> "Now the salamander is a clear case in point, to show us that animals do exist that fire cannot destroy; for this creature, so the story goes, not only walks through the fire but puts it out in doing so."
>
> \- Aristotle (Miller, 2000: 15)

The amphibian has been a creature of much report since the dawn of man's study of the natural world; at times even viewed in mythic proportions. Unfortunately, Aristotle's projection of the Urodel is far from correct. Today, it is well known that salamanders are not only unable to walk through fire, they, along with the rest of the amphibians, are more susceptible to the environment than any other tetrapod that exists, mostly because of their permeable skin (Duellman et al, 1994: 197). In recent decades, herpetologists have observed that amphibians, particularly frogs living in highland and northern areas, are rapidly disappearing (Linzey, 2001: 415). It was not until 1989, however, that the issue of amphibian decline came to the forefront when herpetologists from around the world met at the First World Congress of Herpetology in Canterbury, England. Various members of the conference had noticed amphibian declines in their own particular areas of study and finally came together in one place to discuss the problem at large (Stebbins et al, 1995: 210). One year following the meeting, David Wake of the University of California at Berkeley led a small team of researchers to discuss what should be done about the problem. His team was instrumental in the creation of the DAPTF (Declining Amphibian Populations Task Force) which has since become an international operation involving professional researchers and volunteers from around the globe (Miller, 2000: 161). After much initial study, researchers have observed that the decline was most severe in the 1960's and has since become more gradual (Ben-Ari, 2000: 1).

The observed decline amongst amphibian populations might seem a bit alarming to those outside the scientific discipline, but herpetologists understand that very little is known about the natural fluctuation that exists within amphibian communities. Therefore, it is difficult to determine if these events are cause for alarm. Past discoveries have demonstrated that similar occurrences developed during the last ice age, and so it is entirely possible that the decline is simply a natural incident (Stebbins et al, 1995: 210). But in 1995, just five years after the forming of the DAPTF, the issue of amphibian decline made headlines when a group of middle school students on a field trip in Minnesota discovered an array of deformities in the leopard frogs (*Rana pipiens*) of a local pond (Miller, 2000: 161). Although these extreme irregularities may not necessarily be cause for alarm in and of themselves, their combination with various other issues may be reason for great concern. From the early 1600's to the latter 1970's, there have been only two documented amphibian extinctions (compared with 28 reptile species). The world's amphibian populations have remained rather stable up until the last few decades and suddenly something has gone wrong (Beebee, 1996: 132). Now there are two questions herpetologists seek to answer: why are amphibian populations disappearing, and how much is man to blame (Stebbins et al, 1995: 210)?

Many researchers doubt that any one answer can be given to explain the phenomenon of amphibian disappearance (Miller, 2000: 161). Although the list of known factors that influence the decay of amphibian populations is growing by the minute, some general statements about the nature of these factors can be made. Most herpetologists agree that habitat destruction is the number one cause of decline. The greatest anuran biodiversity occurs in tropical rainforests which are rapidly being destroyed (Duellman et al, 1994: 8). *Bufo periglenes*, better known as the golden toad, is a prime example of a tropical anuran that is rapidly vanishing. Endemic to the Monteverde Cloud Forest Preserve in Costa Rica, the golden toad has not been sighted since 1989, and sadly, he's not the only case of a mysterious disappearance. In Brazil, eight of thirteen species of frogs endemic to the *Reserva Atlantica* have remained unaccounted for since 1981 (Linzey, 2001: 415). These losses demonstrate that even frogs existing in biological preserves are still at risk for decline; therefore habitat destruction cannot be the only cause.

The second leading factor in the demise of populations is man-made chemicals such as pesticides, insecticides, herbicides, and pollution. Most of these agents do not exist in nature at high enough concentrations to directly kill amphibians, but they do cause abnormalities, even subtle ones, that make the animals more vulnerable to disease and predation. Frogs are most commonly affected with dwarfism due to prolonged metamorphic states. This inhibits their ability to hunt normal prey and puts them at greater risk to larger frogs and other predators (Duellman et al, 1994: 8).

In recent years much research has been conducted on the herbicide atrazine to find any link it may have with the decline of amphibians (Renner, 2002: 1). In the past, toxicologists had considered atrazine to be one of the more benign biocides in use. About 27 million kilograms of it are used every year on corn and other such crops in the U.S. alone. Much of that quantity eventually finds its way into rivers and streams and even rainfall. Past studies only found it to effect amphibians at extremely high levels, but those studies did not take the workings of the endocrine system into consideration (Withgott, 2002: 1). Endocrinologist Tyrone Hayes and a group of researchers at the University of California, Berkeley have suggested that even low levels of atrazine found in the wild are having an impact on frogs, particularly males, turning them into hermaphrodites (Renner, 2002: 1). In fact, their study showed that exposed tadpoles are affected at levels 30 times lower than EPA's safe drinking standard (Withgott, 2002: 1). Hayes' team has conducted research on two anuran species, *Xenopus laevis* and *Rana pipiens* (the latter native to California), and found both to experience enough deformity to be cause for alarm (Renner, 2002: 1).

Another team of researchers led by experimental toxicologist James Carr of Texas Tech has found contrary results to Hayes' experiment. Carr's team claims that they are unable to reproduce the effects of Hayes' assay in the *Xenopus*. He questions the validity of Hayes' experiment (of course Carr's research is also part of a multimillion dollar fund by Syngenta; one of the leading producers of atrazine). So there is a degree of conflict that exists within these issues (Renner, 2002: 1-2).

Unfortunately, the direct effects of man-made chemicals are not the only problem at hand. Acid rain that results from pollution can cause insurmountable obstacles for amphibians as well. Acid rain has been known to have pH levels as low as 3 or even sometimes 1 (Beebee, 1996: 139).These low pH levels significantly hinder the reproductive abilities of many anuran species (140). Between 1974 and 1979, the extinction of a frog species in Sweden was found to have a direct link to acid rain. Strangely enough, however, the smooth newt (*Triturus vulgaris*) has seen a large population increase in the same area (probably due to lack of competition). Cases such as this one make the study of decline quite puzzling. Some species seem to be drastically affected while others are untouched. (142). A recent study concluded that deformities and deaths amongst several anurans exposed to low pH levels varied greatly between species (141). The problem in this particular area of study is that no one really knows at what pH level certain amphibian species breed and thrive best (140). And if no one is certain of those things, how can anyone begin to predict what may happen in any one community?

Many scientists have also linked amphibian decline to a fungal disease called chytridiomycosis. This disease is caused by the chytrid fungus (*Batrachochytrium dendrobalidis*) and is believed to have originated in Africa (Weldon, 2004: 1). The fungus kills by either forming toxins inside the animal or preventing gas exchange from occurring through the skin (Nowak, 2003: 1). During the mid-1930's many specimens of *Xenopus laevis* (anuran) were exported throughout the globe, and many herpetologists agree that this was how the fungus was initially spread. Today, this disease can be found in amphibian populations almost anywhere in the world including Australia, Panama, Ecuador, Venezuela, New Zealand, and Spain. At present, *Batrachochytrium dendrobalidis* can be found in association with amphibians on all continents with the exception of Asia. Although it is believed to have come from Africa, its origin has not yet been proven, and researchers are working tirelessly in the lab to discover with certainty where it came from (Weldon, 2004: 1). Time is ticking, however. The fungus has already dealt a great deal of damage, including nine extinctions (Nowak, 2003: 1).

Although habitat loss, chemicals, and chytrid fungus are probably the leading causes of decline, various issues of lesser report add fuel to the fire. Motor vehicle kills are one such problem. A study was conducted involving the European *Bufo bufo* that demonstrated that many anurans are killed while crossing busy streets in search of mates; up to 50% of those that attempt the journey in some areas (Beebee, 1996: 145). Other causes include urbanization, the building of landfills, wetland drainage, introduction of foreign species, and deposition of heavy metals (lead, mercury, cadmium, etc) (Stebbins et al, 1995: 241). Global factors also make a contribution with the thinning of the ozone. Studies in Oregon revealed that increased UV rays contribute to decline, and as with acid rain, some species are more heavily afflicted than others. These studies focused on the ability of the sensitive amphibian egg to repair damage to DNA from UV light (242). Although no one has documented any extinctions as a result of these smaller problems, they certainly play a role in worsening the effects of the leading factors.

Now that the problem of amphibian decline has been somewhat established, it may be useful to explore reasons that the prevention of decline is important. Amphibians play essential ecological roles in nature. Salamanders, for instance, are extremely abundant in the wild and do much good in the establishment of terrestrial communities. A series of studies in the Eastern United States demonstrated that salamanders play crucial ecological roles in deciduous forest systems, particularly in the Appalachian Mountains (Petranka, 1998: 2).

Overlooking the ecological benefits amphibians offer, many people often posit the question all ecologists love to hear: why should I care about the extinction of a slimy toad? It is to such people that this next section is devoted; a section that would remain absent, were it not for human selfishness and the philosophy that creation is worthless without profit.

Man has put amphibians to good use in an abundance of ways. More than likely, any John Doe on the street is familiar with the anatomy of a frog if he has a high school diploma. In the U.S. alone, educators use nearly nine million frogs each year for the study of vertebrate anatomy. Beyond the classroom, however, amphibian studies have greatly advanced such research as embryology, endocrinology, and physiology, and the metamorphosis period makes them ideal for research in genetics, development, and tissue transplant (Stebbins et al, 1995: 205).

Many tropical frogs that excrete alkaloid substances may one day yield drugs for human consumption. In 1992, a painkiller was derived from a species of poison arrow frog (*Epipedobates tricolor*). Although there are some side effects at present, research has demonstrated that this anesthetic is two-hundred times more potent than morphine in lab rats. Sadly, research in fields such as this one is becoming more and more difficult as the number of wild-caught specimens is diminishing. Experiments with family Dendrobatidae have shown that poison arrow frogs commonly surrender their ability to produce toxins after only one generation is raised in a habitat that is anything other than sufficient (Linzey, 2001: 138). As can be easily understood, the inability of a species to produce its primary defense mechanism will certainly decrease its chances of survival.

Other members of family Dendrobatidae excrete substances that have neurological significance and may assist doctors in the treatment of various mental illnesses such as Alzheimer's. Some Australian tree frogs yield a hypotensive peptide called Caerin 1.1 that could someday serve as an antibiotic or even an antiviral medicine (Stebbins et al, 1995: 208). There is even a substantial amount of research that shows amphibians may soon be listed as a surgical tool. Certain anurans excrete a thick, sticky mucus that may help in making a paste to seal up the soft organs (liver and spleen) after surgical procedures (209).

According to Stebbins and Cohen, amphibians have made an enormous contribution to the understanding of vertebrate vision. They have been "indispensable" in research on the vertebrate retina, including its anatomy, physiology, and photochemistry. For instance, the rod cells of a tiger salamander (*Ambystoma tigrinum*) have been used to determine the exact substance in rod photoreceptors that transmits signals to the optic nerve (Stebbins et al, 1995: 53).

Although we receive an abundance of benefits from amphibians, reciprocally, we receive an abundance of detriments in their absence. In the last few decades, for example, there has been a significant increase in the mosquito population of the Orient. Research has linked this increase to the disappearance of frogs that are vastly being harvested for food (Stebbins et al, 1995: 249). Of course this may not pose a monumental threat to countries in Asia, but what if a similar incidence occurred in Central/ South American countries that are prone to seasonal outbreaks of malaria and other such diseases?

Despite the bleak outlook, many conservation attempts are underway, and some herpetologists believe there may be hope for the future. The first step in conservation should probably be to determine exactly how many species exist. There is certainly no way to effectively conserve an organism that no one knows exists. Between 1985 and 1995, the total number of known, named species grew by almost 20 percent (Hanken, 1999: 1). The second step in conservation is to determine which of the known species are most threatened. That task has turned out to be a significant undertaking because very few herpetologists can agree on an acceptable list. Once those priorities are set, however, a few logical steps should follow. Legislation is always a vital part in the conservation attempt of any organism. Although it is unlikely that many laws will be passed that strictly concern amphibians, broader laws dealing with the protection of ecosystems and the regulation of pesticides are certainly an attainable goal (Beebee, 1996: 146). Most laws in the area of conservation serve as a kind of blanket that allows individual states to determine the exact measures and regulations involved. Although the United States has no specific law for amphibians, some states, such as California and Texas, have their own laws that protect native species. But of course, enforcement is the real trick, and sadly, it's usually poorly handled. Many times professional herpetologists and researchers are the ones who are most restricted while those seeking to do harm to the environment are able to slip by (147).

Legislation does have its problems, however. The major factors associated with amphibian decline are pollution and habitat loss; much of which occurs on private property. It's one thing for the government to ban the killing or capture of a few frogs, but it's quite another to tell someone what he can and cannot do with his own land (147-148). In the end, natural preserves may be the best defense against habitat loss. In the United Kingdom, SSSI's (Sites of Special Scientific Interest) are bought by the government to protect areas that exhibit a vast amount of biodiversity. Of course these government-owned lands are just as vulnerable as national parks, and maintenance often suffers because of it (148).

Ultimately, knowledge is the best defense against amphibian decline. Due to the fragile state of all ecosystems, nothing should be done in attempt of conservation without a great deal of prior study. For this reason, most herpetologists put their hope in natural preserves where amphibians can be protected in a well-established environment (Duellman et al, 1994: 9). But as the golden toad attests, even there they are not totally safe. It is extremely unlikely that mankind will change its ways any time in the near future, and so the only way amphibian populations will be saved from extinction is by human intervention (which is in itself, ironic). For so many millions of years amphibians have thrived as the masters of two worlds: terrestrial and aquatic. Now, the very adaptations that first allowed them to leave the sea and walk on land may be the cause of their demise.

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