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THE IMPORTANCE OF SYSTEMATIC RESEARCH IN THE CONSERVATION OF AMPHIBIAN AND REPTILE POPULATIONS

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ABSTRACT -- Systematic research in the tropics is becoming increasingly difficult to pursue, because more and more restrictions are being placed on the acquisition of specimens. These restrictions have the unfortunate consequence of reducing or eliminating the most important source of information on the status of tropical populations -- systematic research. Application of these restrictions is based on the erroneous assumption that scientific collecting is an actual or potential factor in the loss of biodiversity. A recent claim, that the disappearance of two species of Puerto Rican frogs is partly attributable to overcollection by systematists, is rebutted. No species is known to have become threatened, endangered, or extinct due to overcollecting by scientists, yet habitat destruction by humans has caused hundreds to thousands of extinctions. The importance of systematic research in the tropics is that it reveals the existing biodiversity (the number and kinds of species) and delineates species distribution, both of which are the primary sources of information for any conservation effort. Systematic research therefore should be strongly encouraged by relaxed permit regulations and should receive the highest priority for biodiversity and conservation funding.

Throughout the world and especially in the American tropics, it is becoming increasingly difficult to conduct systematic research at a time when systematic studies are most needed. While forest habitats and their associated faunas are disappearing at an alarming rate (Lugo 1988, Wilson 1988), greater and greater restrictions are being placed on the acquisition of specimens. Systematists now are choosing not to conduct research in some countries because of these restrictions. This trend is unfortunate, because virtually 100% of the information that we now have on biodiversity in the tropics is through systematic research. Such restrictive practices by governments are rapidly cutting off the flow of information that is essential for conservation efforts. Here we stress the importance of systematic research and point out that the underlying reason for these restrictions -- that collecting by systematists might pose a threat to species survival -- is unfounded. Although our examples are from amphibians and reptiles, we are confident that our conclusions apply to most other groups of animals. The exceptions would be those species that exist in very low densities, have very restricted ranges, or for which other aspects of their biology make them especially vulnerable.

RESTRICTIONS ON SYSTEMATIC RESEARCH -- For the purpose of understanding population and geographic variation, it is often important to obtain series of specimens. Yet permit-granting agencies often unnecessarily restrict the number of specimens to some arbitrarily small number, such as five per species (or even fewer!). In our experience, the collection of several hundred specimens of one species from a single locality has no obvious effect on the persistence of the species, as evidenced by repeated collections at the same locality (examples below). Another common practice is to restrict collections from areas that often have the most habitat and diversity, such as national or state parks and forests. It is these areas that usually are the most important for systematic research. They are commonly the only areas where certain species can be found, and they have the highest probability of yielding undescribed species.

Practices such as these deter systematic research and are based largely on misunderstanding of the population dynamics of these animals, which are considerably more abundant than most people realize. Routine collecting by systematists does not pose a threat to the survival of any species of amphibian or reptile of which we are aware. The single greatest threat to biodiversity in the tropics and the one factor that far outweighs all other contributions to the global decline of species is large-scale habitat destruction (Myers 1988, Robinson and Robinson 1989), a deterministic cause of extinction (Gilpin and Soulé 1986). Even among stochastic causes of mortality, natural catastrophes such as earthquakes, landslides, floods, and hurricanes have orders of magnitude greater effects on populations of these species than does collecting by systematists. These natural events are dwarfed by the effect of human-caused habitat destruction.

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BENEFITS OF SYSTEMATIC RESEARCH - "Taxonomic classification is a primary determinant of management priorities for endangered species" (Daugherty et al. 1990). The important benefits that systematic research can have on the conservation of amphibian and reptile populations are numerous. One that is often overlooked is the actual determination of species diversity, which includes the discovery and description of new species. This requires the collection and preservation of specimens for the accurate definition of species as well as for documentation. A species must be known before it can be protected, and many new species are discovered among preserved specimens in museums. Another important benefit of systematic research is the accurate delineation of species distributions. Such information is critical for conservation efforts. For example, a species may be currently known from only a single locality. Considerable time, energy, and funds could be devoted protecting this seemingly rare species, when in fact it may have a much wider distribution that is unknown due to restrictions placed on collecting. Further, systematic collecting gives us our first knowledge of a species' natural history: habitat, habits, behavior, etc. (Schwartz and Henderson 1991) Other aspects of biology that may be critical to conservation efforts, such as captive management, can be retrieved from preserved museum specimens (e. g., gonadal cycles, stomach contents). For the majority of species, this will be our only knowledge of their biology for some time to come.

Nearly every species that has been examined has been found to exhibit some geographic variation throughout its range. Sometimes the variation uncovered warrants recognition of subspecies or indicates the presence of sibling species. A recent example involves the wide-ranging salamander *Plethodon glutinosus* of the eastern United States. A detailed electrophoretic study of geographic protein variation in this salamander has revealed a complex of 16 species where only one was known before (Highton et al. 1989). Several of these species are restricted to relatively small areas that, because of this systematic study, may warrant protection in the future. In Puerto Rico, one of the most common species of frogs, *Eleutherodactylus coqui*, was discovered during the process of making extensive collections of *Eleutherodactylus portoricensis*, the species under whose name it had been confused (Thomas 1966). The recognition of the Puerto Rican lizards *Sphaerodactylus nicholsi* and *S. townsendi* as distinct species was the outcome of a population-level electrophoretic study (Murphy et al. 1984). Recently, a similar study on the blind snake *Typhlops richardi* has revealed the presence of three species, with *T. platycephalus* and an undescribed species occurring on Puerto Rico and *T. richardi* restricted to the Virgin Islands (Hedges and Thomas in press). Systematic studies of geographic variation are needed for other wide-ranging and variable species on the Puerto Rico Bank, such as the lizards *Sphaerodactylus macrolepis* and *Anolis cristatellus*, the snakes *Alsophis portoricensis* and *Arrhyton exiguum*, the amphisbaenians *Amphisbaena caeca* and *A. schmidti*, and the frogs *Eleutherodactylus cochranae*, *E. coqui*, and *E. richmondi*. It is not simply that systematic study gives us more information, but inadequate study acts contrary to the interests of conservation. Daugherty et al. (1990) reported that failure to investigate adequately the systematics of "the" Tuatara led to the neglect and subsequent extinction or severe decline of 14 of 40 populations of the genus. What had been regarded as a single species *Sphenodon punctatus* was found by Daugherty et al. to comprise at least three species and two subspecies. Because of incorrect taxonomy that lumped different taxa into *S. punctatus*, the dire circumstance of *S. guntheri* was not recognized; it went extinct on one of the two islands from which it was known. Gans (1991) noted the irony that the Wellington Museum had few and poorly preserved specimens of *Sphenodon*, while the Stephen's island population less than 100 miles away had a population estimated at over 100,000 animals. Systematic collecting is not an adjunct; it is a core activity that needs to be encouraged. It cannot be a one-time event; follow ups are necessary to further refine our knowledge or to apply newer techniques of analysis.

The recent discovery of a population of the boa *Epicrates monensis* on the mainland of Puerto Rico (R. Thomas, unpubl. data) makes it imperative that geographic variation be studied to assess the taxonomic status of *E. m. monensis* (Mona Island), *E. m. granti* (Virgin Islands), and the newly discovered populations, along with the La Cordillera and Culebra populations. The taxa *monensis* and *granti* each could be distinct species, as they were originally described, with the newly discovered populations either recognized as a third species or allocated to one of the original two. Also, more than one species of boa could be confused under the name *granti*. Another alternative, although less likely, is that all populations of these small boas could be called *E. monensis*, with no subspecific recognition. Until geographic variation is carefully studied using systematic methods, we will not be able to truly assess the status of these snake populations.

Avise (1989) has underlined the necessity of systematic research for the conservation of endangered species. He stresses the importance of assessing diversity and knowing the phylogeny, of correctly delimiting species, and the importance of molecular genetic techniques in these endeavors. Avise further notes the usefulness of "pure" systematic research not necessarily designed for specific management objectives. Gans (1991) further commented that "The lesson remains that protectionist impulses that limit or stop sampling do not automatically result in preservation of the species. This is certainly critical in the many parts of the world where forest, game and wildlife departments impose unrealistic bag limits on relatively common but poorly known species."

OVERCOLLECTION: A MYTH -- Perhaps the best evidence that scientific collecting has not had any effect on species abundance or survival is the following example involving West Indian frogs. There are three "famous" herpetological localities in the West Indies: Soroa in eastern Cuba, Hardwar Gap in the Blue Mountains of Jamaica, and El Yunque in eastern Puerto Rico. These three localities are unusual in that they have been visited repeatedly by herpetologists during the last century and thousands of frogs have been collected, preserved, and placed in museums around the world. Systematists normally do not visit the same locality repeatedly, but instead focus on poorly known areas that have a higher probability of producing new species. However, these three localities are easily accessible, have well-developed forest, and harbor a diverse herpetofauna. Thus they have been attractive to herpetologists who visit the islands for only a short time and wish to have representative specimens of many different species. Even herpetologists starting more extensive projects on the islands will visit these places to begin learning the fauna. These sites are convenient when more specimens are needed for the application of new systematic techniques. We have visited each of these three localities within the last two years and have heard or observed all 28 species of frogs ever known to have occurred at those sites (with the exception of *E. karlschmidti* of Puerto Rico, discussed in detail below). This example is important, because at these three localities, some of the most intensive herpetological collecting in the West Indies has taken place; and yet, with the exception of *Eleutherodactylus karlschmidti*, not a single species has disappeared, or has given the impression to us of declining in numbers. In fact, our recent visits to Soroa and Hardwar Gap have revealed two additional species of frogs never before recorded from those sites (Hedges and Thomas 1989). Our observations on the abundance of these frog species, although not quantitative, lead us to the conclusion that repeated collections have not had any significant impact on the abundance or survival of these species.

Another example involves the small Puerto Rican geckos, *Sphaerodactylus macrolepis* and *S. townsendi*, which were sampled intensively at roughly monthly intervals at one restricted site (about two acres) during a 20-month period (Gaa 1983). At the end of the period there was no obvious diminution in their abundance (R. Thomas, pers. observation). Even more extreme (but sporadic) collections of small reptiles of various species have been made at intervals of one to several years at some sites in the Dominican Republic and Haiti. These were made by paid local collectors and the collecting was at times very intensive. Late visits to these sites by us to collect additional specimens for biochemical studies have shown no evident changes in the populations.

It has been suggested that the disappearance or decline of several species *Eleutherodactylus* in Puerto Rico may be due in part to overcollection by systematists (Burrowes and Joglar, this volume). We disagree with this charge but will confine our discussion to the two species that have not been seen in recent years (*E. jasperi* and *E. karlschmidti*), because we have some reservations concerning the status of the other species, which some suppose are declining. Also, one of us (RT) has observed both of these species in the field in past years, and therefore has first-hand knowledge of their habits and abundance.

The bromeliad-dwelling species *E. jasperi* apparently has not been seen since the mid to late 1970's. It is known from a restricted area in east-central Puerto Rico, including Carite State Forest (Drewry and Jones 1976). Only a small series of individuals (16) were listed in the original description (Drewry and Jones 1976), and the species was awarded federal protection (as a threatened species) under the Endangered Species Act in the following year (November 1, 1977). To our knowledge, no additional specimens have been collected since that time, and therefore the total number of *E. jasperi* ever taken appears to be no more than about 20 specimens. This is also approximately the same number of individuals of a bromeliad-dwelling *Eleutherodactylus* recently collected by us from a single clump of bromeliads on a standing dead tree in Cuba. Although the 20 or so *E. jasperi* were taken from more than one area, we offer that comparison only to illustrate the minute sampling of this species that has been made. Even if *E. jasperi* is 10 or even 100 times less abundant than other bromeliad-dwelling *Eleutherodactylus*, such as the Cuban species mentioned, the 20 specimens collected is insignificant compared to the number of individuals of that species that are lost to predation in a single day, or in a single thunderstorm, where lightning may destroy several trees or the wind may blow off some bromeliads. When one considers that thousands upon thousands of *E. jasperi* must have been lost when roads and houses were built in this part of Puerto Rico, the number of frogs collected from habitat that was not destroyed becomes a drop in the ocean. Obviously *E. jasperi* should have been monitored since 1976 by judicious collecting; that way we might be in a better position of knowing its status. If this species has truly disappeared, then it is safe to say the cause was not overcollecting.

Because considerable suitable habitat remains in the Carite State Forest and surrounding areas, we believe that *E. jasperi* probably survives. As mentioned earlier, virtually all information on species comes from systematic collection, but since *E. jasperi* has been federally protected, no systematists have collected the species and consequently we know nothing more about it than we did when it was described in 1976. The assessment that it has "disappeared" ironically may be in part related to its listing as a protected species with the associated collecting restrictions, essentially cutting off the flow of information on this interesting frog. However, recent efforts to find *E. jasperi* at some localities where it occurred previously have been unsuccessful (Moreno; Burrowes and Joglar, this volume). The little knowledge that we have of this species suggests that it prefers relatively isolated bromeliads: those on the ground (Drewry and Jones 1976) or high in trees (R. Thomas, pers. observations). We would prefer to see the results of a vigorous collecting effort extending over a wide area before this species is considered extinct. (As with many small species, it is almost necessary to collect them in order to observe them; in this case, cutting and dismembering bromeliads is the surest way of finding the frogs).

The stream-dwelling species *E. karlschmidti* apparently has not been seen in about 10-15 years. Overcollection also has been suggested as a factor contributing to the apparent demise of this species (Burrowes and Joglar, this volume). Again a careful review of the evidence shows that this claim is unfounded.

The total number of *E. karlschmidti* ever collected is unknown, but the largest collections are those at the University of Puerto Rico (Río Piedras and Mayagüez), numbering approximately 100 individuals. Most of those specimens were collected about 30 years ago and used in a study of food habits (Rivero et al. 1963). It is unlikely that those early collections had any adverse effects on the species, because herpetologists later in the 1960's and 1970's observed this species to be quite common in streams on El Yunque. Specimens were easily found near bridges without hiking more than a few decameters up or down the streams (e. g., R. Thomas, pers. observations). Virtually all of the specimens of *E. karlschmidti* collected were taken in the vicinity of bridges over several widely spaced streams within the forest. Unless one entertains the unlikely idea that bridge abutments represent critical habitat for this species, the conclusion is that the relatively small number of individuals of *E. karlschmidti* ever collected (probably <150) could not have played any part in the disappearance of the species. It is likely that many streams in the Luquillo Forest were never visited by collectors, and of those that were, only a small part of the stream near a bridge was sampled. The apparent decline in *E. karlschmidti* is probably real, because herpetologists (20 or so that we know of) have searched streams in the Luquillo Forest for several years now without finding any *E. karlschmidti*. It is presently unclear whether acid rain, another habitat-saturating toxin, or introduced predators such as the mongoose, cat, or rat have had an effect, but habitat destruction does not appear to be the cause.

If the total number of individuals of both *E. jasperi* and *E. karlschmidti* collected were many times higher than what we estimate, our conclusions would remain the same. We do not believe that scientific collecting could have detrimental effect on a species' survival, unless that species is extremely restricted in distribution and the collecting effort is vigorous, habitatwide and persistent. In the 250 year history of systematics, we know of no case where scientific collecting has exterminated a species of animal. Yet during the same time period, hundreds to thousands of species surely have become extinct due to habitat destruction (Robinson and Bolen 1989: 414). In the West Indies, most of the 61 known species of rodents existing before the arrival of humans are now extinct (Woods 1989), as are many species of reptiles (Pregill 1986). Nearly all of those became extinct before systematic collections were made, as a result of predation and habitat destruction by Amerindians, European colonists, and their inquilines. Unfounded claims of overcollection by scientists, ironically, can be damaging to conservation efforts, because they may result in greater restrictions on systematic collecting and consequently the loss of information on biodiversity.

Those who have not done much systematic collecting often have little appreciation for the minuscule effects of collecting on population levels. It is obvious from the history of human-caused extinctions that sustained and pervasive (distribution-wide) hunting can cause severe decline or extinction, such as happened to the bison, passenger pigeon, heath hen, Carolina parakeet, etc. (Bolen 1989). We emphasize sustained and pervasive. Systematic collecting is always orders of magnitude less in intensity and is irregular in occurrence. The mongoose *Herpestes auropunctatus* is infamous for its depredations on the West Indian fauna (Baskin and Williams 1966, Philibosian and Yntema 1976). Aside from the fact that its impact is less drastic on the larger islands, the critical aspect of the mongoose's effect is its ability to permeate the entire habitat of small, ground-dwelling vertebrates, coupled with its resistance to eradication. The mongoose illustrates two things relevant to our argument: (1) the necessity of sustained and pervasive depredations to drive species to extinction and (2) the ineffectiveness of intense but not sufficiently pervasive depredations to cause extinction: seen in the largely unsuccessful attempts to control the mongoose, i.e., it is very difficult for humans to intentionally drive a species to extinction; it is the habitat-wide byproducts of other activities that do so. Systematic collecting has never been this pervasive.

The point has been made that systematic collecting is one component of many human-engendered effects against species and should be strongly regulated to reduce at least one component. (We detect a sense of despair in these stratagems, as if the authorities say 'Here's one thing, at least that we can control, so let's control it'!). It is certainly true that collecting is a component of mortality in a species; however, our points are twofold (1) Overall, collecting is too limited and sporadic to be significant in all but the most severely depleted populations (we doubt if any one would favor collecting Puerto Rican Parrots, for example), (2) In the specific case of *Eleutherodactylus karlschmidti* (and no doubt other eleutherodactyls, for which a decline, if true, has been postulated), collecting could not have been a factor. It was so insignificant and irregular that other, habitat-wide effects must be considered the real causes of decline.

CONCLUSIONS -- With tropical forests and their fauna disappearing at a rapid rate, we cannot afford the luxury of spending our limited funds on studying the life history and ecology of individual species. We must focus our efforts on finding out how many species exist, where they occur, and on protecting habitats that contain high species diversity. This should be the first order of business for any agency charged with managing natural resources. As long as their habitat is protected, most species will do fine without any intervention by humans, as they have for millions of years. Future generations of biologists will then have time to study the life history of each species. Therefore, we strongly suggest that systematic research on the amphibians and reptiles of Puerto Rico and other areas be encouraged to the greatest extent possible and receive the highest priority for funding.

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