MARINE BIODIVERSITY AND THE NEED FOR SYSTEMATIC INVENTORIES

Paula M. Mikkelsen and Joel Cracraft

ABSTRACT

Despite universal recognition of coral reefs as the ‘ocean’s rainforest,’ the focus of conservation is largely restricted to cnidarians, fish, larger sponges, and macroalgae. These span a wide taxonomic range and can be monitored non-invasively. But a biodiversity picture based on so few taxa is dismally incomplete. As in the rainforest, the overwhelming majority of species and clades on the reef are cryptic. Worms, mollusks, echinoderms, and crustaceans are numerically dominant, contribute to the trophic underpinning, and play pivotal ecological roles. Other than a few charismatic species (e.g., starfish, tube worms, conchs), they are underestimated and overassumed. Proper inventory of such taxa requires factors not routinely employed in conservation: physical sampling and systematic expertise. Yet scientifically robust results can be achieved with minimal damage and investment, and lead to recognition of key species, for which monitoring schemes can be developed. Examples of recent surveys by systematists are provided, involving echinoderms, mollusks, crustaceans, and worms from a variety of marine habitats, and each showing significant results. Despite this evidence of success, acquiring systematic expertise for inventorying marine invertebrates continues to be a limiting factor. After decades of de-emphasizing systematics, the cohort of trained systematists is aging and facing non-replacement, even in museums where extensive specimen collections, laboratories, and libraries provide the best available support for systematic work. In today’s climate of biodiversity interest, new initiatives are attempting to reverse this trend. National Science Foundation’s PEET [Partnerships for Enhancing Expertise in Taxonomy] Program is providing resources for training the next generation of taxonomists working on poorly known groups. At the international level, initiatives such as DIVERSITAS’ Systematics Agenda 2000 International Program are supporting new agendas to document reef biodiversity and promote systematic inventory. The Convention on Biological Diversity is calling for more systematic inventories to facilitate their goals of conservation and sustainable development. Programmatic and financial support for inventories by national, regional, and local conservation and monitoring agencies are the next requirement.

Successful biodiversity conservation of a habitat under threat relies on solid knowledge about (1) the ecological requirements of component species, (2) the probable causes surrounding the loss of any species, and (3) the survival requirements of the remaining species that are most under threat. Biodiversity assessment—obtaining systematic knowledge of what taxa are present—is prerequisite to determination of these factors, and the critical tasks of conservation, in particular monitoring and restoration, cannot effectively proceed until assessment is complete.

Coral reefs are widely recognized as the ‘ocean’s rainforest,’ and are among Earth’s most biodiverse ecosystems (Reaka-Kudla, 1997). Yet as in rainforests, our emphasis has historically been limited to highly visible charismatic organisms. In the rainforest, trees provide the major structural component for monkeys, birds, and flowers. These elements command the most attention, but it is widely acknowledged that the wealth of rainforest biodiversity lies in terrestrial arthropods (especially insects), members of the most diverse taxon on earth, most of which are small and cryptic. Parallel groups on the coral
reef (and likewise the charismatic minority) are the hard and soft corals (providing structure), fish, lobsters, larger sponges, and macroalgae. And as in the rainforest, the wealth of coral reef biodiversity lies in 'other' small, cryptic invertebrates, i.e., the worms, mollusks, echinoderms, crustaceans, etc. Many of these groups are exclusively marine and underlie Paulay's (1997) recognition that coral reefs show much higher diversity at higher taxonomic levels than rainforests. These taxa play pivotal ecological roles, are numerically dominant, and contribute (with algae) to the trophic underpinning of the reef. In most cases, other than highly visible or damage-causing species [e.g., crown-of-thorns starfish [Acanthaster planci (Linné)], Christmas tree tube-worms [Spirobranchus giganteus (Pallas)], queen conch (Strombus gigas Linné)], they are severely underestimated, and the biotic picture of the reef system is incomplete.

The goals of this paper are (1) to emphasize the already well-acknowledged need to inventory invertebrates on coral reefs, not only for the pure increase of scientific knowledge, but for the benefits to conservation programs and other societal uses, (2) to stress that such inventories are best 'driven' by professionally trained systematists, involved as participants and/or consultants before, during, and after collections are made, (3) to concede that because most marine invertebrates are small and cryptic, such inventories must be 'destructive' (i.e., physical samples must be taken), but to stress that the damage caused by such sampling is in most cases minimal, and (4) to show that qualitative (presence/absence) inventories can be more expedient, more expeditious, more cost-effective, and just as scientifically valid as quantitative data for most conservation needs.

**WHY SYSTEMATIC INVENTORIES ARE IMPORTANT**

Most laypersons, and also many biologists, believe that we have already adequately described and understand most of the world’s biodiversity, with possible exceptions in the insects and microbes. They also tend to believe (and this is certainly also true of many conservationists) that complete knowledge of the species present is not necessary to carry out most conservation programs—so why do it? Some conservationists even regard systematic inventoring, because it involves collecting, as 'anti-conservation.'

Yet, more and more people are coming to understand that these beliefs are false. Even in very well-known groups, such as birds and mammals, new species are discovered every year. The ‘unknown’ fauna and flora of the Earth are not restricted to insects and microbes. More and more scientists and conservationists are coming to understand that good conservation must be based on good science. And to do good biodiversity science, we must at an early point know the elements—the taxonomic elements—with which we are dealing. Policymakers, too, are becoming aware of the importance of inventoring and improving taxonomy. These topics have been the focus of recent discussions at recent meetings of the Convention on Biological Diversity (CBD) (see document 5 at http://www.biodiv.org/sbstta2/docs.html, and document 6 at http://www.biodiv.org/sbstta4/docs-e.html).

Collections housed in the world's natural history museums are our only permanent, verifiable record of species-level biodiversity—what it is, where it has been found, and when it was last recorded. Without physical specimens, even the observations of the most competent field biologists lose reliability over time, as systematic revisions change our
species definitions. Even the best observers cannot identify small cryptic species in the field, nor do they take sufficiently comprehensive samples to obtain realistic species lists.

Systematic inventories, and the collections that they build, provide a permanent scientific record for documenting patterns of diversity and endemism across habitats and ecosystems. Such information is essential for identifying and establishing conservation priorities. Inventory data provide baselines for monitoring programs and could identify indicator species of environmental change. Inventories discover and describe new species that have medicinal, agricultural, or other economic uses. All of these, and more, are the elements of the CBD's call for additional inventories to support the conservation and sustainable use of biodiversity.

The Need to Inventory

The need to inventory marine invertebrates is well documented. Small et al. (1998: 1) noted that "no serious effort has been made to actually 'dissect' a well-developed reef ecosystem to determine a realistic biodiversity number". These authors quoted Reaka-Kudla (1997: 102) that "the difference between the numbers of described ... versus expected ... species suggests that coral reefs are repositories of very high undocumented species diversity. Most species on coral reefs are relatively small and cryptic, and difficult to observe and collect". In summarizing the results of a symposium to provide the U.S. Environmental Protection Agency (EPA) with "practical, reliable, low cost monitoring methods for assessing ... coral reefs", Jameson et al. (1998: 1) recommended invertebrate groups that show potentially valuable conservation applications as bioindicators. These included (1) filter-feeding bivalves for bioaccumulation of trace metals/phosphorus, (2) sessile reef invertebrates (e.g., cementing mollusks, tube-worms) for early warnings of pollutant load (noting that "problems of taxonomic resolution" must first be addressed), (3) the abundance of certain macroinvertebrates (e.g., zoanthids, hydroids, tunicates) for which increased numbers can indicate water quality deterioration, and (4) the abundance of coelobites (reef-cavity dwellers, including mollusks, bryozans, serpulid tube-worms) for which abundance decreases in response to increased sedimentation (Jameson et al., 1998: appendix 4).

Also recognizing the need to inventory marine invertebrates are a number of national and international initiatives. The Convention on Biological Diversity has established a program called Global Taxonomy Initiative (GTI) to help build capacity for systematics in all countries. There is also a desire on the part of the CBD to implement the GTI within the context of other programs, including marine biodiversity.

The U.S. National Science Foundation's PEET [Partnerships in Enhancing Expertise in Taxonomy] Program was established in 1995 "to enhance and stimulate taxonomic research and help prepare future generations of experts" through 5-yr funding awards for projects involving monographic research, training, and computer infrastructure. This program specifically addresses the shortage of trained systematists, now aging and facing non-replacement, even in museums where extensive specimen collections, laboratories, and libraries provide the best available support for systematic work. This limitation is especially critical in marine invertebrate systematics (Thomas, 1997). Emphasis in the 1999 PEET program announcement (http://www.nhm.ukans.edu/~peet) was placed on "organisms that are poorly known or little studied," and although marine environments
were not specifically targeted, the list of favored taxa included many components of marine reefs, e.g., microbes, protists, invertebrates, and specifically, mollusks.

At the international level, the biodiversity science initiative DIVERSITAS (est. 1991), a partnership among UNESCO and several large international science unions concerned about biodiversity, seeks to promote and catalyze knowledge about biodiversity by providing “accurate scientific information and predictive models of the status of biodiversity and sustainability of the use of the Earth’s biotic resources” (from http://www.icsu.org/DIVERSITAS). Marine biodiversity is among DIVERSITAS’s five Special Target Areas of Research (STARs) which “focus on problems of special concern ... that are often neglected or receive only limited attention.” Coral reefs are specifically mentioned, and marine invertebrates play a role in all four specified research components. One of these, ‘Systematics and Monitoring of Marine Organisms,’ notes that “numerous species [are] not yet described in even the most familiar of ocean environments” (from http://www.icsu.org/DIVERSITAS).

The international systematics initiative Systematics Agenda 2000 International (SA2000I) has become the organizational framework for DIVERSITAS’s third core Programme Element, ‘Systematics: Inventoring and Classification of Biodiversity’ (see http://www.icsu.org/DIVERSITAS/Plan/agenda2000.html). The goal of this effort is to promote systematic inventory, phylogenetic research, systematic infrastructure and training, and the creation of systematic knowledge bases such as Species 2000 (see http://www.sp2000.org), a worldwide index to all 1.75 million known species on Earth. Invertebrates, including those in marine, freshwater, and terrestrial environments, are among the groups emphasized for attention by SA2000I. A recent workshop report, The Global Taxonomy Initiative, by SA2000I and DIVERSITAS specifically addressed the role of systematic inventory in conservation and the building of biodiversity science capacity (see http://research.amnh.org/biodiversity/acrobat/hti2.pdf).

THE ROLE OF SYSTEMATISTS

The inventory of small, cryptic marine invertebrates requires the participation and/or consultation of trained professional systematists. Among their recommendations, Jameson et al. (1998) stressed the involvement of “taxonomically competent personnel” in monitoring. However, taxonomy (the science of naming and identifying specimens) is only a small part of systematics.

Systematic inventory by professional systematists includes (1) basic identification, accompanied by deposition of voucher specimens (i.e., properly labelled specimens placed in recognized repositories as a permanent record of the identification and occurrence in a particular region, and providing material for future study), (2) recognition of new or unrevised (cryptic) species, (3) production of keys, identification guides, and databases to assist other users, including conservation programs, (4) interpretation of species lists, including possible interactions with predators, prey, and environmental parameters, providing facts relevant to management goals, (5) potential recognition of indicator species, for which monitoring schemes can be developed, and (6) dissemination of results on web pages, and/or more permanently, in published peer-reviewed journals (a step often missing from agency-based studies). Trained systematists have the advantages of (1) access to extensive specimen collections, histology and molecular laboratories, and libraries, ei-
ther through their positions as museum curators or through professional collaborations, and (2) knowledge of their organisms—not only of the proper taxonomic name—but of life histories, reproductive strategies, trophic roles, and phylogenetic relationships.

It is most important that systematists be consulted early, to assure that the questions prompting the work can be effectively addressed by the data collected. At the initiation of a study, systematists can guide how samples are taken and processed. This must include at least minimal ‘destructive sampling.’ Cryptic invertebrates, and even visually conspicuous corals below the generic level, cannot be reliably identified by swim-over transects, visual recording, or video (Tomkins et al., 1999). In some cases, artificial substrates and microcollecting techniques might be most appropriate (Kensley, 1998). The various habitatt(s) present in an area can also be taxon-specific and must be adequately sampled (e.g., by rock scrapings, sediment to a particular depth). The handling of samples also benefits from prior consultation with specialists. Optimal preservation methods differ for zooplankton, jellyfish, mollusks, crustaceans, echinoderms, etc. (Hangay and Dingley, 1985; Camacho and Bedoya, 1994), and damage caused by improper preservation, especially the deleterious effects of formalin (a formerly routine fixative, and still necessary for anatomical study), can render some kinds of specimens unidentifiable.

**Case Studies**

When trained professional systematists are involved in biodiversity inventory of invertebrates, the results can be dramatic. Thomas (1997) summarized studies of the reefs in Madang Lagoon, Papua New Guinea, where various systematists documented higher diversity than previously recorded in amphipods, crinoids, opisthobranch gastropods, polychaetes, cephalopods, and algae. Following are a few additional published examples, authored by systematists working in a range of marine environments, including coral reefs, and temperate and tropical lagoons. These studies also resulted in never-before-assembled species inventories or those far surpassing previous counts, and each resulted in conservation-relevant conclusions based on systematic knowledge.

**LOOE KEY ECHINODERMS.—** In 1995, a beautifully illustrated book was published based on a survey of echinoderms at Looe Key National Marine Sanctuary (now encompassed by Florida Keys National Marine Sanctuary) (Hendler et al., 1995). Prior to this study, no previous survey based on the Florida Keys existed, and that for the Caribbean was “out of print, out of date, and very poorly illustrated” (Hendler et al., 1995: vii). Over a 2-yr period (1984–1986), collection and observational data documented 144 species from 87 stations within and around the boundaries of Looe Key reef at depths of less than 100 ft (30.5 m). Specimens were collected under Sanctuary permit, qualitatively, using scuba or snorkeling, and consisted either of whole macrofaunal animals, or bulk samples (e.g., bags of Halimeda or other algae, whole sponges) for sorting in the laboratory mainly for cryptic brittle stars; a small number of poison stations were made outside Sanctuary boundaries, again for cryptic fauna (P. M. Mikkelsen, pers. observ.). Voucher specimens were placed in the home institutions of the four coauthors, all of whom were systematists: Harbor Branch Oceanographic Museum (Ft. Pierce, Florida), the National Museum of Natural History (Smithsonian Institution, Washington, D.C.), and the Natural History Museum of Los Angeles County (California). Among the significant results was a note that in the Florida Keys, ophiuroids (brittle stars) constitute 27–52% of all macrofauna
under rubble. This underscores the biotic importance of coral rubble as a habitat—one that may be perceived as lifeless sediment at the base of the living coral formations—and of ophiuroids (43% of all echinoderms) to total biodiversity.

**Indian River Lagoon.**—In February 1994, a conference was held at Harbor Branch Oceanographic Institution (Ft. Pierce, Florida) on “Biodiversity of the Indian River Lagoon.” The Indian ‘River’ is a narrow estuarine body of water that parallels the eastern Florida coast beginning just above Cape Canaveral and travelling southeast for 250 km to just north of Palm Beach. It has long been recognized as an extremely biodiverse zoogeographical transition zone at the region of overlap between Carolinian and Caribbean faunal provinces. In 1992, it was federally recognized as an Estuary of National Significance. About a year prior to the conference, the organizers sought biologists with research centered in the Indian River to present papers on aspects of biodiversity of the lagoon. Among these were systematists on a wide variety of taxa, including fishes, mollusks, sipunculans, bryozoans, seagrasses, bacteria, isopods, amphipods, birds, foraminifera, annelids, sea turtles, and cetaceans. Two examples involving marine invertebrates are discussed here.

Mikkelsen et al. (1995) qualitatively surveyed the marine mollusks of the Indian River lagoon using museum collections, private shell collections, published and unpublished (‘grey’) literature, as well as original collections. Four-hundred and twenty-eight species were recorded, surpassing the previous number in peer-reviewed literature (116 species) by 269%, and the previous number in peer-reviewed plus grey literature (259 species) by 65%. The study emphasized the unique fauna associated with lagoon-to-ocean inlets, found the highest molluscan diversity in seagrass beds, and identified the most common and abundant mollusk as the diminutive (<5 mm) gastropod *Bittiolum varium* (Pfeiffer) [Cerithiidae]. Five endemic species and one internationally-protected species contributed toward discussions of habitats in greatest need of protection.

Rice et al. (1995) conducted a similar qualitative survey of sipunculans. Although the final number of species was only 18, this represented a 350% increase over the previous list of four species, all recorded in ecological or single-species publications.

In comments summarizing a panel discussion (Swain and Zahorock, 1995), Conference Coordinator Hilary Swain acknowledged that (1) conservation along the Indian River lagoon had been heavily biased towards vertebrates (birds, fishes, mammals), and that the status of invertebrates was poorly known, and (2) the number of invertebrate systematists is low and invertebrates are generally difficult for parataxonims to identify. She concluded that the “first step [toward resolving these problems] is to facilitate dialogue and information exchange between state and federal agencies and taxonomic specialists” (Swain and Zahorock, 1995: 261).

**Oculina Coral Mollusks.**—John K. Reed (Harbor Branch Oceanographic Institution, Ft. Pierce, Florida) conducted extensive studies in the 1970s and 1980s of the coral *Oculina varicosa* Lesueur, and associated invertebrate communities at three depths off the eastern coast of Florida. Coral heads were collected by lockout divers from manned submersibles, after which all macroinvertebrates were removed and sorted for identification. Quantitative community analyses were published for mollusks (Reed and Mikkelsen, 1987) and decapod crustaceans (Reed et al., 1982).

No previous study of the mollusk community had been conducted. The analysis documented occurrence and abundance of 230 species, 177 of which were considered rare, 42 common, and 11 abundant (*n* > 100). Abundant species comprised 65% of the total num-
ber of specimens. The most numerous species was a tiny snail, *Parviturboideis interruptus* (C. B. Adams) [Vitrinellidae], comprising 21.5% of all specimens. The most frequently encountered species was the boring bivalve *Lithophaga bisulcata* (d’Orbigny) [Mytilidae], which occurred in 78% of all samples. Trophic categorization showed filter feeders to comprise 29% of all species, non-coralivorous carnivores 24%, herbivores 15.5%, and coralivores 4%. Faunal differences in depth noted 75% herbivores or detritivores at the 6 m site, 67% filter-feeders at 27 m, and 62% carnivores at 80 m [carnivores comprised only 5% at 6 m]. Endolithic species were lowest in abundance at 80 m, and greatest at 6 m. When compared with published reports of mollusks in other reef biotopes [including those in the Gulf of Mexico and Australia, the molluscan fauna associated with *Oculina* coral on eastern Florida was declared “richer in number of molluscan species than are other species of coral reported in literature” (Reed and Mikkelsen, 1987: 112). The numbers of species was also substantially higher than those in other mixed coral communities in the Gulf of Mexico [Flower Gardens (65 species), Florida Middle Grounds (65), Alacran Reef (130)]. However, it was acknowledged that the thoroughness of total sampling, seasonal sampling, and range of depth covered by this study likely increased the number of species realized. Voucher specimens were deposited in the Harbor Branch Oceanographic Museum and National Museum of Natural History.

As with the molluscan study, the inventory results on decapod crustaceans were the first of their kind. The inventory documented 50 species from the four depth stations, only 8% of which were present at all depths. A filter-feeding species, *Megabocorhatium sarianum* (Say) [Porcellanidae], dominated at 6 m where wave surge and sedimentation were highest. A detritivore, *Pugilus carolinensis* McLaughlin [Paguridae], dominated deeper, less disturbed stations. Several obligate commensal species (i.e., those that feed on coral mucus) were identified. Voucher specimens were deposited in a number of national and international repositories.

**Assateague Island National Seashore.—** Molluscan surveys at Assateague Island National Seashore on the coast of Maryland/Virginia provide a good example of the positive results of repeated qualitative sampling. Henderson and Bartsch (1914) surveyed the area in 1913, and recorded 82 species of bivalves and gastropods. Counts and Bashore (1991) resampled the same area 75 yrs later, in 1988–1989, and recorded 75 species. Although this initially appears to be a decrease in taxonomic diversity, only 50 species were shared by the two collections. Although 32 species were lost from the 1914 list, another 25 were gained, including members of two additional classes, Polyplacophora and Cephalopoda. Changes in the fauna were attributed to salinity changes due to inlet modification, hurricanes, the introduction of molluscan predators (e.g., oyster drills), and oyster diseases. Seven species newly described from this region in 1914 and considered endemic were not collected again in 1991, and are presumed to be extinct. A third study of benthic macrofauna at Assateague Island is ongoing and in 2 yrs has already identified 29 molluscan species not represented in either the 1991 or 1914 studies (C. L. Counts III and R. S. Prezant, unpubl. data). Both the 1914 and 1991 studies were conducted qualitatively; the ongoing study by Counts and Prezant is generating quantitative data.
DISCUSSION

In an analysis of papers published in conservation journals between 1987 and 1995, France and Rigg (1998) categorized over 2500 papers in a variety of ways, and concluded that biodiversity science in 1995 was largely centered around the same issues being pursued in 1987 (in this case the impact of forest loss on charismatic terrestrial macrofauna). This they called the “founder effect,” that is, that research was still narrowly focused on its initial course, without broadening its scope or interests over time. This same result seems to apply (at least in part) to the present trends in marine biodiversity research, including coral reef studies. A prime example was the meeting that instigated this paper (International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring, and Restoration, April 1999, Ft. Lauderdale, Florida); from a total of 281 printed abstracts for papers and posters, only 17 (6%) dealt with non-coral invertebrates. Another is the record of funded research proposals by NOAA’s National Undersea Research Center [NURC] (see http://www.ucwul.edu/nurc). In spite of a professed goal to “assess and monitor reef communities,” not one of 57 projects funded by NURC since 1991 has centered on systematic inventory; funding emphasis has been placed on environmental parameters and diseases, and taxonomic coverage is heavy on the side of cnidarians, sponges, and algae (only eight projects involved other invertebrate groups, with only three of these multi-species studies). A published example is the volume “Biodiversity II” (Reaka-Kudla et al., 1997) wherein only two of 33 chapters dealt specifically with marine biodiversity issues.

The finite financial resources of conservation efforts admittedly require agencies to set priorities based on need and risk assessment. Marine conservation is already at a disadvantage in this regard; far fewer endemics and extinctions are documented in the marine realm. Possibly as a consequence, the majority of the world’s biodiversity funding goes to terrestrial or aquatic conservation in a few global ‘hot spots’ (e.g., Madagascar, New Caledonia, South/Southeast Asia; Reyers et al., 1998). The issue of limited money translates largely into an issue of time, because it is generally believed that systematic work takes too long and (as a result) costs too much. Although it is true that rigorous systematic revisions do take a great deal of time to complete, it is a misconception that inventory work requires a similar time scale.

One key to resolving this issue is to reconsider the value of data based on qualitative sampling. Qualitative data, in the form of a simple list of species present—perhaps elaborated by categorizations such as relative abundance (abundant, common, rare), habitat, trophic role, etc.—can be far more rapidly produced than qualitative data, which emphasizes hard numbers of individuals per unit area. Sampling, sorting, identification, and analysis to generate these qualitative hard numbers all require substantially more time (and money) than are required by qualitative sampling, and are not necessarily more effective in characterizing a fauna. Nevertheless, qualitative studies are often dismissed as too ‘quick and dirty’ to be scientifically defensible. This disregard for qualitative work unfortunately means that small-scale, time-intensive quantitative studies receive the available funding to provide rigorous investigations of single species or single grassbeds. Meanwhile, entire reef tracts remain completely uninventoried, and conservation decisions must be made on the basis of incomplete data, or at best, minimal data extrapolated unjustifiably. The truth is that qualitative studies may actually be more appropriate for systematic inventoring than are ecology-friendly quantitative studies.
The focus of marine biodiversity needs to be corrected soon by the intentional broadening of research topics considered as fundable. The first requirement in affecting this change has to be providing programmatic support for systematic inventory of marine invertebrates. Although funding agencies often pay supportive ‘lip service’ to biodiversity research, the lists of funded proposals indicate that they are more concerned with, for example, the spread of black-band disease on a single reef. Although the seriousness of global degradation in coral health cannot be denied, such studies do little to improve understanding of the biotic complexity of reef ecosystems.

Managers must be inspired to re-evaluate their needs, and choose the right tool to accomplish them. In the interest of immediacy (we need the inventory data now) and necessity (we have limited funds), we must encourage support and funding for comprehensive qualitative inventories of marine invertebrates by trained systematists. Although the world supply of systematists is dwindling, those that are still available will not come forward until sufficient funding is available for the work from federal, state, or sanctuary levels. A resurgence in systematic funding for work on charismatic coral reefs has the further potential of trickling interest down to university students choosing their majors, to assist global initiatives such as NSF-PEET and DIVERSITAS in replenishing the world’s supply of trained systematists.

**LITERATURE CITED**


Addresses: (P.M.M.) Division of Invertebrate Zoology, American Museum of Natural History. Central Park West at 79th Street, New York, New York 10024-5192. E-mail: <mikkel@amnh.org>. (J.C.) Division of Vertebrate Zoology, Department of Ornithology, American Museum of Natural History. Central Park West at 79th Street, New York, New York 10024-5192. E-mail: <jlc@amnh.org>.