

# The Destiny of Living Animals Imported into Chinese Zoos

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**Abstract:** Ex situ conservation is one of the major ways to strengthen biodiversity conservation. In China, ex situ conservation institutions mainly include zoos, aquariums, and breeding centers. In 1996, China began to import living animals duty-free for conservation purposes. Here, we built a dataset of nearly 300 vertebrate species (mammals, birds, fish and reptiles) imported into China over this past 20 years by interviewing all 123 institutions importing animals duty-free during 1996–2015. We then analyzed the annual variation of the species composition and individual numbers of these imported species, and quantified the relative population growth rate of each imported species for the first time. We found that the number of living animals imported into China decreased significantly year by year. The number of imported bird species and reptile individuals decreased the most, but the population growth rate was increasing for about half of the imported threatened species. We recommend that conservation institutions should enhance communication and promote cooperative breeding among them. Scientific research and sustainability assessments of threatened species should also be enhanced, which will allocate trade licenses and quotas more effectively. We hope that the data presented in this paper will contribute to the development of conservation policies, leading to stronger management of these imported species in China.

**Keywords:** captive population; ex situ; wildlife trade; threatened species; China



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## 1. Introduction

Species conservation is a challenge of equal importance as poverty reduction in the 21st century [1]. At the core of the relationship between sustainable development and biodiversity conservation is wildlife trade [2], for which Asia is a geographical hotspot area [3–5]. However, there is a lack of rigorous analysis of trade data in the existing literature [6], and only the collection and appropriate analysis of trade data can ensure sustainable use of such wild animal populations [7].

China places great importance on wildlife trade work and began to approve wildlife licenses in 1976 [8]. China then became a Party to the Convention on International Trade in Endangered Species for Wild Fauna and Flora (CITES) in 1981. The Chinese Forestry and Grassland Administration (CFGA) is the main CITES management organization, responsible for CITES implementation and enforcement. China implemented the Wildlife Protection Law (WPL) to control wildlife trade in 1989, and this law was last revised in 2018. In the latter year, the list of key protected wild animals was published, last revised in 2021 [9]. In addition, China also joined the Convention on Biological Diversity in 1992, which aspires to ensure that China will make concerted efforts to conserve biodiversity.

Zoos have biodiversity conservation potential [10]. With zoo-reared animals being ambassadors of their species, captive breeding became the main justification for displaying animals to the public [11]. Although captive breeding may not be associated with conservation outcomes [12,13], it is important to master the experience and technology, which will help to provide support for the rescue or ex situ conservation of wild populations as required. Other benefits of captive breeding include reducing the number of wildlife imports and providing research opportunities which may often not be possible with wild animals [14]. Since the 20th century, zoos gradually shifted from entertainment to scientific research and conservation [15–17], and have become an important partner in the protection of threatened species [18]. Moreover, trade among aquariums can also have a unique and positive impact on the marine animal communities [19,20], including captive breeding programs for endangered animals [21] and public education on biodiversity and sustainability issues [22].

In order to enhance biodiversity conservation, and explore the potential value of biological species resources, China began to encourage institutions to breed wildlife in captivity (i.e., in captive institutions), such as zoos, aquariums, and breeding centers which import wildlife. Principally, this was through a duty-free exemption policy for the import of wildlife for non-profit purposes, implemented from the Ninth Five-Year Plan (1996~2000) and subsequently revised every five years. In addition, government agencies are required to issue an updated list of exempt wildlife goods every year, including living animals and specimens [23]. Our study focuses on the import of living animals, including mammals, birds, reptiles and fish.

In this paper, we analyzed the species diversity, volume, and annual variation of duty-free imported living animals from 1996 to 2015, assembling, for the first time, data on the long-term changes in the numbers of imported species and individuals. There are two objectives in this study: (1) to quantify the long-term changes in the numbers of imported species, and (2) to evaluate ex situ conservation outcomes in China.

## 2. Materials and Methods

### 2.1. Data Collection

The study relied primarily on data from the duty-free import (hereafter “import”) wild animals list from the Endangered Species Import and Export Management Office of the Peoples Republic of China (CFGA-CITES) between 1996 and 2015. We conducted independent investigations with all 123 import institutions on the list, distributed across 27 provinces (Figure 1). We collected a total of 1287 valid cases from this list, including imported species diversity and volume (the number of individuals). Specifically, through field investigation and official telephone counseling in 2017, we supplemented more detailed information on births, deaths, present stocks, and transfers (refers to exchanges in and out of the institution), recorded as the number of individuals for each species. Third-party transfer source/destination and outcomes were not known in this research. Imported individuals during the period of investigation (2016–2017) were counted as transfers. In addition, prior to analysis, we removed records that were untrue, unmanaged, and had incorrect scientific names.

### 2.2. Data Analysis

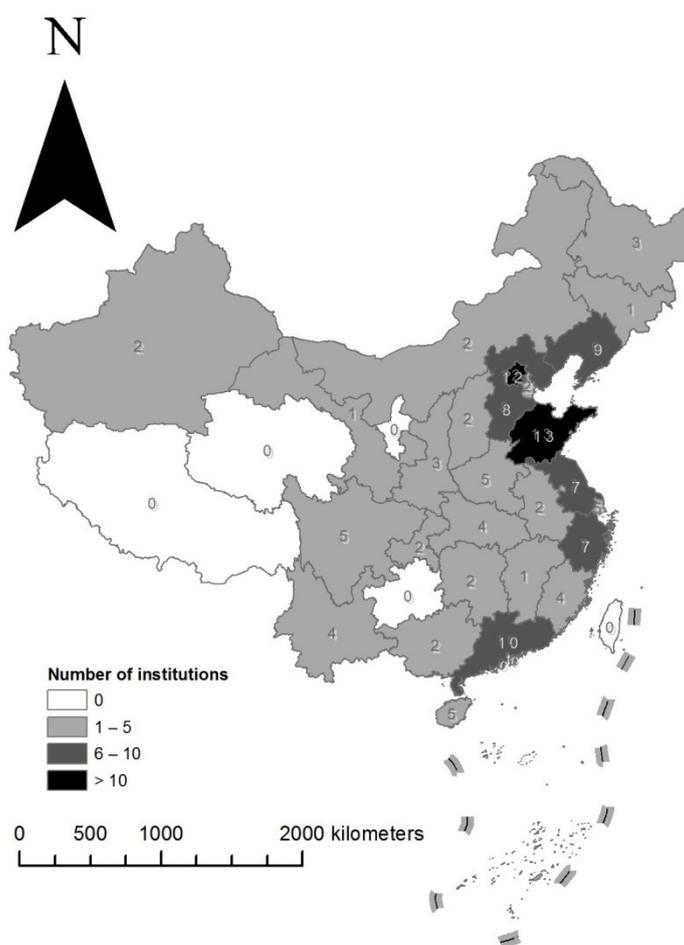
We firstly counted some basic parameters, such as species diversity and volume in different taxonomic classes, and used the Kruskal–Wallis test to test for differences among classes. We also used linear regression to examine annual changes (note that the total number of individuals fit a normal distribution after log transformation) [24]. Next, we used the population growth index as a representative to quantify the annual variation of each imported species since 1996 [25]. We assumed that all captive institutions could cooperate in captive breeding, and thus each imported species is considered to exist as a meta-population within China. The captive population is assumed to be generally not constrained by conditions such as food and space, and thus it is suitable for the continuous

growth model with a constant growth rate [26]. The instantaneous rate of increase ( $r$ ) of each species was firstly calculated and then converted into the finite rate of increase ( $\lambda$ ), as:

$$r = \ln(N_t/N_0) \times t \quad (1)$$

$$\lambda = e^r \quad (2)$$

where “ $N$ ” is the population size, and “ $t$ ” is the time. In our data, “ $N_0$ ” is the total imports per species (1996–2015), “ $N_t$ ” is the number of existing individuals (present stock minus transfers), and “ $t$ ” is the number of years (2017 minus first import year) (Supplementary Table S1). When  $\lambda > 1$ , the captive population is increasing; when  $\lambda = 1$ , the captive population is stable; when  $\lambda < 1$ , the captive population is decreasing; when  $\lambda = 0$ , the captive population has already disappeared, i.e., is considered extirpated.



**Figure 1.** Provincial level distribution of duty-free import institutions in China in this study, according to the Endangered Species Import and Export Management Office of the Peoples Republic of China (CFGA-CITES) between 1996 and 2015 ( $n = 123$ , the numbers in the figure are the number of institutions in each province).

To investigate the results in relation to conservation status, both the scientific name and conservation status were retrieved from the International Union for Conservation of Nature (IUCN) Red List ([www.iucnredlist.org](http://www.iucnredlist.org), accessed on 21 September 2021). This study was specifically concerned about threatened species statuses, including Vulnerable (VU), Endangered (EN), Critically Endangered (CR), and Extinct in the Wild (EW). Data were analyzed using R v3.6.0 [27].

### 3. Results

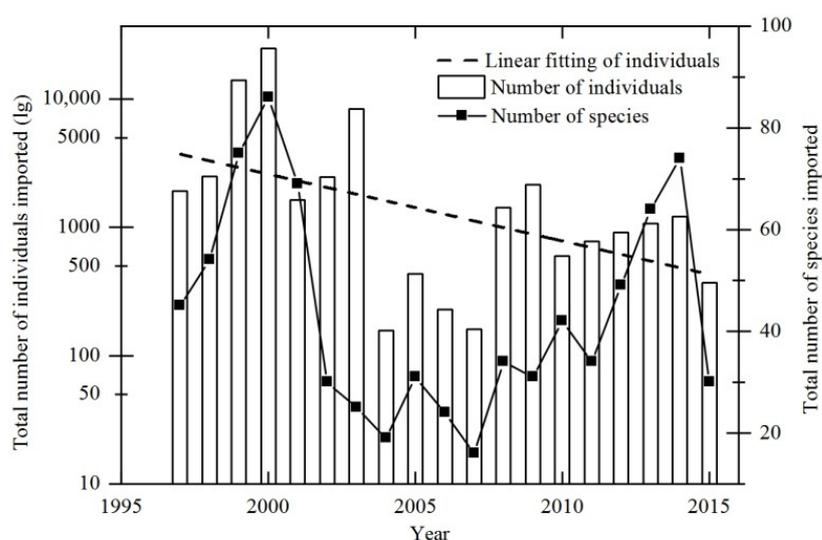
#### 3.1. Imported Animals

Between 1996 and 2015, China imported a total of 64,843 individuals, representing 278 species (Table 1). Most imported species were mammals (46.8%), most imported individuals were reptiles (74.3%), and the taxonomic class with both the least imported species (5.8%) and individuals (0.4%) was fish. A clear outlier with regards to the number of individuals imported per species is the Siamese crocodile (*Crocodylus siamensis*), a CR species for which 5 institutions imported a total of 43,465 juveniles (representing 67.0% of all individuals, and 90.3% of all reptile individuals) between 1997 and 2009, making this the species with the highest number of imported individuals.

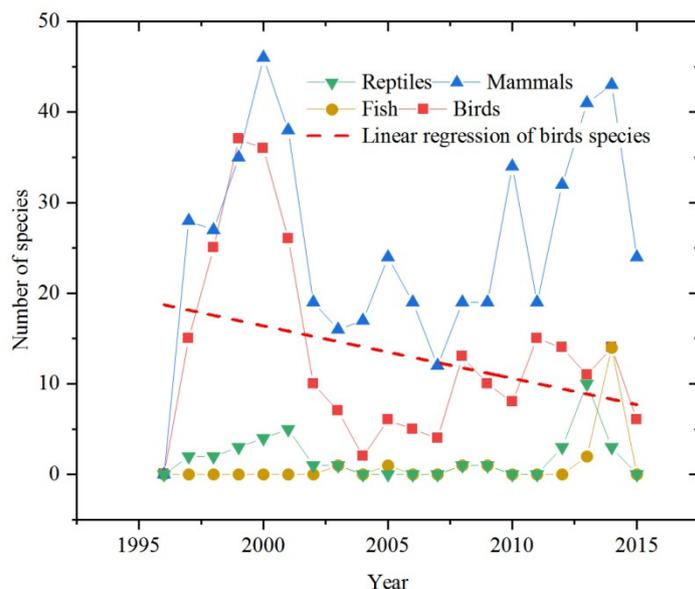
**Table 1.** Total number of imported living animal species and individuals (1996–2015), births, and present stocks (2017) in China.

Class	Number of Species			Number of Individuals		
	Imports	Births	Stock	Imports	Births	Stock
Mammals	130	99	124	7440	6192	7663
Birds	114	46	75	8969	7360	9407
Fish	16	0	16	278	0	262
Reptiles	18	5	13	48,156	24,557	30,962
Total	278	150	228	64,843	38,109	48,294

From 1997 to 2000, the annual number of imported species and individuals increased to a first peak and declined sharply thereafter (Figure 2). Statistically, the total number of imported individuals decreased significantly year by year ( $R^2 = 0.191$ ,  $p = 0.035$ ). The peaks in the years 2000, 2003, and 2009 were due to the imports of large numbers of Siamese crocodiles. Since 2012, the number of imported species per year increased again, with the second peak occurring in 2014 (Figure 2); however, statistically, the number of species did not change significantly over time ( $p > 0.05$ ). Furthermore, for most of the import period, mammal and bird species remained the dominant classes of imports (Figure 3), and the number of bird species imported decreased significantly from year to year ( $R^2 = 0.208$ ,  $p = 0.028$ ). No such relationships were observed for any other animal class investigated.



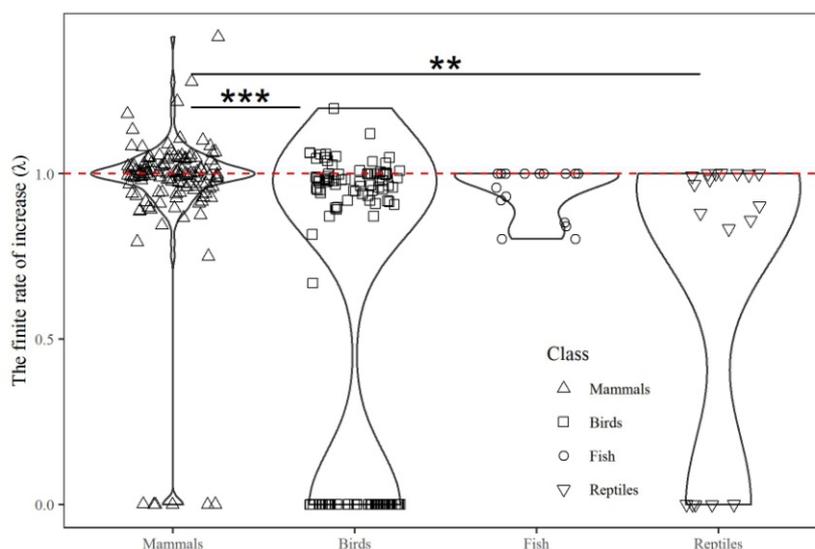
**Figure 2.** Annual variation in the number of imported species and individuals in China (1996–2015). Note the primary y axis scale.



**Figure 3.** Annual variation in the number of imported species of different classes in China.

### 3.2. Captive Population

During the past 20 years, 82% of the imported species survived in captivity (Table 1). Bird species had the lowest rate of survival in captivity (65.8%; Table 1, Figure 4). In addition, comparing the total number of imported individual animals and present stock, there has evidently been a decrease of 25.5%. Fish and reptile individuals decreased by 5.8% and 35.7%, respectively; however, mammal and bird individuals increased by 3.0% and 1.5%, respectively.



**Figure 4.** The finite rate of increase ( $\lambda$ ) of each species imported into China, grouped by taxonomic class (\*\* $p < 0.01$ ; \*\*\*  $p < 0.001$ ).

In terms of breeding in captivity, 54.0% of imported species bred in China. Among classes, mammalian species had the highest proportion of species which bred and produced offspring (76.2%), while fish had no captive breeding recorded in the dataset (Table 1).

In terms of population growth index ( $\lambda$ ), 27.0% of the imported species showed population increases, 10.8% of the imported species had stable populations, 44.2% of populations declined, and 18.0% of the imported species failed in captivity (Table 1, Figure 4). Population growth of all species by class revealed that the population growth index ( $\lambda$ ) of

mammal species was significantly higher than for birds ( $p < 0.001$ ) and reptiles ( $p = 0.002$ ), while the growth index of captive populations of fish species did not differ significantly ( $p > 0.05$ ) from the other classes (Figure 4).

### 3.3. Threatened Species Conservation

China has made great efforts in terms of threatened species conservation in captivity. During the period of 1996 to 2015, China imported 47,096 individuals (72.6%) from 85 species (30.6%) which are globally threatened: 6 individuals from one EW species, 43,601 individuals from 13 CR species, 1357 individuals from 19 EN species, and 2180 individuals from 52 VU species (Table 2 and Supplementary Table S1). By 2017, in total, only eight threatened species failed to breed and survive in captivity in China (Table 2,  $\lambda = 0$ ). One of these species was the EN Grevy's zebra (*Equus grevyi*), of which only a single individual was imported in 2001.

**Table 2.** Imported endangered species on the IUCN Red List (1996–2015) and present stocks (2017) in China, together with their respective finite rate of increase ( $\lambda$ ). IUCN Red List of endangered species categories: endangered (EN), critically endangered (CR), and extinct in the wild (EW). Vulnerable (VU) species can be found in Supplementary Table S1.

Class	Species	Imports	Births	Stock	$\lambda$
	Extinct in the wild (EW)				
Mammals	Scimitar-horned oryx <i>Oryx dammah</i>	6	16	17	1.056
	Critically endangered (CR)				
Birds	Vietnam pheasant <i>Lophura edwardsi</i>	4	0	0	0
Fish	Sharpnose guitarfish <i>Glaucostegus granulatus</i>	2	0	4	1 <sup>1</sup>
Fish	Bowmouth guitarfish <i>Rhina ancylostoma</i>	1	0	2	1 <sup>1</sup>
Fish	Scalloped hammerhead <i>Sphyrna lewini</i>	27	0	27	1
Mammals	Black rhino <i>Diceros bicornis</i>	5	6	11	1.042
Mammals	Western gorilla <i>Gorilla gorilla</i>	2	0	0	1 <sup>1</sup>
Mammals	Celebes crested macaque <i>Macaca nigra</i>	8	2	9	1.009
Mammals	Bornean orangutan <i>Pongo pygmaeus</i>	22	11	25	1.008
Mammals	Cotton-headed tamarin <i>Saguinus oedipus</i>	10	12	22	1.218
Mammals	Saiga <i>Saiga tatarica</i>	12	300	90	1.101
Mammals	Red ruffed lemur <i>Varecia rubra</i>	4	1	5	1.046
Mammals	Black-and-white ruffed lemur <i>Varecia variegata</i>	39	19	51	1.055
Reptiles	Siamese crocodile <i>Crocodylus siamensis</i>	43,465	24,119	30,241	0.983
	Endangered (EN)				
Birds	Sun parakeet <i>Aratinga solstitialis</i>	60	0	32	0.967
Birds	Grey crowned crane <i>Balearica regulorum</i>	219	48	168	0.98
Birds	Saker falcon <i>Falco cherrug</i>	46	0	57	0.919
Birds	Asian crested ibis <i>Nipponia nippon</i>	15	210	242	1.197
Birds	Grey parrot <i>Psittacus erithacus</i>	90	0	111	0.976
Mammals	Brown-headed spider monkey <i>Ateles fusciceps</i>	1	7	3	1.132
Mammals	Black bearded saki <i>Chiropotes satanas</i>	20	6	5	0.997
Mammals	Pygmy hippopotamus <i>Choeropsis liberiensis</i>	2	9	12	1.089
Mammals	Asian elephant <i>Elephas maximus</i>	43	12	51	1.011
Mammals	Sea otter <i>Enhydra lutris</i>	2	1	1	0.955
Mammals	Grevy's zebra <i>Equus grevyi</i>	1	0	0	0
Mammals	Ring-tailed lemur <i>Lemur catta</i>	379	569	764	1.04
Mammals	Golden lion tamarin <i>Leontopithecus rosalia</i>	6	11	20	1.278
Mammals	African wild dog <i>Lycan pictus</i>	36	18	27	0.984
Mammals	Lion-tailed macaque <i>Macaca silenus</i>	24	12	25	1.002
Mammals	Chimpanzee <i>Pan troglodytes</i>	123	25	109	0.989
Mammals	Tiger <i>Panthera tigris</i>	277	845	902	1.063
Mammals	Siamang <i>Symphalangus syndactylus</i>	4	2	6	1.024
Mammals	Malay tapir <i>Tapirus indicus</i>	9	4	10	1.006

<sup>1</sup> These populations had no change and stocks were the numbers after transfer.

On the contrary, more endangered populations achieved growth (Table 2). For example, 12 individual CR saiga (*Saiga tatarica*) were imported into the Wuwei Endangered Animal Research Center, Gansu Province, in 1997, and a population of 90 individuals was recorded at the end of 2017 ( $\lambda = 1.1$ ). Similarly, for EW scimitar-horned oryx (*Oryx dammah*), six

individuals were imported to the Chime Long Safari Park, Guangdong Province, in 1999, and seventeen living individuals were recorded in 2017 ( $\lambda = 1.06$ ). Besides, captive tiger (*Panthera tigris* spp.) populations grew steadily in recent years (Table A1), and thus China has not imported tigers again since 2005.

#### 4. Discussion

Our population growth index is only a relative quantification of captive populations of imported species, which is different from the traditional finite rate of increase ( $\lambda$ ). This is because the structure of our data describes annual imports rather than annual stocks, and thus, the traditional index and analyses of population trends were not appropriate. As a result, we first assumed that all individuals were imported in the first year, including multiple imports of the same species by the end of 2015. Next, we applied a meta-population growth index calculation on the basis that the same species can be imported by a number of different institutions. In addition, our data are verified reports of actual import records, and this may lead to a lower import size being analyzed than is true, though this was unavoidable in our investigation and should be interpreted as such.

##### 4.1. Captive Imported Populations

Animals imported duty-free were used for non-profit purposes in China. With the significant decrease in the number of imported individuals over the past 20 years, China is changing from “enrich individuals” to “species conservation” [28]. For example, the CR cotton-headed tamarin (*Saguinus oedipus*), the EN golden lion tamarin (*Leontopithecus rosalia*), and almost all fish species were first imported after 2013.

We found that imported mammal captive populations grew significantly better than birds and reptiles during the 20-year period, and 51.8% of threatened species overall were successfully bred. This suggests that animal research and cooperative breeding should be actively developed to improve breeding success in China, especially birds and reptiles, which showed significant population decreases or losses. However, the unlimited increase in population size does not necessarily represent an improvement [29]. China must set the population target sizes for the conservation of different species as soon as possible. In practice, this means that China should have a more precise annual approval plan for imported animals and formulate population target sizes based on the conservation capabilities of each importing facility and local conditions.

There are some successful cases of captive breeding of endangered species internationally [30–33]. By 2017, more than half of the imported species had successfully bred in China (53.8%). However this is not easy, as many species not only have a high cost in captivity [34], but they may also require special care to survive, while breeding is more difficult [35,36]. A sustainable captive population will partly reduce the need for additional wild-caught animals to be imported into breeding programs. Thus, we cannot deny China’s contribution in the conservation of endangered species which have been imported. We also believe that captive institutions’ contributions to endangered species conservation should be heralded and encouraged [37].

In recent years, the Chinese aquarium industry has grown rapidly [38]. Aquariums have improved the feeding and management conditions, and partly slowed the decline of captive populations [39]. However, our existing data demonstrate that species diversity and individuals of imported fish are less and may lack representation in China. Fish trade is unsustainable compared with other animal classes [40]. Here, we found that species diversity and individuals of imported fish were the least, while this animal class is also less understood as well [41–43]. Therefore, we recommend that conservation studies on imported fish should be enhanced in China [44].

##### 4.2. The Role of Institutions

More than half of the captive populations of imported species declined or disappeared in China, and some captive institutions will conceal the death cases and causes. This lack of

openness and sharing of information potentially puts other institutions in the same plight when importing these species, resulting in the needless death of individuals. If captive institutions do not communicate information and cooperate in breeding in a timely and effective manner, it will be difficult to maintain these captive populations and achieve biodiversity conservation goals in China. In addition, the pedigree of many imported animals is unclear, which can easily result in mismanaged breeding, including potential for inbreeding [45]. Therefore, it is important to strengthen cooperation and build an animal lineage cloud sharing platform among captive institutions, enabling sharing and updating data on imported animals [46]. Specifically, including the sharing of annual population dynamics and captive management experience could increase survival rates and breeding success. At present, the Chinese Association of Zoological Gardens (CAZG) is gradually improving cooperation systems at home and abroad ([www.cazg.org.cn](http://www.cazg.org.cn), accessed on 21 September 2021).

We found that the captive capabilities of institutions in different provinces were not balanced in China, in terms of distribution of institutions, import histories, and breeding success. Captive institutions do, however, as we produce the evidence here, also have great potential in the conservation of threatened species [47]. Space and funding available to captive institutions should be a priority factor to review when importing threatened species [34]. After all, there could be an opportunity to relieve the stress on the wild population if captive breeding is successful [48]. Institutional capacity is probably a major factor in breeding success.

Thus, we recommend that import institutions should accept qualification review, such as evaluation of living conditions and environment enrichment [14], publish annual reports to enhance surveillance, and encourage public involvement. In particular, special attention should also be given to preventing the flow of threatened species to illegal markets [49].

#### 4.3. Outlook

Our study provided an assessment of the captive situation of imported animals in China, which has accumulated considerable experience in captive management in the past twenty years [14]. This will undoubtedly help to improve the reproduction of imported species and set the population target sizes in the future. Note that not all threatened species are suitable for ex situ breeding [10], but maintaining their sustainable populations remains an important way that captive institutions can help to preserve biodiversity [50,51]. Therefore, continuous assessment of the effectiveness of species management is key to improving the ability of captive institutions to serve as partners in biodiversity conservation [52].

China should, in a well-coordinated manner, construct the development plan of modern institutions breeding animals in captivity, such that modern zoos, aquariums, and breeding centers act as backup bases to National Parks and other nature reserves and protected areas [53]. In October 2021, President Xi delivered the establishment of the first National Parks in China at the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity (COP15). As insurance for wildlife protection, it is also beneficial to increase the connection of zoo veterinarians with wildlife protection experts [14]. Besides improving their ability to support conservation efforts in situ, captive institutions should help preserve biodiversity through their public education, specialized training, scientific research, and fundraising activities to support conservation efforts in situ [54,55].

Finally, wildlife disease and zoonoses risks are critical factors in the management of wild animals in captive breeding institutions. During the outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003 [56], the Chinese Forestry and Grassland Administration suspended the import and export trade of living wildlife in May 2003 [57]. We suspect that this is the reason for the decline in imports after 2003. Currently, affected by the 2019 novel Coronavirus (2019-nCoV, COVID-19) pandemic, the National People's Congress of the People's Republic of China, on 24 February 2020, announced a ban on the capture of all terrestrial wildlife for trade [58]. Although China's total ban on wildlife

trade may encounter many problems again [59], we believe that China has experience in strengthening the control of imported species, and must therefore ensure that it has the capacity to effectively manage captive animals as sustainable meta-populations, whilst continuing to strengthen protection and restoration of free-living populations in the wild.

**Supplementary Materials:** The following are available online at <https://www.mdpi.com/article/10.3390/d14050335/s1>, Figure S1: Percentage of threatened species imported into China (1996–2015), grouped by taxonomic class. IUCN Red List status: extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), and not evaluated (NE). Figure S2: Annual variation in the number of threatened species (a) and individuals (b) in China (1996–2015). Note the primary y axis scale in (b). Table S1: List of duty-free imported wild animals (1996–2015) in China.

**Author Contributions:** Conceived and designed, G.J. and X.T.; investigation, X.T. and B.H.; analyzed the data, B.H.; writing—original draft preparation, B.H.; writing—review and editing, G.J., A.M., S.K.N. and N.J.R.; chart visualization, B.H. All authors have read and agreed to the published version of the manuscript.

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**Data Availability Statement:** The data presented in this study are available upon request from the corresponding author.

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## Appendix A

**Table A1.** Imported EN tiger (*Panthera tigris*) from 1996 to 2015 and present stock (2017) in China, with their respective finite rates of increase ( $\lambda$ ).

Species	Imports	Stock	$\lambda$
Bengal tiger (white) <i>Panthera tigris</i> ssp. <i>tigris</i> (white)	50	197	1.079
Amur tiger <i>Panthera tigris</i> ssp. <i>altaica</i>	221	254	1.067
Bengal tiger <i>Panthera tigris</i> ssp. <i>tigris</i>	157	434	1.060

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