

Article

Domestic Reutilization Status of Invasive Turtle Species in South Korea Based on *Trachemys scripta*

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Abstract: This study was conducted to determine the reutilization, distribution, and import status of invasive alien turtles in South Korea. The results showed that a total of nine invasive alien turtle species including *Trachemys scripta*, which is designated as an ecosystem disturbing species (EDS), were traded in the traditional market, and 84 of 169 turtles registered through the National Animal Welfare Information System were reintroduced to new breeders. Additionally, the distribution of invasive alien turtles was confirmed at 341 points in 109 cities, and we found that, on average, 7 tons of non-indigenous turtles are imported annually from over 20 countries to South Korea. These results indicate the urgent need for efficient management of invasive turtles in South Korea. Therefore, we suggest (1) activating a purchase program of EDS through local governments, (2) establishing links with research institutions and experts to improve the initial species identification accuracy of the National Animal Welfare Information System, (3) establishing a follow-up management system after the designation of EDS, and (4) providing a free collection service for exotic turtles abandoned by breeders. Finally, this study provided the current distribution of invasive alien turtles in South Korea and the exotic turtle import status over 21 years.

Keywords: animal release; invasive species management; turtle abandoned; imported turtles



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1. Introduction

Approximately 61% of the 357 extant chelonians [1] are under some degree of threat or extinct [2]. They are reported as being under more serious extinction risks than other vertebrates [1–4]. Human activities are the main cause underlying the decrease in turtle populations, and the invasion of natural ecosystems by invasive alien species may further accelerate such population decrease [4].

In South Korea, according to the Act on the Conservation and Utilization of Biodiversity (Ministry of Environment), invasive alien species are classified into three categories: (1) alert invasive species (AIS), (2) ecosystem threatening species (ETS), and (3) ecosystem disturbing species (EDS). An AIS is an organism that may cause harm to the ecosystem if it is introduced into South Korea, whereas an ETS is an organism that is judged via risk assessment to be in need of management because it may cause harm if it is released into the ecosystem. An EDS is an organism that may disturb or disrupt the balance of the ecosystem and is determined through the evaluation of basic information on each organism, the possibility of introduction, settlement, and spread, impact on the ecosystem, society, economy, and disease, and reutilization economic value. To date, ten non-indigenous turtle species have been found in the native ecosystem of South Korea (*Chelydra serpentina*,

Chrysemys picta bellii, *Graptemys ouachitensis*, *Graptemys pseudogeographica*, *Mauremys sinensis*, *Pseudemys concinna*, *Pseudemys nelson*, *Pseudemys peninsularis*, *Pseudemys rubriventris*, and *Trachemys scripta*) [5]. As of 2022, the species in the genus *Trachemys* and five other species (*Pseudemys concinna*, *Mauremys sinensis*, *Macrochelys temminckii*, *Pseudemys nelson*, and *Chelydra serpentina*) have been designated as EDS (in 2001, 2020, 2020, 2021, 2021, and 2022, respectively) [6]. Most of the invasive alien turtles found in the wild in South Korea were bred as pets and then abandoned or released for religious ceremonies [7]. Among them, *Trachemys scripta* was the first to be introduced to South Korea in the late 1970s for religious release and pet-keeping purposes. However, as the individuals matured, they were presumably abandoned to nature due to their odor and difficulty to raise in captivity. To date, DNA barcoding analysis of eggshells has confirmed the successful reproduction of *T. scripta*, *Pseudemys* spp., and *C. serpentina* in the wild, and hatchlings were found for *T. scripta* and *P. concinna*, indicating successful settlement ([6,8,9], Koo et al. unpublished).

Trachemys scripta is the most exported species in the United States, along with *G. pseudogeographica* and *P. nelsoni* [10], with 43.6 million exports from 1989 to 1997 and 52 million exports from 1998 to 2022 [11]. According to The Human Society of the United States, more than 8.7 million *T. scripta* were exported from the United States in 1997, representing 93.2% of all turtles exported that year. In the same year, South Korea was the second largest import nation after China, with live turtle imports from the United States exceeding 1 million. Additionally, according to Koo et al. [12], 677 alien amphibian and reptile species were sold online in 2019 in South Korea, a number that is approximately 2.1 times higher than the officially imported species in 2015.

The prevention and control of invasive alien species have received considerable attention worldwide owing to both the ecological impact on native species and the economic resources spent on removal [13–17]. Management measures for *T. scripta* include elimination, public education, and the provision of suggestions on management strategies [10,18,19]. To date, only two studies on the management of invasive alien turtle species have been conducted in South Korea [20,21]. Thus, studies on the current status and management of invasive alien turtle species in South Korea are urgently required.

Therefore, this study aimed to identify the current domestic reutilization status of invasive alien turtle species, as well as the current distribution and import status of invasive turtles in South Korea. In addition, we suggest a management plan for turtles, focusing on EDS turtle species in particular.

2. Materials and Methods

2.1. Distribution of *T. scripta* and Other Alien Turtles in South Korea

We analyzed the distribution of *T. scripta* and other invasive alien turtles in South Korea according to the data provided by the “National Habitat Survey of Alien Species” conducted by the National Institute of Ecology (NIE) from 2014 to 2022. The data used in this study are stored in NIE ECObank (<http://doi.or.kr/10.22756/ASD.20220000000812>, accessed on 19 December 2022) as open-source data. The survey was conducted in all cities of South Korea (excluding Ulleung-gun). The target species included all invasive alien organisms introduced in South Korea; we focused on turtle species considered invasive alien species with potential risks to ecosystems. Additionally, the NIE field surveys were conducted using binoculars and field scopes, photographs of individuals were taken, and morphological traits were analyzed for accurate identification. Turtle locations were recorded using WGS84 coordinates.

2.2. Turtle Sales Status in Traditional Markets

A survey was conducted from February to October 2022 in 13 traditional markets across South Korea to determine the sales of invasive alien turtles, especially EDS turtles in traditional markets. A traditional market is a market with a traditional structure where small merchants gather and sell various goods directly. Such markets began with regular markets where people gathered together, such as the third and fifth markets that have been

held since the Joseon Dynasty. Presently, with the progression of urbanization, permanent markets with an association structure of small merchants have become mainstream. The markets included Cheonggyecheon (Seoul), Moran Market (Seongnam, Gyeonggi), Jayu Market (Mokpo, Jeonnam), Chilseong Market (Daegu), Seomun Market (Daegu), Gwanmun Market (Daegu), Bujeon Market (Busan), and Dongnae Market (Busan), where sales of foreign turtles have been confirmed since 2020. The species, carapace length, and value of the sold turtles were recorded.

2.3. Management Status of Turtles Retrieved from the Wild

The National Animal Welfare Information System (<https://www.animal.go.kr/front/index.do>, accessed on 3 January 2023) of the Animal Quarantine Department is an integrated system that manages all animal protection tasks such as abandoned animal reports, public notifications, animal registration, and farm animal welfare. To identify the status of retrieved invasive alien turtles, we checked the number of reports of turtles registered on the website from December 2019 to December 2022. The registered turtles were recorded on the date of registration, species, sex, place of discovery, morphological characteristics, status, and other information. The “status” category provides information about turtles which were adopted, released (re-radiated to the wild from a captive site), returned (to their lost owners), donated, advertised, euthanized, or died naturally. Among the status categories adoption, release, return, donation, and advertisement were classified as reutilization and converted into total percentages.

In addition, media items, such as news articles recorded on the website (<https://news.naver.com/>, accessed on 23 December 2022) after the 2000s were searched to find out the release status of invasive alien turtles for religious purposes, using the search terms ‘turtle’ and ‘release’.

2.4. Import Status of Invasive Alien Turtles and Data Analysis

Since *T. scripta* was designated as an EDS in 2001, the import status of alien turtles was investigated from 2002 to 2022. In South Korea, the import of unclassified turtles, except for those with CITES, AIS, ETS, and EDS legal status, is permitted without a separate import and export license from the Ministry of Environment. The Ministry of Environment selected 23 products that were highly likely to be recorded when reporting imported organisms, and turtles were classified as product number (HS code) 0106203000. The product number refers to all imported turtles; thus, details on the species, number of individuals, and purpose of importation could not be confirmed. Data from the Trade Statistics Service (TRASS, <https://www.bandtrass.or.kr/index.do>, accessed on 21 February 2023) were used to confirm information on turtles imported into South Korea for 21 years. Data in TRASS are classified by products, country of origin, airport/seaport, domestic region, customs, payment method, transaction classification, and transaction type. In this study, trade by-products using HS code (0106203000) statistical data were used, and the country, weight (kg), and value (\$) of turtles imported into South Korea yearly were confirmed.

The difference between the current status of abandoned alien turtles was examined by one-way analysis of variance (ANOVA), followed by Bonferroni post-hoc analysis. This analysis was conducted using Statistical Package for Social Science (SPSS) [22].

3. Results

3.1. Distribution of *T. scripta* and Other Alien Turtles in South Korea

Over a total of nine years (2014–2022), 10 species and 2174 individuals of invasive alien turtles were identified. Invasive alien turtles were found at 341 sites in 109 out of 161 cities in South Korea. On the other hand, 248 individuals of the native turtles (*Mauremys reevesii*, *Pelodiscus maackii*) were recorded at 132 sites in 75 cities. Compared to the distribution of native turtles, invasive alien turtles were more evenly distributed throughout South Korea, and were found in most cities except for some island areas such as Ulleungdo and Dokdo (Table 1, Figure 1).

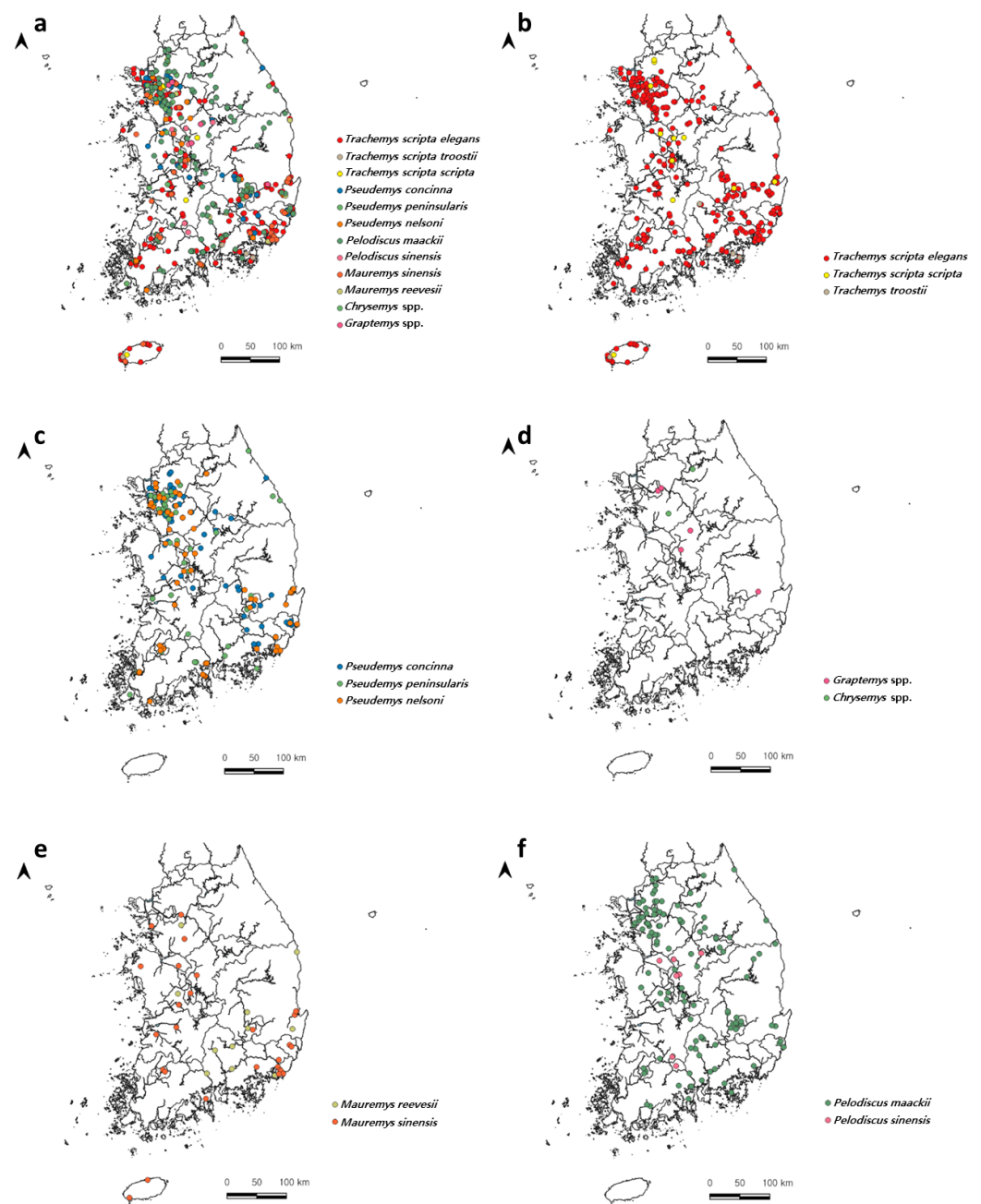


Figure 1. Domestic distribution of turtles identified based on the results of the National Ecological Institute’s “National Habitat Survey of Alien Species” from 2014–2022. (a) all turtles; (b) *Trachemys* spp.; (c) *Pseudemys* spp.; (d) *Graptemys* spp. and *Chrysemys* spp.; (e) *Mauremys* spp.; (f) *Pelodiscus* spp.

Table 1. Status of invasive alien turtles distributed in South Korea from 2014–2022; Number of individuals, number of points (cities), and legal designation status.

Species	Individuals	Points (Cities)	Designation
<i>Trachemys scripta</i>	1440 (66%)	295 (103)	EDS
1-1. <i>Trachemys scripta elegans</i>	1360 (63%)	280 (100)	EDS
1-2. <i>Trachemys scripta scripta</i>	58 (3%)	40 (26)	EDS
1-3. <i>Trachemys scripta troostii</i>	22 (1%)	12 (10)	EDS

Table 1. Cont.

Species	Individuals	Points (Cities)	Designation
<i>Pseudemys concinna</i>	371 (17%)	124 (64)	EDS
<i>Pseudemys nelsoni</i>	136 (6%)	57 (36)	EDS
<i>Pseudemys peninsularis</i>	164 (8%)	80 (43)	
<i>Mauremys sinensis</i>	45 (2%)	29 (19)	EDS
<i>Chrysemys picta picta</i>	1	1 (1)	
<i>Chrysemys dorsalis</i>	1	1 (1)	
<i>Graptemys pseudogeographica</i>	3	3 (3)	
<i>Graptemys ouachitensis</i>	2	2 (2)	
<i>Pelodiscus sinensis</i>	11	7 (6)	
Total	2174	341 (109)	

Data were provided by NIE ECObank, <http://doi.or.kr/10.22756/ASD.20220000000812>, accessed on 19 December 2022.

Of the alien turtles detected, 91% were found to be EDS, with *T. scripta* accounting for 66% of the detections.

3.2. Sales Status of Turtles in Traditional Markets

Sales of 10 alien turtle species (*Chrysemys picta*, *Emydura subglobosa*, *Kinosternon subrubrum*, *Mauremys sinensis*, *Pelodiscus sinensis*, *Pseudemys concinna*, *Pseudemys nelsoni*, *Pseudemys peninsularis*, *Sternotherus carinatus*, *Trachemys scripta*) and 1 native species of *Mauremys reevesii* were confirmed in nine traditional markets (Table 2). Of the 10 invasive species, seven are also found in the wild, with the exception of *Emydura subglobosa*, *Kinosternon subrubrum*, and *Sternotherus carinatus*. We identified a range of carapace lengths for turtles sold in the market, from 5 to 40 cm. Juvenile turtles with carapace lengths less than 10 cm were sold in large quantities and traded primarily as pets. Turtles with carapace lengths greater than 15 cm were sold mostly for religious purposes. *P. sinensis*, regardless of carapace length, was primarily traded for food. For turtles traded for release or food, the larger the carapace length, the higher the value.

Table 2. The species, carapace sizes, values, and numbers of turtles traded in nine traditional markets in South Korea.

Market	Species	Carapace Length (cm)	Value (\$)	Individuals Sold
Cheonggyecheon (Seoul Metropolitan)	<i>Pseudemys peninsularis</i>	5–10	-	100 ↑
	<i>Chrysemys picta picta</i>	5–10	-	100 ↑
	<i>Kinosternon subrubrum</i>	5–10	-	50 ↑
	<i>Trachemys scripta elegans</i>	30 ↑	39–118	5
Moran Market (Seongnam-si)	<i>Trachemys scripta scripta</i>	20	39	1
	<i>Pseudemys concinna</i>	-	39–118	6
	<i>Pseudemys peninsularis</i>	20–40	39–118	3
Jayu Market (Mokpo-si)	<i>Trachemys scripta elegans</i>	20–40	-	12
Jayang Market (Gyeongsan-si)	<i>Pelodiscus sinensis</i>	20–40	39–118	4
Chilseong Market (Daegu Metropolitan)	<i>Pelodiscus sinensis</i>	20–40	11–15	20
	<i>Pseudemys concinna</i>	20–30	31–39	2
Seomun Market (Daegu Metropolitan)	<i>Mauremys sinensis</i>	20–30	31–39	2
	<i>Chrysemys picta bellii</i>	5–10	19	40
	<i>Sternotherus carinatus</i>	15	31–39	1
	<i>Emydura subglobosa</i>	15	31–39	1

Table 2. Cont.

Market	Species	Carapace Length (cm)	Value (\$)	Individuals Sold
Gwanmun Market (Daegu Metropolitan)	<i>Trachemys scripta elegans</i>	20–40	31–39	10
	<i>Pseudemys concinna</i>	20–40	23–39	5
	<i>Pseudemys nelsoni</i>	20–40	23–39	2
	<i>Mauremys sinensis</i>	20–40	23–39	1
	<i>Pelodiscus sinensis</i>	20–40	23–39	15
	<i>Trachemys scripta elegans</i>	5–20 ↑	11–15	36
Bujeon Market (Busan Metropolitan)	<i>Pseudemys concinna</i>	15	11	1
	<i>Mauremys sinensis</i>	-	15	6
	<i>Mauremys maackii</i>	-	15	1
	<i>Pelodiscus sinensis</i>	-	31/kg	80
	<i>Sternotherus carinatus</i>	5	7	1
Dongnae Market (Busan Metropolitan)	<i>Trachemys scripta elegans</i>	20–30	-	5
	<i>Pseudemys concinna</i>	20	-	1

- indicates data not recorded.

We identified a total of 95 individuals of EDS turtles that are traded on the traditional market. Of these, 69 *T. scripta* individuals (five markets), 15 *P. concinna* individuals (five markets), 9 *M. sinensis* individuals (three markets), and 2 *P. nelsoni* individuals (one market) were identified. In addition, the trade of *M. reevesii*, which is designated an endangered species and natural monument, was confirmed. However, it was not possible to confirm the source of the turtles being sold; thus, since there are no edible turtle farms in South Korea except for *P. sinensis*, it is believed that the turtles being sold are captured from the wild.

3.3. Management Status of Turtles Retrieved from the Wild

To understand the current status of turtles retrieved from the wild, the number of cases registered in the system (<https://www.animal.go.kr/>, accessed on 3 January 2023) for 3 years was analyzed. A total of 169 cases and 178 individuals were confirmed; 46 cases were species-identified at the time of registration in the system, of which 8 cases were misidentified. Through the re-identification of turtles based on the morphological characteristics on the registered photographs, the species of 142 cases were identified and 27 cases remained unidentified. The identified species were *Carettochelys insculpta*, *Chelydra serpentina*, *Chrysemys* spp., *Mauremys sinensis*, *Pelodiscus maackii*, *Pelomedusa subrufa*, *Podocnemis unifilis*, *Pseudemys concinna*, *Pseudemys nelsoni*, *Pseudemys peninsularis*, *Sternotherus carinatus*, *Trachemys scripta* (Table 3). To determine the reutilization status of all abandoned turtles, euthanasia and natural death were excluded, and adoption, release, return, donation, and advertisement were identified. Of these, 84 cases were adopted by new breeders, 9 cases were re-released to the place of capture, 3 cases were returned to their breeders, 7 cases were donated, and 5 cases were under advertisement. Reutilization status by adoption was significantly higher than other cases with an average of 7.1 cases ($F = 8.728$, $p < 0.001$).

Trachemys scripta accounted for 31% of the registered turtles; 34 cases were confirmed. Of these, *T. s. elegans* accounted for 26 cases, *T. s. scripta* accounted for 6 cases, and *T. s. troostii* accounted for 2 cases. *T. s. elegans* was found to be overwhelmingly abundant and was most common among all lost turtles. Twenty-nine adoptions of lost *T. scripta* were confirmed, as well as one release, two donations, and two announcements. Only 10 cases of euthanasia and 8 cases of natural death were found, confirming that 65% of *T. scripta* was reused.

As a result of searching for records of turtles released for religious purposes, a total of six news articles were found from 2012 to 2022. The release period varied from February to December. The locations were diverse, such as large reservoirs, small ponds in ecological parks, and coastal areas, and *T. scripta*, *M. sinensis*, and *C. picta* were identified [23–28]. The turtles had the name and date of birth of the person who released them written on

their carapace or plastron, in addition to some wish fulfillment phrases, such as university acceptance or the birth of a son.

Table 3. Status of turtles retrieved from the wild and their reutilization based on “The National Animal Welfare Information System” (<https://www.animal.go.kr/front/index.do>, accessed on 3 January 2023) from 2019 to 2022.

Species	Adoption	Release	Return	Donation	Advertisement	Total	F-Value	p-Value
<i>Trachemys scripta</i>	29	1		2	2	34		
1-1. <i>Trachemys scripta elegans</i>	21	1		2	2	26		
1-2. <i>Trachemys scripta scripta</i>	6					6		
1-3. <i>Trachemys scripta troostii</i>	2					2		
<i>Pseudemys concinna</i>	4					4		
<i>Pseudemys nelsoni</i>	4	1			1	6		
<i>Pseudemys peninsularis</i>	20	3	1	1		25		
<i>Mauremys sinensis</i>	4					4		
<i>Chrysemys</i> spp.								
<i>Sternotherus carinatus</i>	1					1		
<i>Podocnemis unifilis</i>	1					1		
<i>Pelomedusa subrufa</i>	1					1		
<i>Carettochelys insculpta</i>				1		1		
<i>Pelodiscus maackii</i>	1	4				5		
<i>Chelydra serpentina</i>	8		1	2		11		
Unidentified	11		1	1	2	15		
Total cases	20	0.6 ± 0.3 ^b	0.2 ± 0.1 ^b	0.6 ± 0.2 ^b	0.4 ± 0.2 ^b	8.9 ± 2.6 ^b	8.728	<0.001

The values with different letters indicate significant differences at $p < 0.05$.

3.4. Import Status of Turtles for 21 Years

To elucidate the import status of domestic turtles, we analyzed the import and export statistics from the Trade Statistics Service (TRASS). A total of 161,725 kg (>161 tons) and USD 12,784,022 worth of turtles was imported from 63 countries over the past 21 years (2002–2022) (Table S1). Continental nations from which turtles were imported included countries in Africa (16 countries), Asia (13 countries), Europe (15 countries), Central Asia (5 countries), North America (3 countries), and South America (11 countries).

Since 2002, the overall volume of imports decreased (Figure 2b), whereas the number of imports and countries from which the imports came steadily increased, with an average of 20 importing countries (Table 4). The volumes imported from Asia and North America were similar, with average weights of 501 and 505, respectively. However, the monetary value of imports from North America was significantly higher (Figures 3 and 4).

Table 4. Number of countries, value, and weight of invasive alien turtles imported into South Korea by year over 20 years.

Year	Number of Countries	Value (\$)	Weight (kg)
2002	5	208,846	12,620
2003	6	205,691	3329
2004	7	285,471	7356
2005	7	298,998	6406
2006	8	304,912	9556
2007	10	377,421	16,064
2008	13	423,538	17,922
2009	17	465,876	10,588
2010	15	570,234	9736
2011	18	623,751	8002
2012	20	833,614	5952
2013	24	724,737	7533

Table 4. Cont.

Year	Number of Countries	Value (\$)	Weight (kg)
2014	26	775,223	6611
2015	30	659,849	6528
2016	36	920,438	9440
2017	35	762,864	6181
2018	32	810,020	6512
2019	34	668,850	5115
2020	28	869,089	2031
2021	32	1,187,869	2768
2022	23	806,731	1473

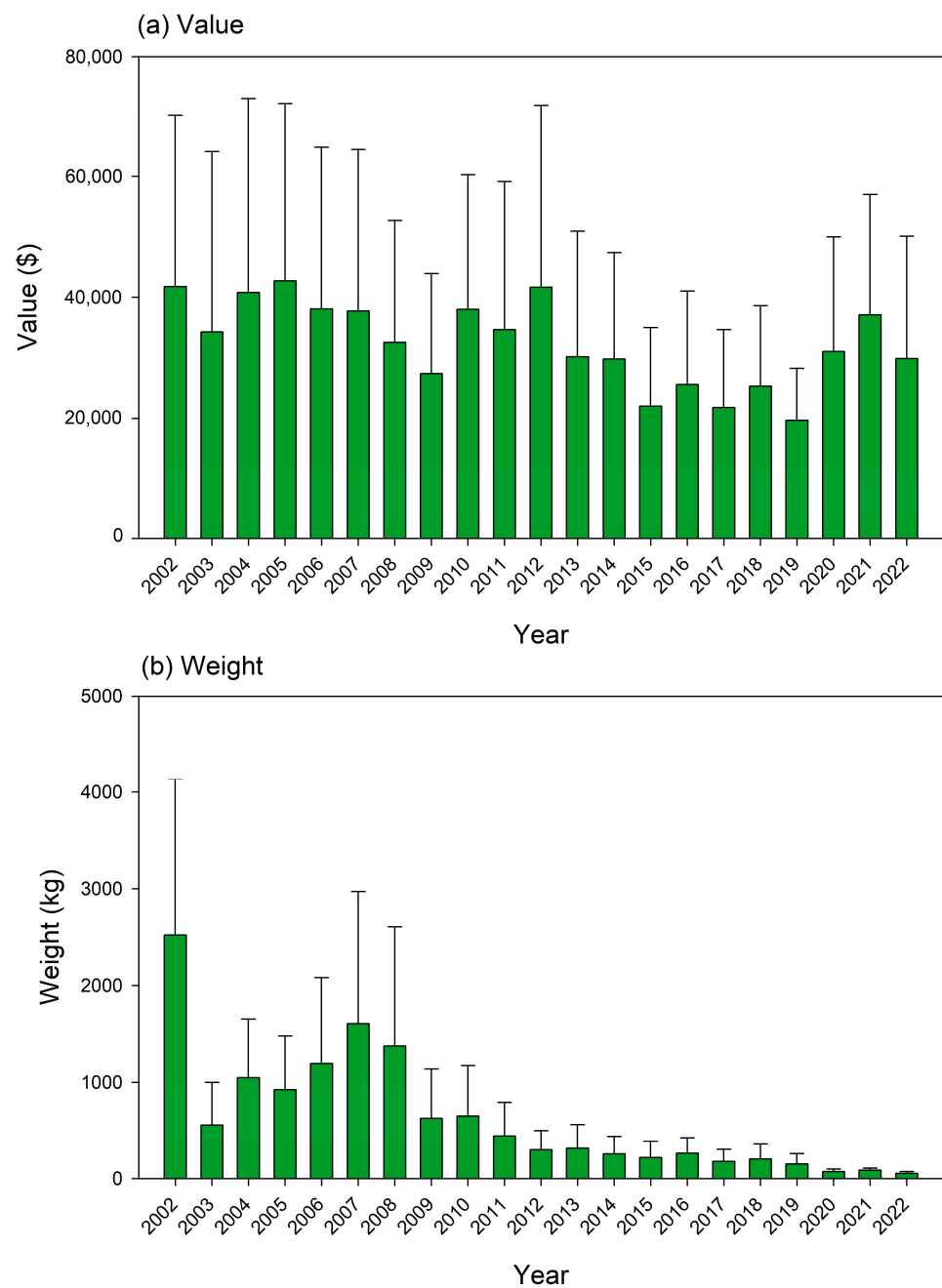


Figure 2. Import status of alien turtles from 2002 to 2022, South Korea. Values are means \pm standard errors.

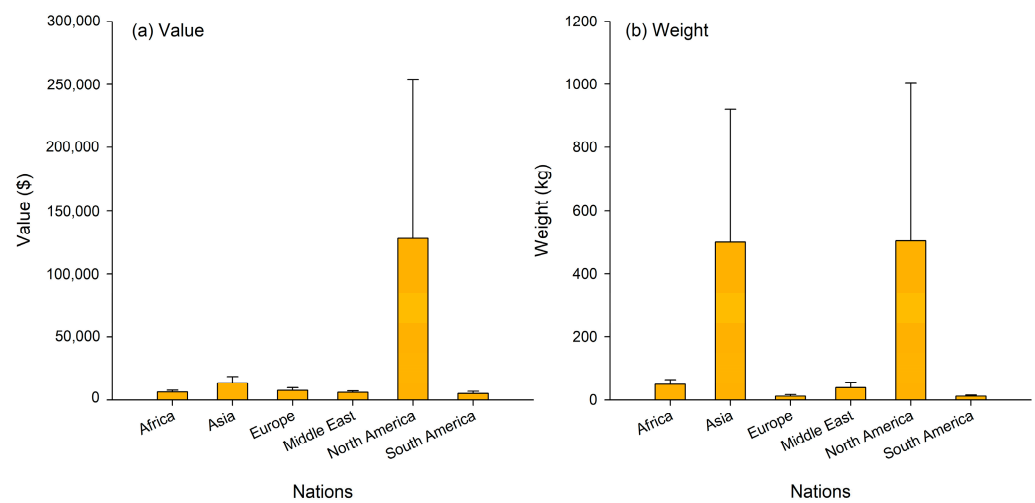


Figure 3. Invasive alien turtle imports by continent from 2002 to 2022. Values are means \pm standard errors.

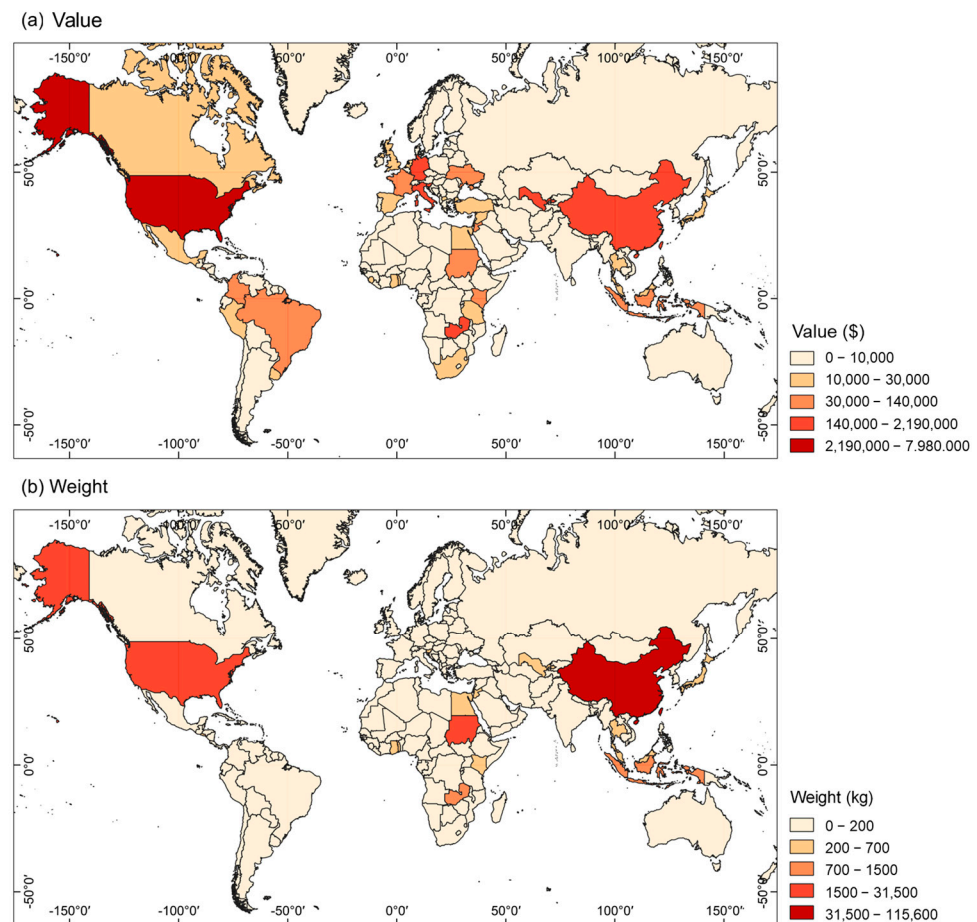


Figure 4. Invasive alien turtle imports by continent from 2002 to 2022.

Since 2002, the overall volume of imports decreased (Figure 2b), whereas the number of imports and countries from which the imports came steadily increased, with an average of 20 importing countries (Table 4). The volumes imported from Asia and North America were similar, with average weights of 501 and 505 respectively. However, North America had a significantly higher import value (Figures 3 and 4).

4. Discussion

In this study, the current status of abandoned and lost turtles in traditional markets and animal protection management systems was identified to examine the reutilization status of the invasive alien species in South Korea. Reutilization refers to the resale and re-circulation of turtles captured from nature. In the case of invasive alien turtles collected from natural ecosystems in South Korea, it is estimated that there are more cases of abandonment of captive-bred individuals than of distribution by natural dispersal; therefore, it is called reutilization because turtles have been adopted once, released back into the wild, and returned to humans for various purposes. In addition, the domestic distribution status of alien turtles, including that of *T. scripta*, was determined, and the import status of turtles imported into South Korea was confirmed.

A total of 1360 *T. scripta* individuals were identified in 103 cities (295 sites), which accounted for most of the discovered invasive alien turtles. *Trachemys scripta* were mainly concentrated in metropolitan cities and, unlike other alien turtles, they were distributed across a wide area, including mountainous islands (Figure 1). Their distribution area is wider than that of *M. reevesii* and *P. maackii*, which are native to South Korea. Furthermore, along with previously conducted DNA analyses to confirm the successful breeding of *T. scripta*, we confirmed the successful establishment and spread of *T. scripta* since their introduction to South Korea in 1970.

Since *T. scripta* was designated as an EDS in 2001, five species of invasive alien turtles were additionally designated as EDS. If an alien turtle species is designated as EDS, existing breeders can apply for the “Approval of Breeding and Grace for IAS” program. However, because this program is limited to initial one-time reporting and follow-up monitoring is not compulsory, its continuous management is impossible [20]. In addition, because the application period is limited to six months after an alien species is designated as EDS, existing breeders, who are often unaware of this program owing to a lack of publicity, often do not apply in time. Moreover, it was confirmed that turtles who had difficulties breeding were abandoned in nature after they had been designated as EDS. Additionally, as an application for this breeding program is only possible via mail, turtles could be abandoned owing to the hassle of registration. The abandonment of EDS turtles accounted for 61% of all alien turtle cases (Table 3). It has been revealed that the observed number of this species increased remarkably the year after it was designated as an EDS [Koo et al. unpublished].

The eradication of EDS is carried out voluntarily by the Ministry of Environment, local governments, and environmental organizations. However, since there is no clear treatment method for captured EDS, it is difficult to identify the status of post-treatment such as captured species, number of individuals, and treatment method. Regarding the size of *T. scripta* individuals being sold in traditional markets, carapace lengths of 20–30 cm were the most common, and individuals with carapace lengths over 30 cm were also identified. Since EDS cannot be reared or bred, it was discerned that *T. scripta* individuals were being resold in traditional markets after their capture in nature. Since the main purpose of their trade is to release them, it poses a fundamental problem, as the individuals captured in nature are traded in the market and returned to nature. Ritualized animal release is a Buddhist and Shamanistic ritual during which captive animals are released into nature to accumulate merit [29–31]. These release events occur intensively each year in May on Buddha’s birthday. Since 2012, the release of turtles has become a social issue, and it has been confirmed that invasive alien turtles, such as *T. scripta* or *M. sinensis*, have been released. Abandoned freshwater turtles released in coastal areas and natural ecosystems are sometimes collected by animal rescue organizations and local governments, but since most of them are EDS, post-processing practices other than euthanasia are practically impossible. Alternatively, there are cases in which animals are rescued by animal rescue organizations and then readopted due to misidentification. In fact, by confirming the loss of freshwater turtles from 2020 to 2022, we confirmed that *T. scripta* individuals rescued from Haeundae, Busan were adopted due to misidentification. In the animal protection management system, the initial identification of these turtles was successful in 22% of cases,

and the reuse rate (adoption, release, donation, and advertisement) of *T. scripta* was 65% owing to misidentification.

Approximately 110 species of alien turtles and tortoises were imported into South Korea, and although there was no considerable difference between the number of imported species between 2015 and 2019 [11], the number of imports decreased, and the monetary value of these imports increased considerably (Table 4, Figure 2, Table S1). The total monetary value of these imports is inversely proportional to the trade of invasive alien turtles for ornamental or pet-keeping purposes and is considered to reflect the desire of the public to possess increasingly rare and exotic turtles. According to Koo et al. [11], 110 alien turtles were sold in domestic online pet shops in 2019, and their value ranged from USD 6.4 to 14,460. In addition, 47 species of turtles and tortoises corresponded to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) index, accounting for 42.7% of the total traded tortoises. Alien turtles found in the wild are inexpensive and relatively easy to purchase [5,12,32,33] and in South Korea, alien turtles found in the natural ecosystem are large freshwater turtles with low selling values. Among them, the observed rate of EDS turtles was remarkably high (92%), and *T. scripta* was the most frequently identified (66%) (Table 1). Similar results were observed in turtles sold in traditional markets or lost owing to abandonment.

This study confirmed that a notable number of *T. scripta* are adopted and reutilization in traditional markets. Going forward, the following should be considered. (1) To effectively manage and remove invasive species, the government should have a program that allows local governments to purchase invasive species as needed. This program should be prioritized for species such as *Myocastor coypus*, *Micropterus salmoides*, and *Lepomis macrochirus*. Therefore, the activation of the purchase program and the increase in the budget can be expected to reduce the flow of wild-caught EDS turtles into traditional markets. In addition, enforcement must be strengthened to prevent the underlying demand and purchase of these species in traditional markets. (2) Private and institutional experts should collaborate to improve the accuracy of initial species identification of abandoned or retrieved invasive alien turtles, thus cutting off the pathway for the reuse of EDS turtles. (3) In the case of the “Approval of Breeding and Grace for IAS” program, the registration system should be changed to improve the convenience of registration, and reporting should be mandatory once a year until the end of breeding. It is also recommended to extend the application period from 6 months to a maximum of 1 year. (4) Finally, a “Free collection system” should be implemented to prevent wild exposure of captive invasive alien turtles due to breeding abandonment. This will reduce the population of invasive alien turtles that are abandoned indiscriminately and disturb the ecosystem, and allow the collected turtles to be used for research and exhibition. Through these methods, it would manage the invasive alien turtles that have been introduced and bred in South Korea to control the abandonment of turtles in the wild and to prevent the reutilization of turtles found in natural ecosystems using conventional markets.

Aichi Biodiversity Targets 9 focuses on two types of actions: control or eradication of invasive alien species and management of introduction routes. In line with international trends, the HS codes currently assigned to turtles collectively need to be refined, and a system for clearly identifying the species, number of individuals, and purposes of invasive alien species introduced into the country is urgently needed. Utilizing such a system, systematic management of the entire biota, including invasive alien turtles, is required, and efforts to conserve native species are urgently needed.

5. Conclusions

This study investigated the domestic reutilization of invasive alien turtles after they were retrieved from the wild. The reutilization of a considerable number of *T. scripta* and other invasive alien turtles was confirmed through the analysis of traditional markets and sales advertisements of abandoned or lost animals. Thereby, the gravity and importance of EDS management, after their designation as such, was revealed. To compensate for this,

measures have been proposed for an efficient follow-up management system for invasive alien turtles that have been designated and announced as EDS. The crucial information elucidated in this study could be used to guide future national policies. However, this study was unable to identify the source of the commercially available EDS turtles such as *T. scripta* in traditional markets. To prevent the supply and demand of EDS turtles, crackdowns on the sale of exotic turtles in traditional markets should be carried out periodically. It is also advisable to promote collection and compensation schemes for the ecosystem-disturbing turtles which are retrieved from the wild to reduce the number of turtles supplied to the traditional market. It is also urgent to establish a systematic management plan such as HS code maintenance, as the current trade management system is not sufficient to manage the clear status of exotic turtles imported into Korea.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/d15080885/s1>, Table S1: Current import status of invasive alien turtles into South Korea from 2002 to 2022.

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References

1. Thomson, S.A. Turtles of the world: Annotated checklist and atlas of taxonomy, synonymy, distribution, and conservation status. *Phyllomedusa J. Herpetol.* **2021**, *20*, 225–228. [\[CrossRef\]](#)
2. Lovich, J.E.; Ennen, J.R.; Agha, M.; Gibbons, J.W. Where have all the turtles gone, and why does it matter? *BioScience* **2018**, *68*, 771–781. [\[CrossRef\]](#)
3. Stanford, C.B.; Rhodin, A.G.J.; van Dijk, P.P.; Horne, B.D.; Blanck, T.; Goode, E.V.; Hudson, R.; Mittermeier, R.A.; Currylow, A.; Eisemberg, C.C.; et al. *Turtles in Trouble: The World's 25+ Most Endangered Tortoises and Freshwater Turtles—2018*; Turtle Conservation Coalition, Hemlock Printers: Burnaby, BC, Canada, 2018.
4. Garber, S.D.; Burger, J. A 20-yr study documenting the relationship between turtle decline and human recreation. *Ecol. Appl.* **1995**, *5*, 1151–1162. [\[CrossRef\]](#)
5. Koo, K.S.; Song, S.; Choi, J.H.; Sung, H.C. Current distribution and status of non-native freshwater turtles in the wild, Republic of Korea. *Sustainability* **2020**, *12*, 4042. [\[CrossRef\]](#)
6. National Institute of Ecology. *Monitoring of Invasive Alien Species Designated by the Act on the Conservation and Use of Biological Diversity (VI)*; Ministry of Environment: Seochon, Republic of Korea, 2022; pp. 61–69.
7. Kraus, F. *Alien Reptiles and Amphibians: A Scientific Compendium and Analysis*; Springer: Dordrecht, The Netherlands, 2009.
8. National Institute of Ecology. *Investigation Ecological Risk of Alien Species*; Ministry of Environment: Seochon, Republic of Korea, 2021; pp. 93–113.
9. National Institute of Ecology. *Information for the Field Management of Invasive Alien Species in Korea*; Ministry of Environment: Seochon, Republic of Korea, 2021; pp. 36–41.
10. Roy, H.E.; Rabitsch, W.; Scalera, R. *Study on Invasive Alien Species—Development of Risk Assessments to Tackle Priority Species and Enhance Prevention. Final Report*; European Union: Luxembourg, 2018. Available online: <https://op.europa.eu/en/publication-detail/-/publication/c01568d9-025e-11e8-b8f5-01aa75ed71a1/language-en> (accessed on 13 December 2022).
11. Ramsay, N.F.; Ng, P.K.A.; O'Riordan, R.M.; Chou, L.M. The red-eared slider (*Trachemys scripta elegans*) in Asia: A review. In *Biological Invaders in Inland Waters: Profiles, Distribution, and Threats*; Gherardi, F., Ed.; Springer: Dordrecht, The Netherlands, 2007; pp. 161–174. [\[CrossRef\]](#)

12. Koo, K.S.; Park, H.R.; Choi, J.H.; Sung, H.C. Present status of non-native amphibians and reptiles traded in Korean online pet shop. *Korean J. Environ. Ecol.* **2020**, *34*, 106–114. [\[CrossRef\]](#)
13. Tobin, P.C. Managing invasive species. *F1000Research* **2018**, *7*, 1686. [\[CrossRef\]](#) [\[PubMed\]](#)
14. Larson, D.L.; Phillips-Mao, L.; Quiram, G.; Sharpe, L.; Stark, R.; Sugita, S.; Weiler, A. A framework for sustainable invasive species management: Environmental, social, and economic objectives. *J. Environ. Manag.* **2011**, *92*, 14–22. [\[CrossRef\]](#) [\[PubMed\]](#)
15. Pimentel, D.; Zuniga, R.; Morrison, D. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecol. Econ.* **2005**, *52*, 273–288. [\[CrossRef\]](#)
16. Kraus, F. Impacts from invasive reptiles and amphibians. *Annu. Rev. Ecol. Evol. Syst.* **2015**, *46*, 75–97. [\[CrossRef\]](#)
17. Levine, J.M.; Vilà, M.; D’Antonio, C.M.; Dukes, J.S.; Grigulis, K.; Lavorel, S. Mechanisms underlying the impacts of exotic plant invasions. *Proc. R. Soc. B Biol. Sci.* **2003**, *270*, 775–781. [\[CrossRef\]](#)
18. Wilcove, D.S.; Rothstein, D.; Dubow, J.; Phillips, A.; Losos, E. Quantifying threats to imperiled species in the United States: Assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease. *BioScience* **1998**, *48*, 607–615. [\[CrossRef\]](#)
19. Teillac-Deschamps, P.; Delmas, V.; Lorrillière, R.; Servais, V.; Cadi, A.; Prévot-Julliard, A.C. Red-eared slider turtles (*Trachemys scripta elegans*) introduced to French urban wetlands. An integrated research and conservation program. *Herpetol. Conserv.* **2008**, *3*, 535–537. Available online: <https://orbi.uliege.be/bitstream/2268/28797/1/TiellacCS12.pdf> (accessed on 23 February 2023).
20. Kim, P.; Yeun, S.; An, H.; Kim, S.H.; Lee, H. Breeding status and management system improvement of *Pseudemys concinna* and *Mauremys sinensis* designated as invasive alien turtles in South Korea. *Ecol. Resilient Infrastruct.* **2020**, *7*, 388–395.
21. Oh, H.S.; Hong, C.E. Current conditions of habitat for *Rana catesbeiana* and *Trachemys scripta elegans* imported to Jeju-do, including proposed management plans. *Korean J. Environ. Ecol.* **2007**, *21*, 311–317.
22. SPSS. *IBM SPSS Statistics for Windows*, version 24.0; IBM Corp.: Armonk, NY, USA, 2016.
23. Bang, J.H. Who Did the Bad Things to Turtle and His Shell? *Maeil Shinmun*, 14 June 2012. Available online: <http://mnews.imaail.com/page/view/2012061410461163218> (accessed on 10 January 2023).
24. Kim, H.J. ‘Poor Release, It Hurts Me.’ Call of the Red-Eared Slider. *Brainworld Korea*, 24 May 2012. Available online: <https://www.brainmedia.co.kr/BrainTraining/9197> (accessed on 10 January 2023).
25. Park, J.H. Respect for Life through Release? Rather Kill Life. *OhmyNews*, 29 February 2016. Available online: http://www.ohmynews.com/NWS_Web/View/at_pg.aspx?CNTN_CD=A0002185995 (accessed on 10 January 2023).
26. Park, G.E. Named on the Turtle Shell with Paint and Release It?... “Killing, Not Releasing.” *Nocutnews*, 24 December 2019. Available online: <https://www.nocutnews.co.kr/news/5263572> (accessed on 10 January 2023).
27. Park, Y.S. [Camera News] Freshwater Turtle Abandoned in the Sea with Red Writing on the Plastron. *Yonhapnews*, 10 February 2020. Available online: <https://www.yna.co.kr/view/AKR20200210116400062> (accessed on 10 January 2023).
28. Choi, H.J. ‘The Plastron is Full of People’s Name’ Why Do Freshwater Turtles Go to Sea. *Ilyo*, 28 April 2022. Available online: https://m.ilyo.co.kr/?ac=article_view&entry_id=427395 (accessed on 10 January 2023).
29. Shiu, H.; Stokes, L. Buddhist animal release practices: Historic, environmental, public health and economic concerns. *Contemp. Buddhism* **2008**, *9*, 181–196. [\[CrossRef\]](#)
30. Holler, D. The ritual of freeing lives. In *Proceedings of the Ninth Seminar of the IATS, 2000. Volume 2: Religion and Secular Culture in Tibet*; Brill Academic Pub: Leiden, The Netherlands, 2002; pp. 207–226. [\[CrossRef\]](#)
31. Chen, J.M.; Lin, M.L.; Suen, M.W. Individuals’ Knowledge, Beliefs, Attitudes, and Behaviors toward Animal Releasing. *Sociol. Mind* **2014**, *4*, 298–304. [\[CrossRef\]](#)
32. Masin, S.; Bonardi, A.; Padoa-Schioppa, E.; Bottoni, L.; Ficetola, G.F. Risk of invasion by frequently traded freshwater turtles. *Biol. Invasions* **2014**, *16*, 217–231. [\[CrossRef\]](#)
33. Kopecký, O.; Kalous, L.; Patoka, J. Establishment risk from pet-trade freshwater turtles in the European Union. *Knowl. Manag. Aquat. Ecosyst.* **2013**, *410*, 02. [\[CrossRef\]](#)

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