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Invasion and Endangerment Lead by Specific Features of Reptiles and Amphibians

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Abstract. Biodiversity is the most emphasized term in ecology that keeps the ecosystem wonderful and stable. However, invasion and endangerment are two phenomena of disturbance of biodiversity. The features of these kinds of species should be determined for further animal protection. Through four main case studies, the article describes how such species proliferate or nearly distinct. Python Bivattatus, Rhinella Marina, Sphenodon punctatus, and Ambystoma mexicanum would be focused, and typical features of reproduction, niche, and feeding behavior indicate the phenomena. It is concluded that invasion is related to climate differentiation, energy cost, and adaptation. The specialty of poikilothermal animals in the ecosystem is important to discover the mystery of their invasion and endangerment. Furthermore, the relationship between invasion and endangerment is revealed, and several government solutions are mentioned.

Keywords: Endangerment, invasion, animal protection, feeding, reproduction

1. Introduction

Reptiles and amphibians are the two classes of typical poikilotherm among the world species. They possess several feeding and living strategies to generate the opportunity to survive. Invasion is a phenomenon caused by human introduction of different species. Some animals are proliferated by the international animal trade. The invasive species would impact the local environment by consuming the food resource and compete with local species. This is a large issue to be solved because the food chain would be interfered and the ecosystem is hard to be restored. Human's daily activity could strongly be influenced by immeasurable and aggressive individuals if the phenomenon of invasion is exceedingly severe. Endangerment, which is an indispensable process in evolution, is impacted by the physical feature of the species and some human behaviors. The number of endangered species soars to an unprecedented scale due to human impact. The government have already focused on it for a long time and costed a lot in preserving the biodiversity in order to protect gene bank. Endangerment could also be associated with invasion as well as climate change or habitat disturbance. The consequence would be extinction if human pay little effort. Thus, it is worthy of determining the feature of invasion or endangerment and setting valid solutions for the environment.

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Through four main case studies and several examples of reptiles and amphibians, this article would contain the arrangement of effective invasive or endangered features and the methods the government utilize to deal with different situation. The target it to provide better overview of the situation with potential threat.

2. Case of python bivittatus

4.1. Quick view

Bivattus is a kind of animal first introduced to Florida as pet with an average size of 3 meters [1]. However, with partial animal common sense, humans released them in the wild and they built up a visible population, which disturbed the local ecosystem. They are in the most beneficial niche in Florida, consuming and competing with local species on a large scale.

4.2. Comparison of provenance and invaded area

They live near a permanent water resource in southeastern Asia and southern China which has high temperatures and precipitation. Most of its habitats are near marshes and forests. Rivers are widely distributed and the high rate of vegetation causes them to be excellent swimmers and hikers, but it could not proliferate and was even near to being rare because of the high bio-diversity in the jungle. Many similar species in the same niche search for the same resource as them or attack them. The young python would be eaten by a lot of predators in the forest. For instance, some large insects, Canidae, and primates all eat python babies. So, the survival rate of these young pythons is not high. Besides, the adults would also be attacked by raptors, tigers, etc. Thus, the number of pythons bivittatus is been controlled with a regular ecosystem.

In Florida, the climate is similar to their provenance. The hot temperature means they could pass the winter successfully in southern Florida. However, in some extremely cold winters, it would kill almost 90% of the local samples of python [2]. But the ability to brumate promotes them to mate in the early spring, which would effectively keep their birth rate. The female python could shiver for thermal energy which means that they could spawn eggs at cooler temperatures. A single female python would spawn approximately 20-50 eggs and even up to 100 [3]. It is shown in one case that the python could have facultative parthenogenesis [4], which means that there exists a potential danger of an unexpected increase in population.

The appropriate numbers of rivers and lakes in the basin of Florida are directly matched with the swimming ability of the python. The unsteady precipitation sometimes leads to a flood in Florida, and this swimming ability could help them better survive these kinds of disasters while some of the other local species would die. That is one factor in how they win over the local species.

The longevity of the python could reach 30 years, so it is a large problem that they consume more prey than other local snakes. Human cannot evaluate a certain number of them because of their long lifetime.

4.3. Diet and niche

They are the fiercest predator in any area. They eat vibrates that they could devour. Their diet is wider than other kinds of animals including small birds and mammals. Exceptionally large pythons may even require larger food items such as pigs or goats, and are known to have attacked and eaten alligators and adult deer in Florida.

Python is in the best niche in Florida. The only competitor for them is the alligator since black bears don’t require the same food resource as them. But local alligators would be killed by the violent python in a few numbers, even though alligators could sometimes defeat them. Bobcat, puma, and the black bear would sometimes eat pythons, but due to their strong reproductive ability, they are still on a growing scale. When they prey, they keep silent and still, strangling to kill their prey. It is the most efficient approach to obtaining food resources. Because of their large figure, they need much more energy to keep active and growing. Thus, they would attack numerous species.

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In their normal diet, they would eat prey that is about 20% weight to their weight. Their normal foods are small rodents and birds, and they need about 8-14 days to completely digest and defecate them [5]. Their digestive ability is advanced. Their digestive system would be re-modeled when they are feeding. Before they eat food, their digestive system is paused. There would be no acid or bile secreted in their stomach or gall bladder, and the enzymes are inhibited. The circulation system also needs a low cost of energy. When they start to digest, their percentage of hydrochloric acid and the demand for blood oxygen would increase at a high rate, which enhances their absorbing productiveness. However, the energy cost of the digestive system is only 0.1-0.2% of the energy that they could attain from their food [6]. Through this strategy, python bivittatus develop a kind of special efficient energy cost-retrieve system. That's how they could live and cater to different environments successfully.

4.4. Influence

A 2012 report stated, "in areas where the snakes are well established, foxes, and rabbits have disappeared. Sightings of raccoons are down by 99.3%, opossums by 98.9%, and white-tailed deer by 94.1% [7]. This is because python bivittatus reproduce without the regulation of predators and competitors. They reach an unusual population number. An expectation model reveals that the number of them would increase over about 10 thousand times in 10 years if there isn't any protection device for the local government. Furthermore, the python would attack humans more frequently that the population grows to a large number and humans in Florida could sometimes meet them in the park or beside the road. The government cost millions of dollars per year to catch them, but it is still hard to control this overwhelming tendency of the increase in python. To restore the local environment, the cost would be much greater since the break in environments is so intense. Also, a nonnative pentastomid parasite (Raillietiella Orientalis) among reptiles that exist in the respiratory tract would impact the local species because of the invasion of python bivittatus. Pythons have already had a relatively efficient immunity to resist this parasite, but the local snakes don't own such immunity, so the disease would spread among the reptiles rapidly, influencing the health of the local animal [8]. Even some local reptiles are more appropriate for this parasite to survive. These reptiles who get this parasite would have difficulty inspiring and decrease their longevity, which is considered by the government as a strong impact on the ecosyste

4.5. Possible resolution

Restricting the trade of snakes could be a long-term approach. Although most snake trades desire snakeskin, the trade of living snakes is also a big deal. Bivittatus occupies 6.2% of the python trade. Python reticulatus occupies 28.7% of the trade, but they are snakes that exist in more tropical provenance [9]. The most appropriate temperature for the eggs to be hatched is about 31 centigrade, so it is hard for them to reproduce successfully in the wide. Also, surviving in the winter to invade is impossible in cooler areas. Thus, Python reticulatus do not cause a consequence as severe as bivittatus. Furthermore, the artificial breeding technique of bivittatus is not mature enough to keep them steady as other snakes like python regius. The import of bivittatus in the US is still a great amount. So, if the animal trade is confined, the import of bivittatus could be reduced, which is both beneficial for the provenance and invaded area.

Artificial breeding should be developed for any specie to keep their population. Its progress is also going to reduce the demand for wild individuals from the provenance. It's effective to protect the python from trading in those endangered areas. Since artificial feeding is well-prepared, preventive treatment in the wild should be improved. The government could hire local residents to organize a large team of catching the bivittatus. For those pythons that are caught, they could be sent to the provenance to Southeastern Asia in order to fix the position of the exported python in the broken food chain. In this way, the ecosystem in both areas would be restored. But the problems existing are the tremendous cost of labor and transportation and the relationship between the policies in the two areas. If the government in the provenance doesn't do an effort on controlling animal exportation, the

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balance of the trade is not going to be normalized despite the little number of pythons that are sent back to where they originated. That problem is within the realm of international ecology and cosmopolitan policy. Something is better than nothing.

From table 1, trading is the most possible reason for an invasion. Tropical or subtropical species with high reproductive ability, advantageous position in the invaded food chain, and energy efficiency are prone to invade. Most of the invasive species don't have a predator in the local food chain. Most of the behaviors are related to energy requirements. Whether animals could survive the winter weather is a determinant for invasion.

Table 1. Review of typical invasive reptiles

Species name	Provenance	Reasons for invasion	Main feature for invasion
Trachemys scripta	southern US and Mexico	Animal trade	Longevity, Wide diet, Fight for sunlight
Boiga irregularis	Islands in eastern and northern, coastal Australia and eastern Indonesia	Accidental ferry	Wide diet, Concealing ability,Frequent reproduction
Chamaeleo calyptratus	Arabian Peninsula	Animal trade	Frequent reproduction Rapid sexual maturity
Iguana iguana	Southern Brazil and Paraguay	Animal trade	The most introduction individuals, Social behavior, Large figure
Salvator merianae	Eastern and central South America	Animal trade	Wide diet, Rapid sexual maturity, Endothermy for reproduction
Macroclemys temminckii	Southeastern US	Animal trade	Wide diet, large figure, Longevity
Python Bivittatus	Southeastern Asia	Animal trade	Wide diet, Longevity, Large figure

3. Case of rhinella marina

3.1. Quick view

Marina, as a kind of toxic invasive species, they are first introduced to Australia to cope with the beetles in the cane field. Out of human exception, they grew without control and influence the conventional food chain since plenty of predators die after biting the toad. They consume resources and damage the ecosystem with their toxin in an irreversible tendency.

3.2. Comparison of provenance and invaded area

They live in tropical area within central and south America. The climate there is hot and wet as same as in southeastern Asia. This leads amphibians to proliferate for adequate water resource. The habitat of the cane toad is in the low-altitude region of the river valley; thus, the food supply supports the visible population. Although the invaded area is not as humid as Central America, the condition is enough for cane toad to survive. The ability of them to survive in the dry area is extremely strong

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since they could be active with only 50% of their body moisture, and the salinity of water can also be tolerated [10], so they can adapt to the worse condition in such regions.

The wide adaption for temperature is also excellent. The critical thermal maximum is nearly 40 centigrade, and the minimum is 10 centigrade. The severely hot summer in Australia would not kill a large scale of toads. Plus, they could survive the temperate winter in north Australia.

The reproductive strategy is super-efficient for them to adapt to a new environment. They mate and lay eggs most time of the year. For each roll a single female would have 8000-25000 eggs, and the eggs hatch within 48 hours [10]. Although the mature rate is only 0.5% because of lack of food or cannibalism, the large scale of the offspring ensures the great number of surviving tadpoles, consuming local resource in Australia. They would soon reach sexual maturity in 2 months, and start the next roll of mating and reproducing. Hence, the toad proliferates in Australia over the past 70 years.

3.3. Diet and niche

They are one of the largest amphibians in the world, so they would consume more than other species in the same position in the food chain. Their diet is wide, including small rodents, invertebrates, birds, and even feces and human products like rubbish or dog food. It would promote the population rapidly and cause unprecedented competition between species in the same niche. Many insects, other amphibians, and fish would be tremendously impacted by less space and food to survive.

Predator is always the most effective determinant for the stable restriction in the scale, while what is special for the toad is their toxin. They will secrete a substance called bufotoxin when they are in danger, preventing the predators from harming them anymore. This is a kind of neurotoxin that can cause dilution and seizure [11]. Even after being devoured by a snake, the toxin would stimulate the snake to spit them out. In the invaded area like the coastline in Australia, the local ecosystem is delicate for its separation from other continents. The local species don't have the ability to consist of the toxin, which means that the consumers die after biting the toad. More surprisingly, the eggs and the tadpoles are even fatal to fish, which means that they are not as vulnerable as other Anura in their young [12]. After they become adults, the toxicity will be exponentially grown. The predators who luckily survive the toxin would avoid preying on them again, so the possibility to restrain the population is further decreased. Differing from the invaded area, the regulation of them is complex predators that can successfully prey on them and keep them not affected by their toxin like alligators, eels, catfish, etc. The toads will not spread without control.

3.4. Influence

In the reproductive seasons, the ponds would be filled with the eggs of the toads. Since the eggs are hatched, all the creatures in the water area would endure a disaster. The population of the tadpoles would partly break the ecosystem and reduce the biodiversity in the wild. The toxicity of a single toad is enough to kill an adult alligator, and so do humans. The biodiversity is also impacted by such a toxic species which kills numerous wild local animals and even some careless humans. Besides, they steal the habitat of the freshwater region, so other kinds of aquatic fish, amphibians, and invertebrates would be threatened.

There are only a few species that benefit from the invasion of cane toads. Because their toxin is enough to kill the predators, they often keep still when they are attacked. However, this leads to special ants biting and tearing their tissue efficiently, so this kind of ants make more successful captures than the original environment. Furthermore, the sea turtles are advantageous because their rate of hatchability survival rate would be increased because of the reduction of the predators of the eggs and baby sea turtles like Varanus Panoptes [12]. Another saying is that the invasion of the cane toads is just overemphasized, which claims that the government cost too much on dealing with the toads. But the issue of the ecosystem is always a big issue that cannot be postponed.

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3.5. Resolution

It is hard to fix the situation because of the exceedingly overwhelming reproductive ability, and killing a toad would cause the spilling of the toxin that is harmful to the environment. The toxin is even useful after they die for a long time. It seems that the best situation is not to introduce the species to Australia 70 years ago. It gives people an alarm that although there might exist potential benefits to the temporary effect, a species that is not affiliated with the natural environment can usually break the local ecosystem.

4. Case of sphenodon punctatus

4.1. Quick view

Sphenodon, a very ancient reptile, are not lizards or other kinds of reptiles, but a unique species [13]. This species has existed on Earth for a long time, appearing since the beginning of the Triassic. There are only two species alive, and all are found on New Zealand islands, feeding on animals smaller than themselves. But because of a lot of people, the number of these reptiles has plummeted. As primitive reptiles, they have many characteristics that reptiles possess and body structures that modern reptiles do not have. For example, their teeth grow on the skull and are part of the skeleton, which means these teeth are extremely hard, but if they are destroyed [14].

4.2. Environment

New Zealand has a temperate Marine climate, and these animals live on various remote New Zealand islands. These temperatures are not too high, because Sphenodon, unlike lizards, is more adapted to cool environments. They live at about 22℃, and over 13℃. They live in forests, and their habitat has not changed since ancient times.

4.3. Diet

These reptiles had a maximum length of 80 cm and once had no natural enemies on the island where they lived. Their skulls are not the same structure as lizards. First, they have a bill, then their teeth are fixed to the jaw bone which is so hard that they can help these animals hunt various insects, little lizards, and eggs by biting them during the night. But when the reptiles get old, their teeth wear out and they are not replaced by new ones, so their food changes from hard shells, small lizards, or eggs to soft larvae. The diet of Sphenodon is limited, only for some small animals, and because the population distribution is not extensive, the diet of prey is more limited. Although they can bite through some hard carapace, their teeth are not sharp, not threatening to animals of comparable size or larger predators. The reason they could live on these islands for so long was that they had no natural enemies. With the beginning of the maritime age, some mice, dogs, cats, and ferrets were brought to the islands by humans, causing the number of Sphenodon populations to drop rapidly.

4.4. Reproduction

Sphenodon is very long-lived and can live for more than 100 years. This is because they are metabolized so slowly that it will take thirty years to reach full adulthood. Males and females are sexually mature from age 20, while males can remain in estrus. Females can lay 15 to 18 eggs at a time, but they can lay their eggs very slowly, and the eggs develop for a very long time [15]. As a result, many eggs are eaten by exotic species led by mice even before they hatch, while slow-developing juveniles are eaten by mice, ferrets, or dogs. This led to the instantaneous disappearance of Sphenodon on some of the islands. Moreover, the sex of hatched Sphenodon depends on the temperature, and the sex of hatched Sphenodon is mostly male due to global warming, which makes them unable to reproduce.

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4.5. Influence

If Sphenodon goes extinct [16], this will cause a complete collapse of the food chains on several New Zealand islands. Moreover, Sphenodon is a great research value of reptiles, is also very characteristic reptiles, if they are extinct, it will have many negative effects on human zoological research.

5. Case of axolotl maxicanum

5.1. Quick view

Axolotl is a kind of amphibian that only lives in the freshwater area of Mexico as carnivore. Because of their special habits and appearance, the axolotls are well-known amphibians. The axolotls have a very special characteristic-most of the axolotls will remain juvenile, keeping their gills permanently. They can achieve sexual maturity in this case while only a few of the axolotl will degrade their gills and go to land. Keeping their gills and maladapted bodies means that most of the axolotls are fully aquatic amphibians, so environmental changes in a lake have a huge impact on them. This has led to a sharp decline in the local development of the lakes where the axolotl lives. Today, the wild axolotl is rated as an extremely dangerous species on the IUCN Red List.

5.2. Environment

The axolotls are found only in lake Hochmilko and lake Chalco in Mexico. They prefer to live in dark underwater caves, so the living places of wild populations are extremely limited. They live in waters ranging from 14 to 20℃, and 17 to 18℃ as the optimal temperature [17]. Low temperatures can slow down their metabolism. However, at 10℃, they better fight the cold disease. High temperatures can make it feel stressed and increase their food output. If the wild axolotls are compared with the man-bred axolotl, the wild axolotls require more strict water quality.

5.3. Niche and diet

The axolotls eat more widely and prefers to be a carnivore. The axolotl feeds mainly on small fish species and small crustaceans. In the lakes and caves where the axolotls live, the smaller animals may become their prey, so they don't have too many limitations in eating. Axolotls living in the water is often more aggressive and attacks small prey or even its peers, suggesting that they are a higher predator in their own niche. In the water body where the axolotls live, only large local fish can catch them and treat them as food, acting as higher-level consumers.

5.4. Reproduction

Axolotl generally lays eggs in ponds or streams during early spring breeding, and individual species spawn on land in the autumn. When the winter rain comes, the young enter the water. The eggs attach to twigs or other objects. The female axolotls lay about 100 to 300 eggs, and the eggs are divided into many long series of eggs, each averaging about 16. The eggs are black and brown after about 30 to 45 days, and are about 12 mm long [18]. During the heavy rain, the adult body can be seen on the ground. Juveniles are found all year round. Most of them are developed in 1 year. The juvenile outer gill and caudal fin are well developed. The famous axolotl is mostly sexually mature and morphologically immature, with a juvenile size. Axolotls occasionally complete growth into an adult induced by thyroid hormone.

5.5. Cause of Near-Extinction

For many years, the axolotl has lived in a few lakes in Mexico, and it is highly dependent on local water quality, environment, and food. But, as the times progressed, homes, farms, and factories began developing near the lake. This results in a smaller lake size, while excess industrial waste is discharged into the lake. As a result, the axolotl grew smaller by heavily damaging the environment.

Artificial breeding does not effectively solve the same axolotl crisis, because the artificial breed is different from the wild axolotl. The cultured axolotl is actually a product of genetic modification. For

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more benefit, the farm has changed the body color of these out, so that their skin has various colors. Such modifications will also include the living environment and applicability of the axolotl. If the bred axolotls are released in the wild, they will most likely not survive, and also affect the genes of the local wild population.

5.6. Influence

First of all, even if artificial farming technology is very developed, it has nothing to do with the wild axolotl. The decline in the axolotl population, affecting the local ecological balance, could lead to a surge in some species. The axolotl is endemic to Mexico, and the loss of this population is also a loss for a culture. The axolotl has strong regenerative power, and maintaining its juvenile characteristics is also worth studying [19]. Now scientists do not thoroughly understand their ecology and habits, so their extinction is a huge loss to science.

6. Discussion

6.1. Relationship between Invasion and Endangerment

Invasion and endangerment are highly relevant. For cane toads, their toxin as protection in their provenance would break the ecosystem in the invaded area. The competition in the invaded area would be abnormally high caused of the unusual species that keep from preying. The food chain is influenced, indicating the break of the environment. What is special about reptiles and amphibians is that they are not primary consumers, so they directly hurt the upper and lower level of the food chain. Also, they are poikilothermal animals, temperature is a determinant. They must adapt to the climate to set a population in the wild, so species in the cooler areas are less likely to invade. The distribution of poikilotherm animals in cold zones is rare. Sphenodon as a species in the oceanic zone, thus cannot spread, but mammals or birds in that latitude are more likely to invade.

For Python Bivittatus, its invasion will more or less have a certain impact on the number of local animals and the local ecosystem, but it is an endangered animal in its provenance. The appropriate way is that even if Python Bivittatus is an invasive species, people also need to do protection on them. The government can set up a special snake-searching team to control the population of Python Bivittatus in local areas and transport the captured snakes back to their provenance. This would not only restore the local food chain but also gradually restore the ecological system in both places, but the problem with this approach is too much of its cost and international economical issues. The effort that various countries need to do is to control importing and exporting trade. Strengthening animal and plant quarantine is also a very effective measure since few pythons are seized by customs and sent back to their provenance.

Similarly, due to the introduction of new species, the original food chain in New Zealand was destroyed. The sphenodon which used to own no predators now needs to compete with a lot of invasive mammals, causing the decline of their population. The New Zealand Department of Conservation first instigated a recovery plan specifically for Sphenodon in 1993, which was updated in 2001 with a ten-year plan that includes captive breeding and the establishment of populations through translocation to predator-free islands. Many zoos and conservation groups are also breeding them and releasing them into the wild, even if it's a long process because of their long breeding cycle, but it's a useful way to protect them. One of the reasons was to keep their numbers from falling, and it also had a lot to do with their eating habits, because their teeth didn't allow them to hunt animals that were bigger or similar in size, and there weren't lots and lots of prey on the island.

Axolotls are in the same situation as Python Bivittatus. They are endangered in Mexico, but have a wide distribution in the animal trading market because of the technology of breeding and reproducing. Nevertheless, axolotl didn’t invade when they are spread worldwide through the animal trade. Their requirement for the environment is more strict, so they cannot tolerate the complex condition in the invaded area when they escape from the human. Because the gene was selected, like many artificial species, these individuals cannot survive in the wild for their color. The situation is a little different for

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sphenodon because they are bred just in their provenance. If the wild population extinct, it is also a loss of biodiversity since the artificial population is more vulnerable even if they might return to the wild state again. Just setting up an artificial population is not the best way to maintain biodiversity, but protecting the environment in provenance.

7. Conclusion

There are many limiting factors to determine whether a species is endangered or invasive. If a species also has strong environmental applicability, strong reproductive ability, a high ecological niche, and tenacious vitality, it may become invasive species under the influence of some human factors. But if some of these conditions are missing, under the interference of some human factors, such as the introduction of other species, these races will be significantly less competitive in other environments and even their own environments, thus becoming endangered species. The impact of invasion depends on the different living strategies of the species. At present, some countries have relatively mature laws for the protection of endangered animals, but many governments in many countries have not widely popularized the definition of endangered animals and invasive species, which leads to most people having no understanding of this aspect, thus indirectly harming endangered species or helping invasive species. Humans should not destroy any one species, but they should not let some species reproduce wantonly and then destroy the balance of nature. In today's case of a large number of human factors interfering in the ecological balance, only human help can alleviate the natural balance crisis. For example, the government can use the media to spread more definitions and identification of endangered species and invasive species, organize professional hunting teams to capture invasive species released elsewhere, and use the latest artificial breeding technology to breed endangered species able to return to the wild and release them in the place of origin. Only by formulating laws and strategies can the problem of species extinction or invasion be effectively alleviated.

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