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Article

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Abstract: The pond slider (*Trachemys scripta*) was designated as an invasive alien species in South Korea in 2001. Although the prevention and control of invasive species have received considerable attention worldwide, studies on the current status and effective management of *T. scripta* in South Korea are lacking. This study aimed to elucidate the status of domestic reuse of *T. scripta* and provide effective management suggestions. Analysis of the National Institute of Ecology's "Nationwide Survey of Non-native Species in Korea" conducted from 2015 to 2022 confirmed the habitats of 1,440 *T. scripta* individuals at 295 sites. *T. scripta* is the most frequently observed among invasive turtles identified in the Korean Peninsula. To determine the reuse of *T. scripta*, 13 traditional markets were surveyed; five markets were confirmed to have *T. scripta*. Although the exact distribution route is unknown, individuals living or abandoned in the region might be resold in the market. *T. scripta* is mostly sold for ritual purposes. Moreover, *T. scripta* accounted for 31% of freshwater turtles abandoned between 2019 and 2022. Their continuous reuse has been confirmed 22 years after their designation as an invasive alien species. Therefore, effective and fundamental management measures for *T. scripta* are required.

Keywords: animal release; invasive species management; South Korea; traditional markets; *Trachemys scripta*

1. Introduction

Approximately 61% of the 357 extant turtle species [1] are endangered or extinct [2]. Among them, reptiles such as turtles and tortoises reportedly face more serious extinction risks than other vertebrates [2–5]. Artificial human activities are the main cause underlying the decrease in the turtle population, and the invasion of the natural ecosystems by alien species further accelerates the population decrease of existing turtles [5].

Invasive alien species are organisms that disturb or are likely to disturb the balance of the ecosystem [6]. In South Korea, invasive alien species are designated and managed according to the law to respond to their impact on the ecosystem. In South Korea, the genus *Trachemys* spp. and five species, *Pseudemys concinna*, *Mauremys sinensis*, *Macrochelys temminckii*, *Pseudemys nelson*, and *Chelydra serpentina* were designated as invasive alien species in 2001, 2020, 2020, 2021, and 2022, respectively. Most of the invasive alien turtles found in the wild were bred as pets and then abandoned or released for religious ceremonies. Among them, *Trachemys scripta* was the first to be introduced to South Korea in the late 1970s for religious and pet-keeping purposes. To date, DNA barcoding analysis of eggshells has confirmed the reproduction of *T. scripta*, *Pseudemys* spp., and *C. serpentina*, and

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hatchlings were found for *T. scripta* and *P. concinna*, indicating successful settlement [6–8, Koo et al. unpublished].

T. scripta is the most exported species in the United States, along with *T. scripta troostii*, *G. pseudogeographic*, and *P. nelsoni* [9], with 43.6 million exports from 1989 to 1997 and 52 million exports from 1998 to 2022 [10]. According to The Human Society of the United States (2001), more than 8.7 million *T. scripta* were exported from the United States in 1997, of which *T. scripta elegans* accounted for 93.2%. In the same year, South Korea was the third largest import nation after China and Hong Kong, with live turtle imports from the United States exceeding 1 million.

According to Koo et al. [11], 677 alien amphibians and reptiles species were sold online in 2019 in South Korea being approximately 2.1 times higher than officially imported species in 2015. To date, ten invasive turtle species have been found in the native ecosystem of the Korean peninsula (*C. serpentina*, *M. sinensis*, *Chrysemys picta bellii*, *Graptemys ouachitensis*, *Graptemys pseudogeographica*, *P. concinna*, *P. nelsoni*, *Pseudemys peninsularis*, *Pseudemys rubriventris*, and *T. scripta* [12]). Among these, five species (50%) are designated as invasive alien species. The prevention and control of invasive 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]. To date, only two studies on the management of invasive turtle species have been conducted in South Korea [19,20]. However, studies on the current status and management of invasive alien turtle species in South Korea are insufficient.

Therefore, this study aimed to identify the current domestic reuse status of *T. scripta*, as well as the current import status of invasive turtles in South Korea. In addition, we suggest an effective management plan for turtles, focusing on invasive alien turtle species in particular.

2. Materials and Methods

2.1. Distribution of T. scripta in South Korea

To confirm the distribution of *T. scripta*, data from the "National Habitat Survey of Alien Species" conducted by the National Institute of Ecology (NIE) from 2014 to 2022 were analyzed. The data used in this study are stored in NIE ECObank (http://doi.or.kr/10.22756/ASD.20220000000812) as open-source data. The survey was conducted in all cities of the Korean Peninsula (excluding Ulleung-gun). The target species included all alien organisms introduced in South Korea; in the case of alien amphibian reptiles, there were a total of 363 species (25 amphibian and 338 reptile species). Among these, the key species were invasive alien species and those with potential risks to ecosystems. Reservoirs, ecological parks, and rivers were subject to investigation, and data on all species (including species, individuals, sizes, and places of discovery) were recorded.

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 reuse of *T. scripta*. The traditional 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 price of the sold turtles were recorded.

2.3. Management status of abandoned and lost turtles

To identify cases of abandoned or lost *T. scripta*, cases reported by the Animal Protection Management System of the Animal and Plant Quarantine Agency from December 2019 to December 2022 were recorded. Registered turtles were classified into adoption, release, return, donation, announcement (still on resale), euthanasia, and natural death categories, of which the cases categorized as adoption, release, return, donation, and announcement were classified as reuses and converted into total percentages.

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In addition, media items, such as news articles recorded after the 2000s were searched to find out the release status of alien turtles for religious purposes.

2.4. Import status of alien turtles

Since *T. scripta* was designated as an invasive alien species in 2001, the import status of alien turtles was investigated from 2002 to 2022. The Ministry of Environment selected 23 items that were highly likely to be recorded when reporting imported organisms, and turtles were classified as item number (HS code) 0106203000. The item number refers to all imported turtles; thus, details on the purpose and number of turtle species could not be confirmed. Data from the Trade Statistics Service (TRASS, https://www.bandtrass.or.kr/index.do) were used to confirm information on turtles imported into South Korea for 21 years. Data in TRASS are classified by item, country, continent, airport/port, domestic region, customs, payment method, transaction classification, and transaction type. In this study, trade by items using HS code (0106203000) statistical data were used, and the country, weight (kg), and value ($) of turtles imported into South Korea yearly were confirmed.

2.5. Data analysis

The Kolmogorov-Smirnov test was performed in order to confirm the normality of the cases of abandoned and lost alien turtles; none of the variables met the normality assumptions. Therefore, an analysis of the cases of abandoned and lost alien turtles differences of each variable was performed using the Kruskal-Wallis H test, a nonparametric test. All analyses were carried out using Statistical Package for Social Science (SPSS) [21].

3. Results

3.1. Distribution of T. scripta and other alien turtles in South Korea

For a total of nine years (2014–2022), the habitats of ten alien turtle species were confirmed at 341 points in 109 of 161 cities in South Korea. The alien turtle species identified were *T. scripta*, *P. concinna*, *P. nelsoni*, *P. peninsularis*, *M. sinensis*, *C. picta picta*, *C. dorsalis*, *G. pseudogeographica*, *G. ouachitensis*, and *P. sinensis*. In total, 2,174 individuals from 10 species were identified (Table 1). The distribution status of alien turtle species in South Korea is shown in Figure 1 and Table 1.

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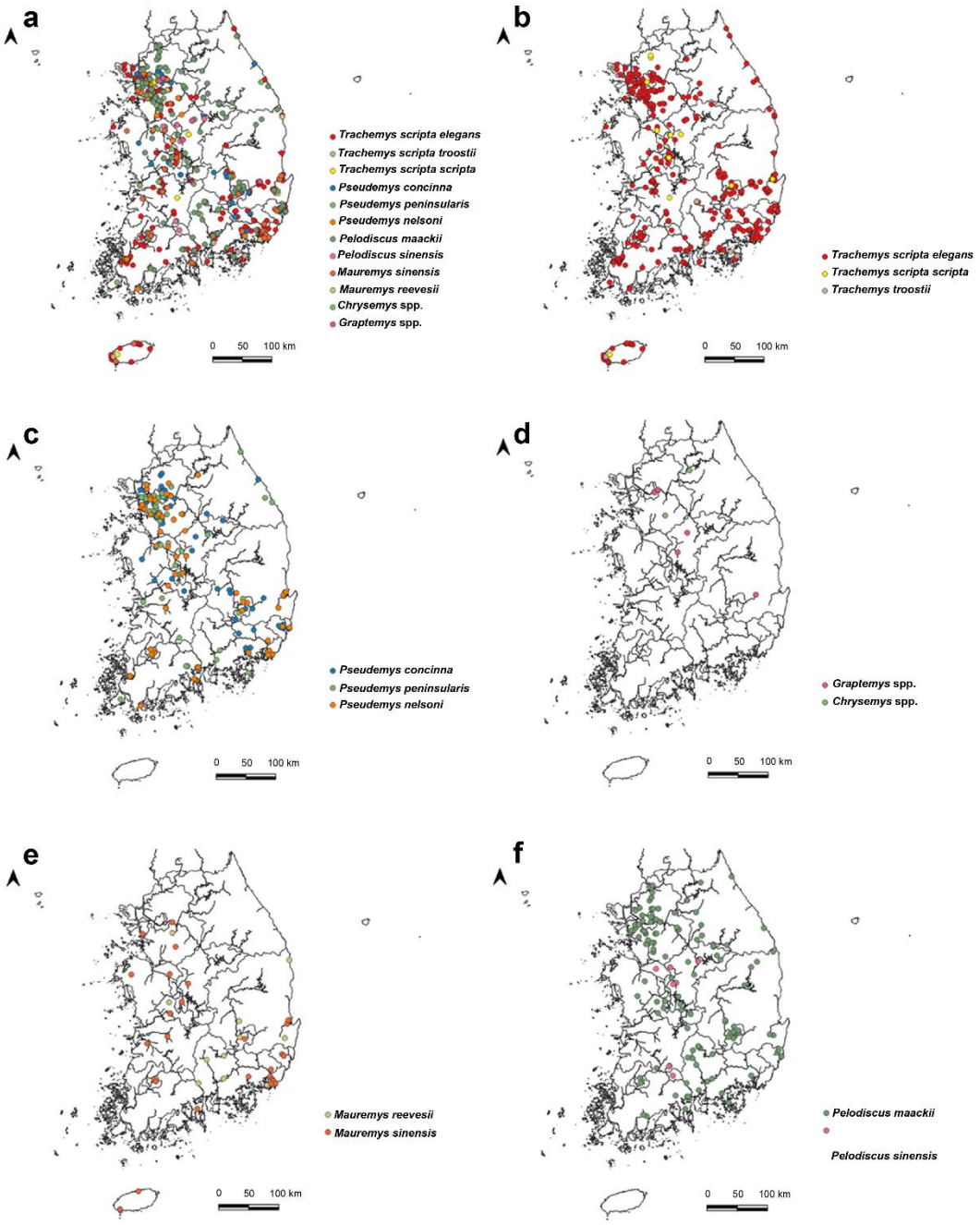

Figure 1. Distribution status of turtle species confirmed from 2014 to 2021. a) all turtles; b) *Trachemys scripta*; c) *Pseudemys* spp.; d) *Mauremys* spp.; e) *Pelodiscus* spp.; f) *Graptemys* spp. and *Chrysemys* spp.

Table 1. Current status of alien turtles identified in South Korea from 2014 to 2021.

Species	Individuals	Points (cities)	Designation
Trachemys scripta	1,440 (66%)	295 (103)	Invasive alien species
1-1. Trachemys scripta elegans	1,360 (63%)	280 (100)	Invasive alien species
1-2. Trachemys scripta scripta	58 (3%)	40 (26)	Invasive alien species
1-3. Trachemys scripta troostii	22 (1%)	12 (10)	Invasive alien species
Pseudemys concinna	371 (17%)	124 (64)	Invasive alien species
Pseudemys nelsoni	136 (6%)	57 (36)	Invasive alien species
Pseudemys peninsularis	164 (8%)	80 (43)	

Mauremys sinensis	45 (2%)	29 (19)	Invasive alien species
Chrysemys picta picta	1	1 (1)	
Chrysemys dorsalis	1	1 (1)	
Graptemys pseudogeographica	3	3 (3)	
Graptemys ouachitensis	2	2 (2)	
Pelodiscus sinensis	11	7 (6)	
Total	2,174	341 (109)	

Data were provided by NIE ECObank, http://doi.or.kr/10.22756/ASD.20220000000812.

Among the *T. scripta* subspecies, *T. s. elegans* were overwhelmingly abundant and their habitats were widely distributed in South Korea, from artificially created urban ecological parks to reservoirs and rivers located in natural ecosystems, excluding some island areas such as Ulleungdo and Dokdo.

3.2. Sales status of turtles in traditional markets

Sales of 11 alien turtle species (T. scripta, Pseudemys concinna, P. nelsoni, P. peninsularis, M. sinensis, P. sinensis, C. picta, Sternotherus carinatus, Kinosternon subrubrum, Emydura subglobosa, and M. reevesii) were confirmed in nine traditional markets nationwide (Table 2).

Table 2. Status of alien turtles sold in traditional markets in 2022.

Market	Species	Carapace length (cm)	Price ($)	Individuals sold
Cheonggyecheon	*Pseudemys peninsularis*	5–10	-	100↑
(Seoul Metropolitan)	*Chrysemys picta picta*	5–10	-	100↑
	Kinosternon subrubrum	5–10	-	50↑
Moran Market	*Trachemys scripta elegans*	30↑	39–118	5
(Seongnam-si)	*Trachemys scripta scripta*	20	39	1
	Pseudemys concinna	-	39–118	6
	Pseudemys peninsularis	20–40	39–118	3
Jayu Market	*Trachemys scripta elegans*	20–40	-	12
(Mokpo-si)				
Jayang Market	*Pelodiscus sinensis*	20–40	39–118	4
(Gyeongsan-si)				
Chilseong Market	*Pelodiscus sinensis*	20–40	11–15	20
(Daegu Metropolitan)				
Seomun Market	*Pseudemys concinna*	20–30	31–39	2
(Daegu Metropolitan)	*Mauremys sinensis*	20–30	31–39	2
	Chrysemys picta bellii	5–10	19	40
	Sternotherus carinatus	15	31–39	1
	Emydura subglobosa	15	31–39	1
Gwanmun Market	*Trachemys scripta elegans*	20–40	31–39	10
(Daegu Metropolitan)	*Pseudemys concinna*	20–40	23–39	5
	Pseudemys nelsoni	20–40	23–39	2
	Mauremys sinensis	20–40	23–39	1
	Pelodiscus sinensis	20–40	23–39	15
	Trachemys scripta elegans	5–20↑	11–15	36

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Bujeon Market	*Pseudemys concinna*	15	11	1
(Busan Metropolitan)	*Mauremys sinensis*	-	15	6
	Mauremys maackii	-	15	1
	Pelodiscus sinensis	-	31/kg	80
	Sternotherus carinatus	5	7	1
Dongnae Market	*Trachemys scripta elegans*	20–30	-	5
(Busan Metropolitan)	*Pseudemys concinna*	20	-	1

- indicates data not recorded.

By identifying the trade status by species and focusing on invasive alien species, 69 *T. scripta* individuals were identified in five traditional markets; their carapace lengths ranged from 5 to 40 cm and prices ranged from $11 to $118. Fifteen *P. concinna* individuals were identified in five traditional markets; their carapace lengths ranged from 15 to 40 cm and prices ranged from $11 to $118, similar to those of *T. scripta*. Two *P. nelsoni* individuals were identified in one market; their carapace lengths ranged from 20 to 40 cm and prices ranged from $23 to $39. Nine *M. sinensis* individuals were identified in three markets; their carapace lengths ranged from 20 to 40 cm and prices ranged from $15 to $39. In addition, the trade of *M. reveesii*, which is designated an endangered species and natural monument, was confirmed. In the case of invasive turtles, the price was determined according to the size of the carapace length: the larger the carapace, the higher the transaction price.

3.3. Management status of abandoned and lost turtles

To understand the current status of lost turtles, freshwater turtles registered in the animal protection management system (https://www.animal.go.kr/) for approximately three years (from December 1, 2019 to December 19, 2022), were 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 registered photographs, the species of 142 cases were identified and 27 cases remained unidentified. The identified species were *T. scripta*, *P. concinna*, *P. nelsoni*, *Pseudemys peninsularis*, *M. sinensis*, *Chrysemys* spp., *S. carinatus*, *Pelomedusa subrufa*, *Podocnemis unifilis*, *Carettochelys insculpta*, *P. maackii*, and *C. serpentina* (Table 3). To determine the reuse status of all abandoned turtles, euthanasia and natural death were excluded, and adoption, release, return, donation, and announcement 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 announcement. Reuse status by adoption was significantly higher than other cases with an average of 7.1 cases (χ^2=26.928, p <0.001).

Table 3. Status of abandoned and lost alien turtles identified from 2019 to 2022 in South Korea.

Species	Adoption	Release	Return	Donation	Announced	Total	Kruskal-Wallis H	*p*-value
Trachemys scripta	29	1		2	2	34		
1-1. Trachemys scripta elegans	21	1		2	2	26		
1-2. Trachemys scripta scripta	6					6		
1-3. Trachemys scripta troostii	2					2		
Pseudemys concinna	4					4		
Pseudemys nelsoni	4	1			1	6		
Pseudemys peninsularis	20	3	1	1		25		
Mauremys sinensis	4					4		
Chrysemys spp.								
Sternotherus carinatus	1					1		
Podocnemis unifilis	1					1		
Pelomedusa subrufa	1					1		
Carettochelys insculpta				1		1		
Pelodiscus maackii	1	4				5		
Chelydra serpentina	8		1	2		11		

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Unidentified	11	1	1	2	15		
Total cases	7.1 ± 2.2	0.6 ± 0.3	0.2 ± 0.1	0.6 ± 0.2	0.4 ± 0.2	8.9 ± 2.6	26.928	<0.001

T. 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 two 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, including one release, two donations, and two announcements. Only 10 cases of euthanasia and 8 cases of natural death were found, confirming that 65% of the *T. scripta* was reused.

As a result of searching for records of turtles released for religious purposes, a total of 6 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 [22–27]. 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.

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 $12,784,022 worth of turtles were imported from 63 countries over the past 21 years (2002–2022) (Table 4). Since 2002, the overall volume of imports decreased, whereas the number of imports and countries from which the imports came steadily increased, with an average of 20 importing countries (Table 5, Figure 2).

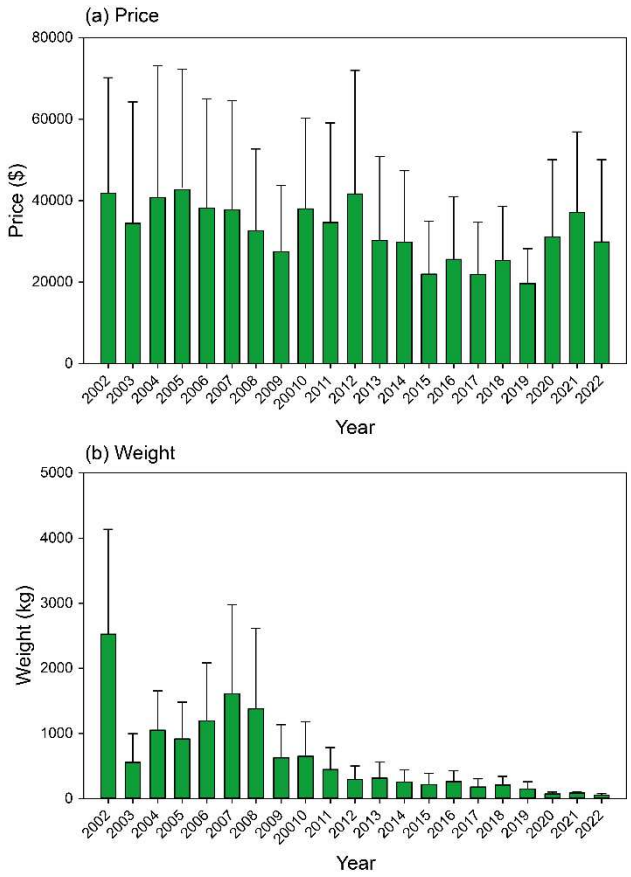

Figure 2. Import status of alien turtles from 2002 to 2022, South Korea. (a) Price, (b) Weight. Values are means ± standard errors.

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Table 4. Current import status of alien turtles into South Korea from 2002 to 2022.

Continent	Country	Year	Price ($)	Weight (kg)
		02030405060708091011121314151617181920212 2		
Africa	Zambia	○○○○○○○○○○○○○○○○○○○	224,913 (14,994 ± 2,393)	1,458.5 (97.2 ± 20.5)
	Kenya	○○○○○○○○○○	103,923 (11,547 ± 1,830)	490.5 (54.5 ± 23.6)
	Seychelles	○ ○ ○○○ ○○	71,784 (10,255 ± 5,130)	327.0 (46.7 ± 28.3)
	Sudan	○○○○ ○○○○○	54,476 (6,053 ± 2,193)	2,170.0 (241.1 ± 41.3)
	Mauritius	○○○ ○○	48,584 (9,717 ± 4,443)	68.8 (13.8 ± 4.0)
	Ghana	○○ ○ ○○ ○○	33,342 (4,763 ± 1,420)	229.0 (32.7 ± 8.2)
	Togo	○○○○○○○○○○	30,591 (3,399 ± 816)	628.2 (69.8 ± 14.0)
	Egypt	○ ○ ○ ○ ○	26,634 (5,327 ± 3,640)	344.0 (68.8 ± 34.1)
	Tanzania	○○○○ ○○○	23,827 (3,404 ± 881)	81.0 (11.6 ± 5.8)
	Republic of South Africa	○○○○○	21,551 (4,310 ± 2,181)	47.6 (9.5 ± 6.4)
	Sierra Leone	○	19,015	30.0
	Nigeria	○ ○○ ○	6,997 (1,749 ± 998)	68.0 (17.0 ± 8.6)
	Congo	○ ○○	5,998 (1,999 ± 1,433)	27.1 (9.0 ± 8.5)
	Mali	○ ○	3,434 (1,717 ± 717)	125.0 (62.5 ± 57.5)
	Benin	○○ ○ ○○	2,821 (564 ± 265)	17.0 (3.4 ± 0.7)
	Cameroon	○	680	15.0
Asia	China	○ ○○○○○○○○○○○○○○○○○○○	903,739 (45,187 ± 4,099)	110,691.8 (5,534.6 ± 890.2)
	Hong Kong	○ ○○○○ ○○○○○○○○○○	770,410 (48,151 ± 9,205)	2,676.6 (167.3 ± 34.4)
	Taiwan	○○○○○○○○○○○○○○○○○○○	510,995 (26,894 ± 4,022)	2,272.4 (119.6 ± 34.3)
	Uzbekistan	○○○○○○○○	235,952 (29,494 ± 8,146)	723.8 (90.5 ± 24.8)
	Indonesia	○○○○○○○○○○○○○○○○○○○	82,022 (3,906 ± 728)	1,283.7 (61.1 ± 21.0)
	Singapore	○○ ○ ○ ○	54,119 (10,824 ± 8,952)	2,079.5 (415.9 ± 374.0)
	Japan	○ ○○○○○○○○○○ ○	30,936 (2,578 ± 1,198)	238.5 (19.9 ± 15.1)
	Thailand	○○○○○○○○○○○○○○○ ○○	30,866 (1,816 ± 485)	661.1 (38.9 ± 17.2)
	Malaysia	○ ○ ○○○ ○	17,774 (2,962 ± 2,136)	297.0 (49.5 ± 23.8)
	India	○	1,629	10.0
	Vietnam	○ ○	1,439 (720 ± 531)	6.0 (3.0 ± 2.0)
	Sri Lanka	○	130	0.0
	Philippines	○	113	4.0
Europe	Germany	○○○○○○○○○○○○○	310,558 (25,880 ± 3,920)	135.3 (11.3 ± 1.5)
	Slovenia	○ ○ ○○○○○○	212,837 (26,605 ± 6,425)	656.3 (82.0 ± 18.1)
	Italy	○○○○○○○○○○○○	188,698 (17,154 ± 4,286)	168.8 (15.3 ± 5.3)
	France	○ ○ ○○○○○○○	59,718 (6,635 ± 2,159)	36.7 (4.1 ± 2.1)
	Ukraine	○○○○○○○○	52,728 (6,591 ± 1,317)	127.0 (15.9 ± 3.6)

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	United Kingdom	○○○○○	31,096 (6,219 ± 2,401)	10.7 (2.1 ± 1.3)
	Macedonia	○○○ ○○	27,554 (5,511 ± 1,158)	54.0 (10.8 ± 4.7)
	Netherlands	○○○○○○○○○○	22,691 (2,269 ± 853)	130.5 (13.1 ± 6.9)
	Spain	○ ○○○	15,474 (3,869 ± 2,218)	10.0 (2.5 ± 1.1)
	Croatia	○	6,172	2.0
	Czech	○○○○	5,173 (1,293 ± 723)	14.5 (3.6 ± 1.4)
	Belgium	○	1,287	1.0
	Slovakia	○○	1,230 (615 ± 50)	10.5 (5.3 ± 2.8)
	Poland	○	440	0.4
	Iceland	○	110	1.0
Middle East	Jordan	○ ○○ ○○○○ ○○○○	57,323 (5,211 ± 947)	476.1 (43.3 ± 16.6)
	Syria	○ ○	19,700 (9,850 ± 8,350)	205.0 (102.5 ± 62.5)
	Türkiye	○○	13,650 (6,825 ± 872)	4.0 (2.0 ± 0.0)
	Kuwait	○ ○○	13,289 (4,430 ± 396)	90.0 (30.0 ± 10.4)
	Saudi Arabia	○	3,000	12.0
North America	United States of America	○○○○○○○○○○○○○○○○○○○○	7,978,493 (379,928 ± 32,283)	±31,474.8 (1,498.8 ± 368.5)
	Canada	○○○ ○○ ○○○○○○	32,898 (2,991 ± 963)	102.0 (9.3 ± 2.2)
	Belize	○	1,810	7.0
South America	El Salvador	○ ○○○○○○○ ○ ○○	135,553 (12,323 ± 2,432)	358.2 (32.6 ± 9.5)
	Brazil	○ ○ ○○○○○○○○	94,109 (9,411 ± 3,556)	172.2 (17.2 ± 4.6)
	Colombia	○ ○○○○	78,494 (15,699 ± 7,658)	160.3 (32.1 ± 11.9)
	Mexico	○○○○○	33,287 (6,657 ± 4,136)	57.3 (11.5 ± 7.3)
	Peru	○ ○ ○ ○ ○○	20,530 (3,422 ± 1,060)	30.0 (5.0 ± 1.8)
	Uruguay	○○ ○ ○ ○	13,109 (2,622 ± 589)	20.1 (4.0 ± 1.4)
	Suriname	○ ○○○○○○○○○	10,000 (1,000 ± 231)	31.1 (3.1 ± 2.2)
	Guyana	○ ○○○○ ○	7,705 (1,284 ± 353)	46.6 (7.8 ± 5.5)
	Barbados	○ ○ ○	6,636 (2,212 ± 564)	24.0 (8.0 ± 4.0)
	Venezuela	○○ ○○	5,239 (1,310 ± 553)	4.2 (1.1 ± 0.6)
	Nicaragua	○○○○○○○○	4,737 (592 ± 235)	20.7 (2.6 ± 0.9)

○ indicates that imports were made in the corresponding country in the relevant year. Values are total and numbers in parentheses indicate means ± standard errors.

Table 5. Import status of alien turtles from 2002 to 2022.

Year	Country	Price ($)	Weight (kg)
2002	5	208,846	12,620
2003	6	205,691	3,329
2004	7	285,471	7,356
2005	7	298,998	6,406
2006	8	304,912	9,556
2007	10	377,421	16,064

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2008	13	423,538	17,922
2009	17	465,876	10,588
2010	15	570,234	9,736
2011	18	623,751	8,002
2012	20	833,614	5,952
2013	24	724,737	7,533
2014	26	775,223	6,611
2015	30	659,849	6,528
2016	36	920,438	9,440
2017	35	762,864	6,181
2018	32	810,020	6,512
2019	34	668,850	5,115
2020	28	869,089	2,031
2021	32	1,187,869	2,768
2022	23	806,731	1,473

In 2016, imports were made from 36 countries (Table 5, Figure 2). Continental imports included Africa (16 countries), Asia (13 countries), Europe (15 countries), Central Asia (5 countries), North America (3 countries), and South America (11 countries). Asia provided the largest volume of imports, which was approximately three times higher than that of North America, whereas North America had the highest import value, which was approximately 3.5 times higher than that of Asia (Figures 3 and 4).

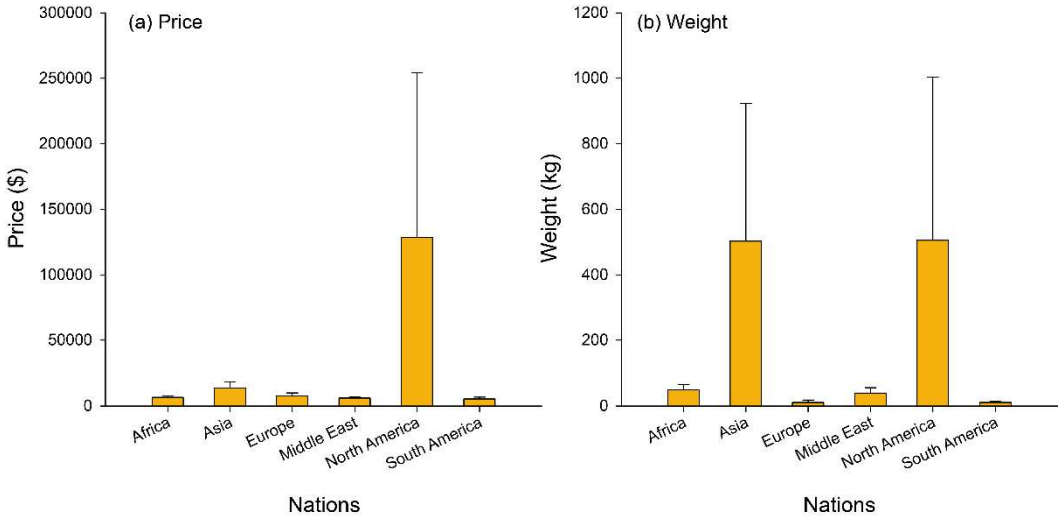

Figure 3. Alien turtle imports by continent from 2005 to 2022. (a) Price, (b) Weight. Values are means ± standard errors.

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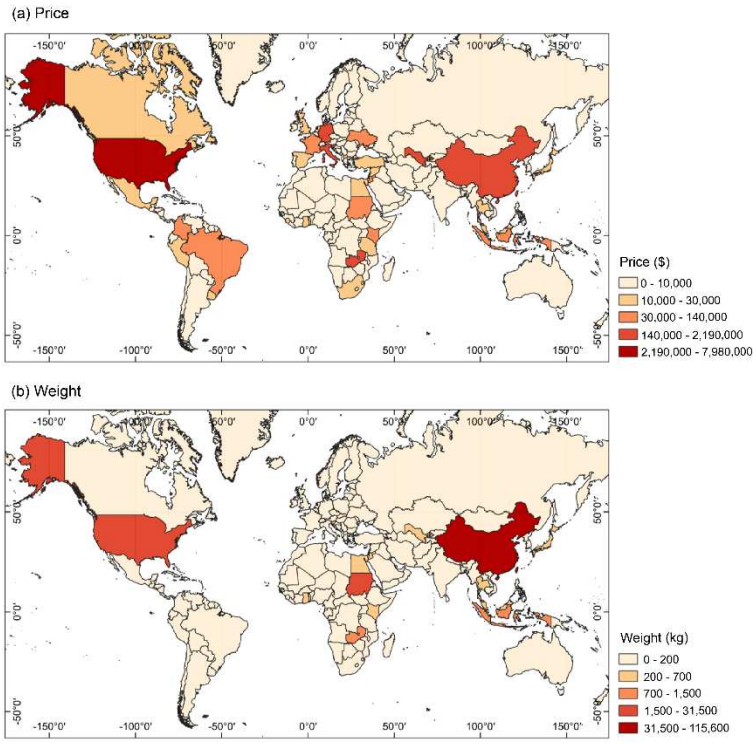

Figure 4. Alien turtle imports by continent from 2005 to 2022. (a) Price, (b) Weight.

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 reuse status of the invasive alien species *T. scripta*. 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 1,360 *T. scripta* individuals were identified in 103 cities (295 sites), which accounted for most of the discovered alien turtles. *T. 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 the DNA analysis to confirm the success breeding of *T. scripta* we confirmed the successful establishment and spread of *T. scripta* since their introduction to South Korea in 1970.

Since the *T. scripta* was designated as an invasive alien species in 2001, five species of alien turtles were additionally designated as ecosystem disturbing organisms. If an alien turtle species is designated as invasive, 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 [19]. In addition, because the application period is limited to six months after an alien species is designated as invasive, existing breeders are often unaware of this program owing to a lack of publicity. Moreover, it was confirmed that turtles who had difficulties in breeding were abandoned in nature after they had been designated as an invasive alien species. Additionally, as application for this breeding program is only possible via mail, turtles could be abandoned owing to the hassle of registration. The abandonment of invasive turtles accounted for 61% of all alien turtles (Table 3); after being designated as an invasive alien species, it has been revealed that the observation of the species has remarkably increased from the following year [Koo et al. unpublished].

The eradication of invasive alien species is voluntarily carried out by the Ministry of Environment, local governments, and environmental organizations. However, because there is no considerable regulation on the post-processing system, it is difficult to confirm the exact post-processing unless the Ministry of Environment independently conducts a removal event. Regarding

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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 invasive alien species 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. 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 invasive alien turtles, 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 announcement) 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 5, Figure 2). The total monetary value of these imports is inversely proportional to the trade of 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 price ranged from $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 [11,12,28] and in South Korea, alien turtles found in the natural ecosystem are large freshwater turtles with low selling prices. Among them, the observed rate of invasive alien turtles disturbing the ecosystem was remarkably high (92%), and *T. scripta* turtles were the most frequently identified (66%) (Table 1). Similar results were observed in turtles sold in traditional markets or lost owing to abandonment. In this study, it was confirmed that the types of turtles sold online vary by season and are traded in various ways, such as being sold at officially registered stores only when the quantity is received in a guerrilla way. Therefore, it is impossible to determine the exact import purpose, species, and quantity of turtles imported and distributed in South Korea, and revision of the import registration system is required to clearly identify the use and quantity of turtles.

This study confirmed that a notable number of *T. scripta* are adopted and reused in traditional markets. Going forward, the following should be considered: 1) To prevent the reuse of captured *T. scripta* and other invasive alien turtles through traditional markets and animal protection systems, the eradication project of invasive alien species should be post-processed in the form of purchases by the Ministry of Environment. 2) The accuracy of initial species identification for abandoned and lost exotic turtles should be improved and the results should be shared with research institutes and private experts to prevent missing cases. 3) In the case of additional invasive alien species designation, active publicity is required, such as actively publicizing additional designation notices of invasive alien species and distributing related brochures to each online/physical pet shop. 4) Finally, efforts should be made to reduce the rate of abandoned turtles by changing the application of existing breeders to an online, rather than postal, application system, and by extending the application period to up to one year. The current post-management strategies of invasive alien species are insufficient; therefore, the Ministry of Environment, local governments, and research institutes must cooperate to develop suitable monitoring and follow-up management plans for invasive alien species.

5. Conclusions

This study examined the domestic reuse of *T. scripta* from 2002 to 2022, after it had been designated an invasive alien species. The reuse of a considerable number of *T. scripta* and other invasive alien turtles was confirmed through the analysis of traditional markets and sales announcements of abandoned or lost animals. Thereby, the gravity and importance of invasive alien species management, after their designation as such, was revealed. To compensate for this, measures have been proposed for an efficient follow-up management system for alien turtles that have been designated and announced as invasive. The crucial information elucidated in this study could be used to guide future national policies. However, since this study could not identify the source of the *T. scripta* that were sold in traditional markets, it could not suggest a solution to this fundamental problem that could block supply and demand. Therefore, future research and investigations related to this issue are essential.

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References

1. Thomson SA. Turtles of the world: annotated checklist and atlas of taxonomy, synonymy, distribution, and conservation status. Phyllomedusa. *J. Herpetol.* **2021**, *20*(2):225–228.
2. Lovich JE, Ennen JR, Agha M, Gibbons JW. Where have all the turtles gone, and why does it matter? *BioScience* **2018**, *68*:771–781.
3. Stanford CB, Rhodin AGJ, van Dijk PP, Horne BD, Blanck T, Goode EV, Hudson R, Mittermeier RA, Currylow A, Eisemberg C, Frankel M, Georges A, Gibbons PM, Juvik JO, Kuchling G, Luiselli L, Haitao S, Singh S, Walde A (2018) Turtles in trouble: The world's 25+ most endangered tortoises and freshwater turtles-2018. Turtle Conservation Coalition, Hemlock Printers, Canada.
4. Kraus F (2009) Alien reptiles and amphibians: a scientific compendium and analysis. Springer, Dordrecht.
5. Garber SD, Burger J. A 20-yr study documenting the relationship between turtle decline and human recreation. *Ecol. Appl.* **1995**, *5*:1151–1162. https://doi.org/10.2307/2269362
6. National Institute of Ecology (2022) Monitoring of Invasive Alien Species Designated by the Act on the Conservation and Use of Biological Diversity (VI). Ministry of Environment: Seocheon, Korea, pp 61–69.
7. National Institute of Ecology (2021) Investigation Ecological Risk of Alien Species. Ministry of Environment: Seocheon, Korea, pp 93–113.
8. National Institute of Ecology (2019) Monitoring of Invasive Alien Species Designated by the Act on the Conservation and Use of Biological Diversity (VI). Ministry of Environment: Seocheon, Korea, pp 61–69.
9. Roy HE, Rabitsch W, Scalera R (2018). Study on invasive alien species–development of risk assessments to tackle priority species and enhance prevention. Final report. https://op.europa.eu/en/publication-detail/-/publication/c01568d9-025e-11e8-b8f5-01aa75ed71a1/language-en. Accessed 13 December, 2022

10. Ramsay NF, Ng PKA, O'Riordan RM, Chou LM (2007) The red-eared slider (*Trachemys scripta elegans*) in Asia: a review. In: Gherardi F (ed) Biological invaders in inland waters: Profiles, distribution, and threats. Springer, Dordrecht, pp 161–174.
11. Koo KS, Park HR, Choi JH, Sung HC. Present status of non-native amphibians and reptiles traded in Korean online pet shop. *Korean J. Environ. Ecol.* **2020a,** *34*:106–114.
12. Koo KS, Song S, Choi JH, Sung HC. Current distribution and status of non-native freshwater turtles in the wild, Republic of Korea. *Sustainability* **2020b,** *12*:4042. https://doi.org/10.3390/su12104042
13. Tobin PC (2018) Managing invasive species. F1000Research, 7.
14. Larson DL, 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.
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.
16. Levine JM, Vilà M, D'Antonio CM, Dukes JS, Grigulis K, Lavorel S. Mechanisms underlying the impacts of exotic plant invasions. *Proc. Biol. Sci.* **2003**, *270*:775–781.
17. Wilcove DS, 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. https://doi.org/10.2307/1313420
18. Teillac-Deschamps P, Delmas V, Lorrillière R, Servais V, Cadi A, Prévot-Julliard AC (2008) Red-eared slider turtles (*Trachemy scripta elegans*) introduced to French urban wetlands. An integrated research and conservation program. Herpetological Conservation 3:535–537. https://orbi.uliege.be/bitstream/2268/28797/1/TiellacCS12.pdf Accessed 13 December 2022.
19. Kim P, Yeun S, An H, Kim SH, Lee H. Breeding status and management system improvement of *Pseudemys concinna* and *Mauremys sinensis* designated as invasive alien turtles in South Korea. *Ecology and Resilient Infrastructure* **2020**, *7*:388–395.
20. Oh HS, Hong CE. 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.
21. SPSS (2016) IBM SPSS Statistics for Windows; Version 24.0; IBM Corp.: Armonk, NY, USA.
22. Bang JH (2012) Who did the bad things to turtle and his shell??. 매일신문사. http://mnews.imaeil.com/page/view/2012061410461163218. Accessed 10 January 2023.
23. Kim HJ (2012) 'Poor release, it hurts me.' Call of the Red-eared slider. Brainworld Korea. https://www.brainmedia.co.kr/BrainTraining/9197. Accessed 10 January 2023.
24. Park JH (2016) Respect for life through release? Rather kill life. OhmyNews. http://www.ohmynews.com/NWS_Web/View/at_pg.aspx?CNTN_CD=A0002185995. Accessed 10 January 2023.
25. Park GE (2019) Named on the turtle shell with paint and release it.?... Killing, not releasing.노컷뉴스. https://www.nocutnews.co.kr/news/5263572;
26. Park YS (2020) [Camera news] Freshwater turtle abandoned in the sea with red writing on the plastron. Yonhapnews. https://www.yna.co.kr/view/AKR20200210116400062. Accessed 10 January 2023.
27. Choi HJ (2022) 'The plastron is full of people's name' Why do freshwater turtles go to sea. ilyo. https://m.ilyo.co.kr/?ac=article_view&entry_id=427395. Accessed 10 January 2023.
28. Masin S, Bonardi A, Padoa-Schioppa E, Bottoni L, Ficetola GF (2014) Risk of invasion by frequently traded freshwater turtles. Biol Invasions 16:217–231. https://doi.org/10.1007/s10530-013-0515-y