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The Impact of Invasive Traits in the Spread of Alien Animal Species in China

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Abstract: The invasive characteristics of alien animal species pose a serious threat to China's ecosystem. This paper reviews the invasive characteristics of exotic animals and how these characteristics have contributed to their spread and colonization in China. By analyzing the ecological adaptability, reproductive strategies, and environmental tolerance of exotic animals, this study provides a reference for establishing a list of potential invasive animals, analyzing the risks of potential invasive animals, and improving China's biological invasion prevention capabilities.

Keywords: Communication Mechanism; Ecological Impact; Invasive Species; Evolutionary Traits; Invasion Resistance.

1. Introduction

The issue of invasive species is influencing the world on a large scale, including aspects of biodiversity, ecological systems, economy, and human health. Invasive species are mainly introduced to new environments by human activity and living industries, often unintended, making the management of spreading complex and effort-consuming. The biological invasion is a continuous and complicated process, including transport, introduction, establishment, and dispersal (Roy et al., 2023). Invasive organisms include animals, plants, microorganisms, and so on. Many researchers have found that at each stage different evolutionary traits can help the species fit into the environment and achieve survival and prosperity. As a result, invasive characteristics play an important role in the spread of alien animal species in China.

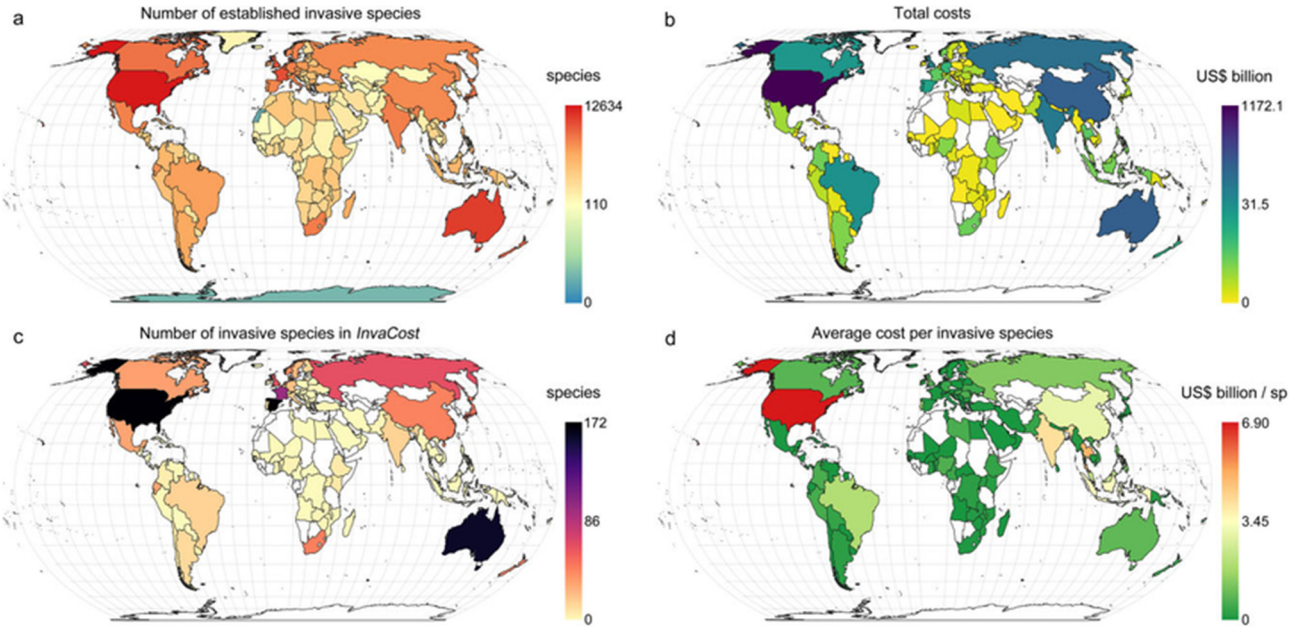

Figure 1. The Number and Costs of Invasive Species in China Compare to the World

As a country rich in biodiversity, China is faced with the severe challenge of invasive animals. According to Figure 1 by Ahmed et al. in 2023, China has been one of the countries that identified a large number of invasive species and is burdened by the issue financially (Ahmed et al., 2023). These alien species, such as the Alligator snapping turtle (*Macrochelys temminckii*) and the Red-eared Turtle (*Trachemys scripta elegans*) (Gong et al., 2023), have successfully colonized and rapidly spread across multiple ecosystems in China through their unique invasive characteristics, such as rapid reproduction, strong adaptability, and effective transmission mechanisms. Understanding the invasive traits of alien animal species is an important step in answering the question of how to successfully regulate alien species in the future. One theory suggests that invasive traits can determine the competitiveness of plants by surpassing the ones of the indigenous species (Mathakutha et al., 2019). Similarly, some specific behavioral characteristics can be critical for the survival of animals. For alien species, the distinct traits can make them compete violently with the local species by occupying ecological niches, often without the threat from enemies. As Figure 2 shows, among all the invasive species in China, Chordata and Arthropoda animals have the dominating numbers of species, with 52.15% and 33.84% respectively (Pagad et al., 2018).

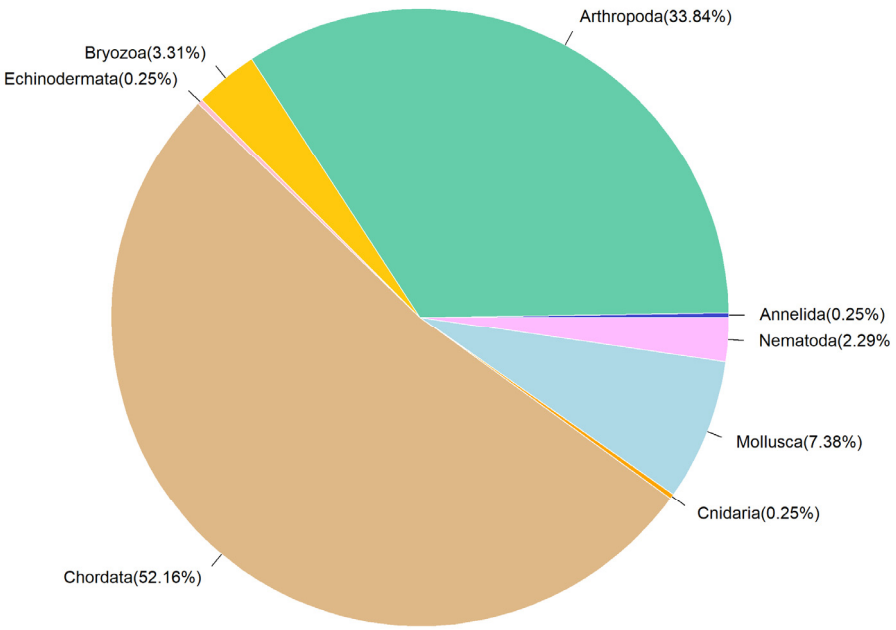

Figure 2. Percentage of Invasive Animals classified by Phylum

2. Invasive Characteristics in spreading

2.1. Transportation Tolerance

The technological development allows the globalization of species diffusion. Trading pathways including sea, air, and land networks make long-distance travel possible for animal species (Zhou et al., 2021). Transmission tolerance is the ability of a species to resist environmental stress during transmission. For invasive species, this tolerance is one of the key factors in their successful spread and colonization. The larvae of invasive species may have a high tolerance to environmental conditions such as droughts, floods, and extreme temperatures, allowing them to survive adverse conditions. For example, the African giant snail (Achatina fulica) has a strong tolerance for dry conditions, can survive long periods of drought, and can breed in a variety of soil types (Zhang et al., 2024). Other invasive animals that can endure extreme conditions include: Red fire ants (Solenopsis invicta), Zebra mussel (Dreissena polymorpha), Asian carp (Silver carp)

2.2. Ecological Adaptivity

The high adaptivity of invasive animals is one of the key factors in their successful colonization. These species are not only able to adapt to extreme changes in their environment, but they are also able to thrive in these conditions, causing great loss in ecology and economy. This adaptation allows them to establish populations in diverse habitats, from urban environments to remote nature reserves. Specifically, ecological adaptivity consists of four facets: temperature, moisture variation, food resources, and habitats. Ecological development theory suggests that organisms require certain environmental clues to develop from one stage to another (Gilbert, 2012). High-risk invasive species tend to have a wide range of adaptivity (Hulme, 2009).

2.2.1. Temperature

Exotic animals are usually able to survive in extreme temperatures. For example, red fire ants can remain active in extremely high temperatures, while Patagonian toothfish (Dissostichus eleginoides) can thrive in low temperatures. The American bullfrog (Rana catesbeiana) can adapt to a variety of climatic conditions from cold to tropical, which has allowed them to successfully invade several regions of the globe (Ficetola et al., 2007). Temperature changes may cause great effects on some species' development processes, as studies show that temperature has a significant influence on the Asian longhorned beetle (Anoplophora glabripennis) 's survival, reproduction, and egg-hatching rate (Keena, 2006). Although many species depend on temperatures to thrive, invasive animals can adapt to different environmental conditions, so the characteristics of exotic animals are conducive to their colonization in new habitats.

2.2.2. Moisture Variation

Water conditions are crucial to the survival of animals. Invasive animals are often able to adapt to different moisture environments, including dry and wet conditions. They may adapt to water changes by regulating water loss, storing water, or using limited water sources, and they have higher resistance to moisture change than local species (Skálová et al., 2013). Studies show that invasive amphibious animals such as cane toads (Rhinella marina) and American bullfrogs (Lithobates catesbeianus) are better at using skin to absorb water in dry conditions than indigenous species (Kosmala et al., 2020; Rowe et al., 2021). Other examples that use different physiological approaches to adapt to different moisture condition include African giant snails. They can reduce water evaporation in dry conditions by closing its shell mouth, and can reproduce quickly in wet environments (Naokuni & Teruhisa, 1986).

2.2.3. Food Resources

Invasive animals typically have a wide range of diet and are able to utilize a variety of food resources, including plants, insects, small animals, and other invertebrates. The dietary plasticity of invasive animals allows them to survive in

different environmental conditions, even when food resources are limited. Many invasive animals are opportunistic and are able to quickly adjust their food choices in response to changing environmental conditions (Caut et al., 2007; Courant et al., 2017). For example, the common carp (Cyprinus carpio) has clear food preference in the larvae stage of their growth to help them grow quickly and avoid predator in the local water (Lechelt & Bajer, 2016). Other invasive animals that obtain a variety of diet include: red fire ants (Solenopsis Invicta) (Vogt et al., 2002), black rat (Rattus rattus), and Burmese python (Python bivittatus). The wide range of diet promised the invasive animal species to adapt quickly to local food resources, interfere the local food chain, and compete successfully with local animals.

2.2.4. Habitat

Invasive species are often able to adapt to multiple habitat types, from wetlands to forests to urban environments, and this diversity allows them to survive in different habitats, and they can quickly identify and exploit ecological niches in new environments, fill gaps in native ecosystems, or compete with native species. Their behavioral flexibility changes their activity patterns to adapt to new environments such as changing foraging times or breeding seasons. For example, the species with wide distribution around the world include Aedes albopictus (Stegomyia albopictus), common red ant (Myrmica rubra), black rat (Rattus rattus), and zebra mussel (Dreissena polymorpha). Alien animals with a wide range of habitats are often highly adaptable and ecologically malleable, able to survive and thrive in a variety of environmental conditions.

2.3. Reproductive Strategies

Reproductive strategies play a pivotal role in the success of invasive species by allowing them to rapidly establish and expand their populations in new environments. High reproductive rates Invasive species enable them to produce a large number of offspring in a short period. This strategy ensures that even if a fraction of the offspring survives, the population can grow quickly. Typically, invasive species produce more offspring at a time. Although the living rate may be lower, the reproduction economically continues to grow of population (Elofsson et al., 2012). Some invasive species have mating systems that favor the rapid production of offspring, such as polygamous systems that increase genetic diversity and the chances of successful adaptation. Red fire ants (Solenopsis invicta) have a complex social structure, including worker, soldier, and breeding ants. They spread their genes by producing large numbers of winged females and males, and after they mate during wedding flights, the females are able to establish new nests (Bourke, 2002). The reproductive strategies of invasive animals are critical to their rapid spread and successful invasion of new environments.

Continuous mating ability plays an important role in reproduction. Studies have shown that the virgin male of the Bursaphelenchus xylophilus can successfully mate with multiple virgin females in succession and impregnate them to lay eggs without feeding. However, after successful mating, the virgin female will preferentially lay eggs, rather than mating continuously. This suggests that males and females differ in reproductive strategies, with males being able to mate continuously while females focus on laying eggs after mating (Liu et al., 2023).

3. Summary

The invasive characteristics of exotic animals are critical to their successful invasion, and understanding these characteristics can help develop effective management and control strategies. More in-depth research on the ecological adaptation and reproductive strategies of invasive species is needed to reveal how they establish and spread in new environments. In the future, humans need to research and develop new control technologies, such as biological control and genetic control methods, as well as integrated management strategies to reduce the negative impact of invasive species. For non-invasive species, the content of early monitoring can be added, such as: strengthening entry quarantine to protect biosecurity; Do a thorough assessment of introduced species, etc., to avoid carrying other pests and diseases.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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