years per person and also less than one new species described per ten years per person. Surely this negligible effort is not doing much at all to help solve the taxonomic impediment.

That small fraction of participants in the Fiji project in Table 2 who were slow to publish on the new species found during the survey are, I contend, victims of the taxonomic process and their own addictions to the “hunt” [= collecting], “discovery” [= sorting of new taxa], combined with an avoidance of “eating their vegetables” [= i.e., having to sit down and do the humdrum work of describing a species]. They followed the steps outlined below but would ultimately get stuck at one point and would not be able to progress further. Going out and collecting and even sorting and finding new taxa was reward enough for them. The drudgery of having to write and/or type up a description was the smallest blip on their radar screens — or it wasn't even present. Constant prodding sometimes moved the description of a new species up the priority list for some, but for others, no amount of prodding or gentle persuasion would budge that person beyond the early steps — thus, they would unfortunately fail in completing the steps in the taxonomic process.

So, what are these steps? I call them the *Eight Steps to Enlightenment and Taxonomic Nirvana*. That is, if one follows them all, there is no doubt that the gods of taxonomy will be looking kindly upon them for achieving success and helping fill in the jigsaw-puzzle picture of life on this planet. With constant taxonomic productivity, that picture will become more and more complete.

The Eight Steps to Enlightenment and Taxonomic Nirvana

1. Realizing and embracing the **enjoyment of nature**
2. Realizing and embracing the **enjoyment of collecting**
3. Realizing and embracing the **enjoyment of sorting**
4. Realizing and embracing the **enjoyment of the discovery**

5. Realizing and embracing the **enjoyment of researching taxonomic literature**
6. Realizing and embracing the **enjoyment of describing**
7. Realizing and embracing the **enjoyment of submitting your manuscript for publication.**
8. Realizing and embracing the **enjoyment of educating others**

The Step-By-Step Process

Step 1. Realizing and embracing the enjoyment of nature.

This is the critical first step in the process. If one does not like nature, there is definitely no future for that person in taxonomy. Most who fail at this Step ultimately become accountants.

As biologists, we should all be able to achieve this Step with no problem. We appreciate our surroundings and ask questions about them, we are normally curious at how things work in each ecosystem, and we generally embrace and enjoy the complexity and beauty of the world we live in.

Ways to Success: A normal first thing for most taxonomists to do at this step is to select an area in which to explore and discover, travel to, and arrive at this particular area. Often these areas will be unexplored or little-explored areas, or they may be areas that are known to harbor an unusual organism or a great abundance of different organisms.

Hedging at This Step. Reading about an area and not physically visiting it does not necessarily qualify as properly completing this step. However, vicarious pleasures are the only way for some folks who do not or cannot leave the lab yet they still adequately complete the later steps in this process.

Step 2. Realizing and embracing the enjoyment of collecting specimens.

This is the “exploration” step of the process. Sociologists have pegged most of us humans as instinctive “hunters” so collecting is essentially the “hunt” our ancestors HAD to do in order to survive. Some of us are better hunters than others. Those that aren’t no doubt become scientific illustrators or molecular biologists

Ways to Success: To successfully complete this step, one must set up a trap, use one’s hands, or use a tool in order to procure said organism. For botanists, this is most often ripping a plant away from its substrate and placing in old newspapers or small envelopes. For zoologists, tools are normally used to immobilize the organism because the hunt involves a prey item that moves and has what is called an “avoidance mechanism” --and they usually move away rather quickly from someone trying to remove them from their native habitat and/or end their life. Of course, those zoologists who work with the more lower evolved organisms like amoebas are dealing with beasts that have avoidance mechanisms pretty much along the same lines as plants, so collecting them can be just as onerous as it is for the botanists.

Hedging at This Step. Sending out a team of collectors to do the job for you. It works — and many collectors in the 18th and 19th centuries did this (and some today use indigenous peoples who know their land and biota better than the adventurous collector to get the good stuff for them) — but to truly understand your quarry, it is best for you to do the job yourself. Again, there are a few who do not or cannot leave the lab for various reasons, physical or mental, yet they do successfully complete the subsequent Steps in this process.

NB: Some self-proclaimed “taxonomists” incredibly stop at this step. However, this is abnormal behavior, as most will be curious as heck as to what they collected, will fidget nervously, have sweaty palms, and will quickly move on to Step 3.

Step 3. Realizing and embracing the **enjoyment of sorting** species that have already been collected, whether by you or others.

After completing Step 2, one takes the harvest back to the lab and dumps it out to be sorted and properly curated. This is the step of “discovery”. The anticipation of finding something new is the drug that fuels the otherwise monotonous activity of sorting. For the collection of large vertebrates and many plants, the sorting may even take place in the field and it is merely the proper labeling and tagging and preservation that takes place in the lab. But for the invertebrate zoologist or other biologist dealing with droves of biodiversity, the sorting is delving into the unknown (whether it be a Malaise trap residue or a net full of marine invertebrates) and sorting and identifying the critters that one has collected.

Sorting can be quite a heady step to overcome and many taxonomists fail to get beyond this step. It is fraught with addiction. There HAS to be something NEW in this batch ... or the next batch ... or the next!!!

If a taxonomist has an *a priori* hypothesis that unknown species X of genus Y MUST occur in a particular area and years and years of high-volume trapping such as with Malaise traps has taken place, there are known cases where that taxonomist has never come out of the lab to see daylight until that dangd new species turns up. It may take years. And in some cases it has taken even longer.

Ways to Success. Aside from the anomalous taxonomist who likes nothing else than sorting through specimens in hopes of finding the new and unusual, this is an easy Step to complete for most. There are some who abhor the sorting process (see Hedging below) and would rather have someone else do the “dirty work”; but for the most part, the natural curiosity that drives most biologists allows one to easily complete Step 3.

Hedging at This Step. Having someone else do the sorting for you. This is true of many professors who have a large pool of students from which to tap to do this laborious chore of sifting through numerous uninteresting organisms in search of something worth screaming about. Granted, researchers and professors are often more highly paid than students, thus this can be a very cost-efficient way of moving through this step. It is not necessarily condoned by this author, but it is understood that finances often dictate how a job is completed.

Problems at This Step. There is the mindset of some that sorting is the ultimate activity. There is always the goal in the back of that person’s mind that if they find something new and unusual, they will be admired and adored by colleagues and may even get a patronym out of it. Thus, they are either always stuck here or at the next Step.

Step 4. Realizing and embracing the **enjoyment of the discovery** of new or rare species from your efforts at sorting.

Finding a new taxon can be a most rewarding experience and the thrill to some taxonomists is such that they cannot wait to put a name on it, describe it, and see their description in print. One would presume that the amount of the thrill would be proportional to the size of the organism discovered. Considering that the larger vertebrates are more well-known than their tinier invertebrate cousins, finding a new bird or mammal is indeed a rare and exciting event. Yet, the thrill is just as keen for

the worker of the more abundant insects and other invertebrates. Even in the most biodiverse taxa of insects there is a thrill to finding something new — but it is usually not finding just one new taxon but a dozen or so at once that does the trick. Or else it is finding a new genus or family or even order of animals or plant that can elicit an adrenaline rush rather than the find of a singleton not previously described.

Ways to Success. The best way to blaze through this Step is to either have an incredible knowledge of all described taxa you are working on, or have good keys prepared that help you verify whether or not it is in fact new.

Hedging at This Step. Probably the worst thing that one can imagine that is done at this Step is to exclaim that one has found a new taxon just merely to say they have found it when in fact they have not. I'm not talking about a find that is honestly thought to be new and subsequently found to be a junior synonym of something previously described. No, the worst case scenario here is the premeditated manufacture of something exclaimed to be new when it is not. It works best in taxa not studied again by anyone else for decades so that the fraud is not discovered until well after said taxonomist has left the earth. It unfortunately has happened.

Step 5. Realizing and embracing the **enjoyment of researching taxonomic literature** related to your new discovery.

Having all the literature of your taxon under study is essential to completing this Step. One cannot confidently say they have something new to describe if they do not have the original descriptions of related taxa or keys to those taxa to use for identification and comparisons. Combined with this is the oft-time necessity of examining types of related taxa to be sure your taxon is indeed something new to science.

Ways to Success. Having all this ready to go when you are at Step 4. Doing it here is the vetting process that assures you have a new taxon, but having the literature already at hand during Step 4 allows you to jump past this Step and on to Step 6.

Hedging at This Step. There really is no 100% successful hedge here. If you do not feel having the literature is necessary, you ultimately become vulnerable to a potential junior synonym. It's the gamble you pay.

Step 6. Realizing and embracing the **enjoyment of describing** and illustrating these new species.

This is the sit-down-and-describe-what-you-see (or, for the blind, feel) Step. Description and naming of your new taxon is essential to disseminating and communicating with others what is out there. An illustration is an added benefit to aid future researchers in identifying what you have described.

Ways to Success. To ease the “pain” of describing more than one taxon in a group with many new taxa, one can create a template description that only needs changes at various parts when the taxon being described differs from what is in your template. The advent of digital photography has made many illustrations unnecessary in some cases and has thus expedited the descriptive process.

Hedging at This Step. Describing the minimal amount of information to be legal according to each biological Code. For example, in zoology, one only needs to describe characters that differentiate one taxon from another. At a minimum, one could theoretically say “Yellow, 20 mm long” and that

would validate the description and naming of a new taxon. Although of no real benefit to others as it does not convey all of the characters of the taxon being described, it has been done.

Step 7. Realizing and embracing the **enjoyment of submitting your manuscript for publication** of these new species and completing the publication process.

This critical Step is the final one that validates your description. Publication in a peer-reviewed journal is optimal. Review and certification by ones colleagues is the ultimate test of one's description.

Ways to Success. There are many journals now that offer expedited publication yet still adhere to peer-review. Other journals that take a bit more time from manuscript to publication may offer benefits other than speed, such as free color, or the prestige of a being published in a high-impact journal.

Hedging at This Step. Self-publication. It speeds up the process but avoids necessary feedback from colleagues who might assist by letting you know that you are publishing something that has already been described. Also, tacking one's name onto a paper done primarily or worse, solely by someone else. It gives you unwarranted credit for doing taxonomy when you really haven't.

Step 8. Realizing and embracing the **enjoyment of educating others** to your new discoveries

Your publication being read by others is the primary education that is done at this step. But added value comes from every taxonomist who passes on information to others by educating them in any way possible to the uniqueness, wonder, or biodiversity of the groups that they work on.

Ways to Success. Give lectures to the public and make your publications available for free via pdf or online in some other form (subject to copyright of the publisher).

Hedging at This Step. Publishing in obscure journals or self-publishing and not making reprints available to others. This is done primarily by those who only want to see their name in print and really do not care about educating others in what they do or the organisms they study.

Summary

It is apparent that some taxonomists are as not as productive as others, and some, who may have published early in their careers, just plain stop publishing or put their name on student's papers to keep their "name alive". There are numerous legitimate reasons for this inactivity — most having to do with squeezing their taxonomic research in between other obligations (administration, bioinformatics, phylogenetic analyses that do not name new taxa, non-taxonomic research, teaching loads, travel, meetings, etc.). However, there are some researchers that do not have any of these excuses, yet still are labeled as taxonomists and included among the number when we account for what expertise we have taxonomically in various areas. These "taxonomic deadbeats" are content to either collect, or sort, or both, but reluctant to sit down and crank out the written results of their discovery of new taxa and give them names and publish them. Thus, they are not truly taxonomists, but highly paid biological technicians, the latter who can essentially do those same tasks of collecting and sorting but at a lower pay or for free. However, by not publishing the results of their discoveries, biology as a whole loses out because of their not making public what they know is new. The quote at the beginning of this article by Christopher Columbus scholar Mauricio Obregón says it best. Essentially, a discovery is not a discovery until it is made public.

If we are to solve this taxonomic crisis, there are apparently two taxonomic impediments to overcome: 1) to increase our base of taxonomic expertise to handle the biodiversity that exists yet to be described; and 2) to get those already trained as taxonomists to get beyond Step 3 or 4 and publish their findings.

I've outlined the steps that need to be taken. All that is necessary now to achieve what I term "Total Enlightenment and Taxonomic Nirvana" is the discipline of each taxonomist to live up to their professional label.

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