Herpetological Conservation and Biology 6(3):324–339.
Submitted: 9 September 2011; Accepted: 1 November 2011; Published: 31 December 2011.

TRADE IN NON-NATIVE AMPHIBIANS AND REPTILES IN TEXAS: LESSONS FOR BETTER MONITORING AND IMPLICATIONS FOR SPECIES INTRODUCTION

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***Abstract.*—In the United States, trade is monitored at different levels of government and state level insight requires combining federal, state, and local sources of information. Trade in wildlife and their products has implications on wild populations of species involved and introduction of non-native vertebrates, especially amphibians and reptiles, is linked to the commercial trade in these animals. We used: (1) federal databases; (2) surveys of pet owners at live animal expositions; (3) observations of sales at live animals expositions; and (4) data collected from dealers on the Internet to quantify imports, exports, and use of exotic herptiles traded in Texas. We recorded 1,192 unique taxonomic entities of amphibians and reptiles in commercial trade in Texas. A total of 949,901 live specimens were imported to Texas from 2002 to 2008. The top 16 imported taxa made up 73.36% of the trade. Internet and exposition-based trade was dominated by few species of common pets, with others represented in small numbers. Much trade persists in known invasive species and others that must have the potential to become invasive. We documented trade in 36 known invasive species, three of which are invasive in Texas. Our approach could serve as a template for assessing trade in non-native species at regional scales. Modifications to national databases would allow exports to be distinguished from re-exports, and adoption of standardized taxonomy would improve understanding of impacts of trade on species. State level management changes should be consistent across all 50 states to add continuity to laws governing non-native amphibians and reptiles kept as pets.**

Key Words.—exotic species, invasive species, LEMIS database, wildlife trade

INTRODUCTION

Trade in wildlife, including products and live specimens, is estimated to be a billion dollar industry and involved the import of more than 1.48 billion live animals to the United States between 2000 and 2006 (Smith et al. 2009). Of this startling total, amphibians and reptiles ranked third (28,084,566 specimens) and fourth (10,379,175 specimens), respectively, after fish and crustaceans. It is increasingly clear that establishment of non-native species of vertebrates, including amphibians and reptiles, is linked to the commercial trade in these animals for pets and food (Goh and O'Riordan 2007; Westphal et al. 2008; Kraus 2009). Trade in pets, skins, products, and meat poses risks to species' populations in their native range. Trade in live animals threatens ecosystems in the area where they may potentially become established as invasive species. Non-native species are introduced via a variety of methods including intentional and unintentional pathways and invasions are generally irreversible (Kraus 2009). The pet trade is often most clearly linked with the introduction of non-native species as pets fall out of favor or escape. A stark example of the impact of pet trade on an entire species assemblage is the lizard fauna of the peninsular Florida, USA, which now consists of more non-native species than native (Meshaka et al. 2004; Meshaka 2011). At least 38 non-native species of lizards, four snakes, one crocodilian, and three amphibians are established in Florida; most of these species have been linked to the pet trade (Crother et al. 2008; Kraus 2009; Meshaka 2011). In most cases, the pet trade is a direct causal factor (Enge et al. 2004). The problem is not endemic to Florida; for example, at least six species of non-native lizards are listed as established in Texas, USA (Crother et al. 2008).

When introduced, either intentionally or unintentionally, non-native amphibian and reptile species pose ecological risks to native landscapes by immediately changing the diversity and structure of native communities, and thereby impacting both common and rare species even when the non-native species are considered "benign" (Dextrase and Mandrak 2006; Elliott et al. 2010). Recent concerns regarding taxonomic homogenization have heightened concern and encourage the protection of biodiversity at a global level (Kraus 2009; Romagosa et. al. 2009). Direct documented impacts caused by non-native amphibians and reptiles include: altering fundamental properties of communities and ecosystems through predation, displacement and competition with native species, and damaging local aesthetic and economic property values (Kraus et al. 1999; Mack et al. 2000; Enge et al. 2004; Simberloff 2005; Shwiff et al. 2010). The often cited

case of the introduction of one species, the Brown Treesnake (*Boiga irregularis*), on Guam resulted in devastation of native bird and lizard fauna, enormous economic impacts, and problems for human safety and well-being (Rodda et al. 1997).

Species traded live as pets also pose a secondary risk for introduction of disease. Recent attention is being given to the problem of secondary invaders, such as ecto-parasites and fungi, which hitchhike along with species in the live animal trade. Burridge et al. (2000) reported finding non-native tick species in 91% of the establishments where non-native reptiles were housed in Florida. Two of the tick species discovered are known vectors of heartwater disease, which is lethal to deer, cattle, goats, and sheep. Chytrid fungus (*Batrachochytrium dendrobatidis*), a pathogen responsible for mass amphibian die-offs, is another example of the dangers of un-checked trade in non-native species. The fungus is thought to have originated from African Dwarf Frogs (*Hymenochirus* sp.*)* traded for decades in the medical and pet industries (Daszak et al. 1999; Raverty and Reynolds 2001). This fungus has been linked to popular pet frogs, Green Tree Frogs (*Litoria caerulea*) and poison dart frogs (*Dendrobates* spp.), which may spread the disease via the pet trade. Chytrid is now a major threat to amphibian populations globally (Pessier et al. 1999; Raverty and Reynolds 2001). African Clawed Frogs (*Xenopus laevis*), a species used in the pet trade, can be a covert carrier of ranavirus (Iridoviridae) another disease associated with pet trade implicated in amphibian declines (Pearman and Garner 2005; Robert et al. 2007).

Regulatory agencies in the USA, including Food and Drug Administration (FDA), United States Fish and Wildlife Service (USFWS), and state agencies have taken different approaches to monitoring wildlife trade. This makes it difficult to assemble a clear picture of the wildlife trade when using data from only one source. Few federal regulations govern trade of non-native reptiles and amphibians. For example, the FDA restricts the sale of all turtles < 10.2 cm (4 in) in carapace length for pets, but other uses are permitted. Therefore, restrictions derived from the FDA ban have been largely ignored by Internet and exposition vendors and hatchling turtles have persisted in the trade (Reed and Gibbons 2002). The USFWS maintains the Law Enforcement Management Information System (LEMIS), a wildlife import/export database that records all reported wildlife shipments entering or leaving the United States, and provides regular reports at a country level (USFWS. 2004. U.S. Wildlife Trade: An Overview for 1997-2003. Available from http://www.fws.gov/le/ [Accessed 1 October 2006]). However, detailed reporting at the state level is not reported by the agency, but raw data are available to the public on request. The states in the USA vary in the level of wildlife trade monitoring and regulation, and interstate commerce in specimens is not restricted. At the local scale of governance, city governments are only beginning to regulate ownership of potentially dangerous live animals such as venomous snakes.

Studies using multiple sources of information on commercial trade in reptiles and amphibians are generally lacking for specific states in the USA, including Texas. In the USA, state government is largely responsible for policies related to wildlife trade exclusive of federally and internationally protected species. Thus a study of the commercial trade in wildlife within a state can serve as a good model for understanding the trade in general as well as leading to appropriate recommendations for improved trade monitoring systems.

Texas has a long history of involvement in wildlife trade and Texas ports rank high in the number of amphibians and reptiles imported annually (USFWS 2004. *op. cit.*). The pet industry is active in Texas, with several amphibian and reptile trade shows and expositions occurring in metropolitan areas throughout the year. Thus, multiple sources of information on the commercial trade in reptiles and amphibians are available in Texas that allow a relatively thorough assessment of trade in non-native herptiles.

Our three goals in analyzing the trade in Texas were to: (1) understand the extent to which non-native species are commercially traded; (2) to gain insights into trade monitoring systems that are generally applicable; and (3) to provide recommendations specific to the commercial trade in non-native species in Texas. To better understand the commercial trade in non-native reptiles and amphibians and specifically trade in live species associated with the pet industry, we considered data from expositions, Internet sales, and data collected by USFWS. Using these sources, we determined which species were traded, and we described and quantified trends in import, export, availability, price, use, and quantities of species traded. After synthesizing results and drawing attention to significant trade patterns, we identified strengths and weaknesses of the current permitting and reporting systems used by state (Texas Parks and Wildlife Department [TPWD]) and federal (USFWS) agencies, and provide recommendations for improving monitoring of commercial trade in non-native amphibians and reptiles.

MATERIALS AND METHODS

Data collection.—We used patron/seller observations, paper surveys (written questionnaires), Internet surveys, and data requests to collect information on amphibian and reptile trade from various user groups and regulatory agencies. All surveys contained only closed-format questions. We kept surveys as simple as possible to

TABLE 1. Sources and sample sizes of amphibian and reptile trade data collected for Texas, USA 2007 through 2008.

Trade Data	Source	Sample size	Responses
Reptile and amphibian dealers	six expositions	1,406 Observations[1]	1,406
Pet owners	six expositions	587 Expo attendees[2]	560
Pet shops	Texas Department of Commerce	1,264 Shops[3]	4
Meat and seafood establishments	Texas Department of Commerce	389 Shops[4]	337
Internet dealers	www.kingsnake.com	118 Dealers[5]	118
Import and export records	USFWS LEMIS database	70,813 instances[6]	70,813

1. Observations at expositions included unique records of species, age stage, price, and vendor by date.
2. Attendees to the exposition.
3. Pet shops operating in the state of Texas.
4. Meat and seafood establishments in the state of Texas.
5. Internet dealers of reptiles and amphibians willing to ship live specimens to Texas.
6. Import and export records as reported to USFWS for specimens shipped into or out of Texas ports 2002–2008.

minimize the proportion of non-respondents and to reduce biases associated with misinterpretation (White et al. 2005). We defined non-native species as taxa that are not native to Texas. Thus, for our purposes, non-native species included those native to outside the USA as well as species that occur in the USA but are not native to Texas.

We obtained schedules of the amphibian and reptile expositions from a popular resource for hobbyists, kingsnake.com (http://www.kingsnake.com). We visited six expositions in Texas and recorded the following information: organizer, total number of vendors, species offered, life stage of animals (hatchling, pre-juvenile, juvenile, adult), origin of animals (captive bred, import, farm raised, wild caught), color morph (wild or cultivar) of animals, and price of animals. Sample sizes varied from each source (Table 1).

To characterize species sought by hobbyists, we presented a written questionnaire to the public attending herpetological expositions. The questionnaire included the following questions: "Do you keep any reptiles or amphibians?"; "What species are your pets?"; "Which type of amphibian is your favorite?"; "Which type of reptile is your favorite?"; "How many expos do you visit per year?"; and "Where do you usually purchase your reptiles and/or amphibians and supplies?". We set up a table at expositions and solicited survey responses from patrons leaving the show. Respondents were handed a clipboard with the paper survey and allowed to complete it on their own. At each exposition, the same person (Heather Prestridge) conducted surveys to avoid bias created by different interviewers. To calculate the response rate, the number of non-respondents was recorded. As an incentive and gesture of goodwill, a summary of this information was given to the organizers of the expositions.

We created Internet-based surveys using SurveyMonkey.com to sample pet shops operating in Texas. We used IP addresses to identify and avoid double submission. We obtained pet shop addresses and phone numbers through the Texas Department of Commerce (TDC). Whether the shops sold live reptiles or amphibians was determined via phone calls. We sent an e-mail to the owner with a link directing them to the online survey. The online survey asked: "In what city does your shop operate?"; "What species do you have?"; "What age are they?"; "Price per animal?"; "What is the origin of the animals?"; "Do you ship live amphibians and reptiles to customers?"; and "If so, where (within Texas, United States, internationally)?".

Meat, fish, and seafood establishment contact information was obtained from the TDC. Short telephone surveys were conducted for stores located in Texas counties with > 100,000 residents. Following Ceballos (2001), we asked these questions: "Do you have turtle, snake, or frog meat for sale?"; "What type of meat do you have?"; "Where does it come from?"; and "How much is a pound of meat?". A sole interviewer conducted all phone surveys for this group, eliminating interviewer bias (White et al. 2005).

We visited individual websites of amphibian and reptile dealers and, if it was verified that a business would ship live amphibians and reptiles to Texas, the following data were recorded: location of Internet dealer home office; list of species available through Internet trade; life stage of species for sale (hatchling, juvenile, adult); color morph (wild or cultivar); price; and species source (wild vs. captive).

We used the USFWS LEMIS database to obtain the following data for 2002 through 2008: import and export records for all amphibians and reptiles entering or exiting Texas: species, quantity, wildlife description code, country of origin or destination, shipment date, port of entry/exit, purpose of shipment (scientific, trade, personal, zoological), and US exporter/importer name. We sorted the records to show data for live, non-native specimens entering commercial trade.

Taxonomy and nomenclature.—Taxonomy and nomenclature are hopelessly confused in wildlife trade

databases and among user groups. In the pet trade, taxonomic revisions are embraced or ignored seemingly independent of the primary literature. Taxonomic confusion, use of subspecies, and identification only to level of genus results in multiple database entries for the same species. Because animals were identified to overlapping taxonomic levels (i.e., genus, species, and subspecies) it was, unfortunately, impossible to determine precisely how many species appeared in trade. Some shipments are listed to genus only, and many genera contain species that are not listed in other shipments in the database. To address these problems, we standardized all taxonomy using The Reptile Database (Uetz, P. et al. 2006. The Reptile Database. Available from http://reptile-database.org/ [Accessed 21 October 2006]) and AmphibiaWeb (AmphibiaWeb. 2006. Information on Amphibian Biology and Conservation. Berkeley California. Available from http://amphibiaweb.org/ [Accessed 16 November 2006]).

Because these problems make it impossible to know which species of certain genera were traded, we counted taxa using two criteria. First, for specimens listed by genus only, the genus was counted as a taxonomic entity if all species in that genus did not appear elsewhere in the database. For example, five species of *Thamnophis* snakes were recorded in the trade out of 31 recognized species in the genus. Therefore, any record identified only as *Thamnophis* sp. was counted as a single taxonomic entity, leading us to report six taxonomic entities for *Thamnophis*. Secondly, when subspecies were reported, we counted subspecies as taxonomic entities because we wanted to document subspecies in trade that were not native to Texas. As in the first criterion above, when not all known subspecies were reported in the database, we considered reports to species-level another taxonomic entity. For example, we counted *Thamnophis sauritus* ssp. and *Thamnophis sauritus sauritus* as two taxonomic entities, because there are three recognized subspecies of *T. sauritus*. We would not have counted *T. sauritus* as a taxonomic entity if all three subspecies had been listed because it obviously would represent one of the subspecies already counted.

These criteria may bias the number of entities positively or negatively. If no other members of the genera or subspecies were actually traded, the number would be inflated by one. However, if several species or subspecies were traded but reported only to genus or species, the number would underestimate the total number of taxonomic entities in the trade. In the case of *Thamnophis*, there could have been more than six species traded. Because so many records are reported only to genus, and many known subspecies are not reported, these criteria may underestimate the actual number of taxa in the trade.

Some wildlife description codes do not represent one actual specimen; the LEMIS database reports numbers of parts of animals and it is unknown how many individual animals were used for a particular product like a boot or handbag. For example, an entry with the wildlife description code for leather product (LPS) may consist of parts from one animal, parts from several different individuals, or one individual could make up several LPS entries. Additionally animal parts may have come from a wild animal or one bred in captivity, but this is impossible to determine from LEMIS records. Therefore, we report results as instances of import or export, rather than number of individual animals in the trade. This underestimates the total number of animals in most cases because many products use multiple animals, and few individual reptiles and amphibians can be used to make multiple products.

RESULTS

Taxonomic entities in the trade.—We recorded 77 families and 1,192 taxonomic entities of non-native reptiles and amphibians involved in the commercial trade in Texas (Table 2). We were able to confirm a minimum of 877 species in the trade: 187 amphibians, 337 lizards, 242 snakes, 100 turtles, and 11 crocodilians. An additional 60, 92, 52, 18, and two genera of these groups, respectively, were reported at a higher taxonomic level that may or may not represent additional species. Lizards primarily consisted of representatives of Gekkonidae (geckos), Agamidae (agamas), Scincidae (skinks), and Chamaeleonidae (chameleons) with 180, 45, 36, and 24 taxa, respectively, with 52 entities belonging to other families. Both non-venomous and venomous snakes were traded. Common non-venomous snakes were primarily in the Colubridae and Boiidae with 183 and 77 taxa, respectively. A total of 68 viperids (pit vipers), 30 elapids (cobras and coral snakes), six hydrophiids (sea snakes), were recorded in the commercial trade. The frog family, Hylidae, was the most numerous amphibian family in the trade with 35 taxa, followed by salamanders in the family Salamandridae with 24 taxa. Other frog families in the

TABLE 2. Tallies of non-native reptile and amphibian taxa involved in the commercial wildlife trade in Texas, USA during 2002–2008.

	Amphibians	Lizards	Snakes	Turtles	Crocodilians	Total
Families	32	21	12	10	2	77
Taxonomic entities in trade	247	429	373	129	14	1192

TABLE 3. Instances of non-native amphibians and reptiles or products made from non-native amphibians and reptiles imported or exported through Texas, USA ports by taxonomic category 2002–2008. Source: USFWS LEMIS database.

Group	2002	2003	2004	2005	2006	2007	2008	Total
Imports								
Anura	270,760	152,871	77,114	122,996	329,012	624,268	32,199	1,609,220
Caudata	228	3,276	3,702	4,080	5,730	3,232	77	20,325
Crocodylia	159,659	178,766	184,195	220,095	213,520	61,283	190,497	1,208,015
Sauria	601,090	479,248	430,188	489,538	413,743	522,621	341,574	3,278,002
Serpentes	67,601	110,790	73,656	112,008	103,493	79,873	91,358	638,779
Testudines	3,490	5,803	34,580	4,248	2,944	3,644	1,636	56,345
Total	*1,102,828*	*930,754*	*803,435*	*952,965*	*1,068,442*	*1,294,921*	*657,341*	*6,810,686*
Exports								
Anura	16,454	17,506	36,438	34,308	38,122	43,459	26,997	213,284
Caudata	1,562	710	2,142	2,620	4,842	8,310	375	20,561
Crocodylia	14,210	13,224	9,314	17,225	15,945	9,457	8,282	87,657
Sauria	136,818	38,519	58,888	110,030	107,598	68,999	81,519	602,371
Serpentes	16,632	27,123	26,014	30,585	21,460	12,168	9,363	143,345
Testudines	191	203	386	312	749	533	333	2,707
Total	*185,867*	*97,285*	*133,182*	*195,080*	*188,716*	*142,926*	*126,869*	*1,069,925*

trade were Dendrobatidae with 20 taxa, Bufonidae and Ranidae with 19 taxa each. Most turtle taxa in the trade belonged to three families Testudinidae (tortoises) with 30 species, Geoemydidae (Asian turtles) with 29 species, and Emydidae (pond, box, and freshwater turtles) with 23 taxa. Crocodilians in the trade included eight taxa of Alligatoridae and six taxa of Crocodylidae.

International trade.—Overall, there were roughly six times more imports than exports of amphibian and reptile products and live animals during 2002–2008, the ratio largely due to the prevalence of frogs and lizards in the trade (Table 3). Anurans and saurians together comprised 71.76% of the import trade (4,887,222 import instances), while exports of the same groups accounted for 76.23% of the total (815,655 export instances). Trade in salamanders was nearly equal when comparing imports to exports. Snake imports outnumbered exports by 495,434 (a ratio of 4.5:1.0). Imports of crocodilians numbered 1,208,015 while exports numbered only 87,657 (13.8:1.0).

Specimens entering Texas for commercial trade were summarized by wildlife description code to determine uses of animals along with relative intensity of trade across taxonomic groups (Table 4). Lizards occurred in more use categories (13) than any other group followed by crocodilians (11), and snakes (eight). It was not surprising these groups were more heavily exploited for trade because of their use for skins and food as well as for pets.

Because one of our primary goals was to detail the quantity of live specimens entering the trade, we separated data for live specimens entering the trade for commercial purposes and found a total of 949,901 live, non-native amphibian and reptile specimens entered the United States through Texas ports between 2002 and 2008 (Table 5). Anurans and saurians made up the majority of the import trade in live specimens for this period accounting for 88.16% of the total. An increase in number of anurans was apparent in 2006 and 2007 but decreased precipitously by 62.16 % in 2008. A general increase in the number of salamanders, lizards, and snakes was apparent from 2002 through 2007 but trade in these groups also decreased in 2008. The trade in imported, non-native turtles and tortoises was relatively constant during 2002–2007, but hit a seven-year low in 2008. No live crocodilians were reported as being imported. Live crocodilians are traded as pets in Texas and throughout the USA, but import of these species is regulated by Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and trade in live crocodilians appears to be entirely domestic in the USA.

We found a total of 562,378 live, non-native specimens were exported from Texas. Exports of non-natives from Texas included captive-bred specimens, but it is also possible that the majority of specimens registered as exports were actually re-exported from the state (Table 6). The LEMIS system does not identify re-exports (material imported in order to be exported somewhere else). Because of this, export data were confounded by import and re-export of the same individuals. Exports of all groups increased during 2002–2007; however, imports decreased in 2008 to their lowest levels seen in the study period. Anurans and saurians were exported in the greatest quantities and made up 88.62% of the total export of live specimens.

Although a large number of taxa were traded, relatively few accounted for the majority of trade. The top 16 taxa imported to Texas accounted for 76.36% of the total, and the top 82 made up 94.08% of all imports (Fig. 1). On average, the top 10 taxa of non-native

TABLE 4. Categories and quantities[a] of commercially traded specimens imported to Texas, USA during 2002–2008. Wildlife description codes are as follows: BOD (dead, whole animal); CAR (carving- other than bone, horn, or ivory); EGG (egg- dead or blown); GAR (garment- excluding shoe or trim); JWL (jewelry- other than ivory); LEG (frog leg); LIV (live specimen); LPL (leather product- large manufactured); LPS (leather product- small manufactured); MEA (meat); SHO (shoe- including boot); SID (side); SPR (shell product); SKI (skin- whole raw or tanned); SKP (skin piece- raw or tanned, including scraps); SKU (skull- except when part of trophy); SOU (soup); SPR (shell product); TAI (tail); TEE (teeth); TRI (trim- shoe, garment, or decorative); and UNS (unspecified). Source: USFWS LEMIS database.

Wildlife Description Code	Anura	Caudata	Sauria	Serpentes	Testudines	Crocodylia
BOD	60	70	314	23		126
CAR					2	
EGG			205		311	
GAR						439
JWL			256	1,144		239
LEG	1334 kg					
LIV	429,197	14,006	408,248	83,342	15,108	
LPL			855	12,510		8,157
LPS			124,600	369,114	1	114,271
MEA			63 kg plus 157 inds.			
SHE			1,127			
SHO	120		519,725	369,114	4	374,416
SID						2,183
SKI	1,986		632,637	110,130		270,559
SKP			1,575,785	15,109		43,233
SKU				200		7
SOU			367 kg plus 2628 inds.			
SPR			46			
TAI						135,333
TEE						1
TRI			816	755		378
UNS						2

[a]Instances listed in individual units (inds.) unless otherwise denoted.

TABLE 5. Quantities of live, non-native amphibian and reptile specimens imported to Texas, USA from 2002–2008. Source: USFWS LEMIS database.

	Import Year							
Order	2002	2003	2004	2005	2006	2007	2008	Total
Anura	16,754	21,838	31,328	48,566	126,526	133,621	50,564	429,197
Caudata	198	736	280	3,980	5,700	3,042	70	14,006
Crocodylia	0	0	0	0	0	0	0	0
Sauria	23,208	38,988	61,793	57,452	84,706	64,777	77,324	408,248
Serpentes	7,457	5,317	6,723	13,890	14,095	25,217	10,643	83,342
Testudines	2,499	2,127	2,858	1,555	2,411	2,515	1,143	15,108
Total	*50,116*	*69,006*	*102,982*	*125,443*	*233,438*	*229,172*	*139,744*	*949,901*

TABLE 6. Quantities of live, non-native amphibian and reptile specimens exported from Texas, USA during January 2002–June 2008. Source: USFWS LEMIS database.

	Export Year							
Order	2002	2003	2004	2005	2006	2007	2008	Total
Anura	16,294	17,506	36,422	34,048	38,092	41,923	26,893	211,178
Caudata	1,550	710	2,108	2,620	4,822	8,298	375	20,483
Crocodylia	0	0	0	2	6	7	32	47
Sauria	19,959	21,212	47,600	50,528	47,276	49,259	51,360	287,194
Serpentes	966	1,397	6,300	8,623	10,946	8,308	4,238	40,778
Testudines	187	203	385	312	746	533	332	2,698
Total	*38,956*	*41,028*	*92,815*	*96,133*	*101,888*	*108,328*	*83,230*	*562,378*

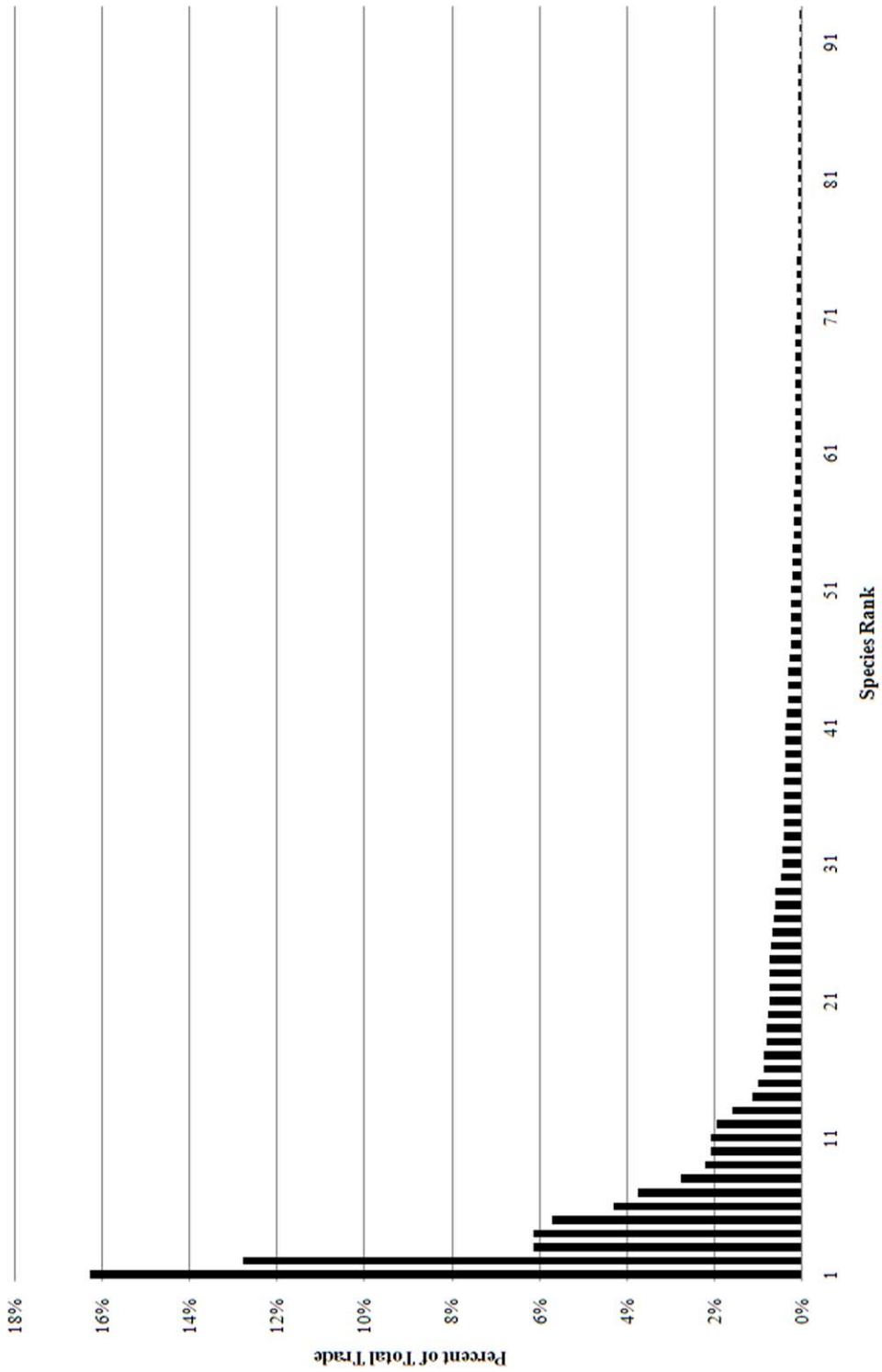

FIGURE 1. Ranked percentage of total imports of live, non-native amphibians and reptiles into Texas, USA between 2002–2008. The top 93 taxonomic entities made up 94.53% of the total imports.

TABLE 7. Frequency of occurrence (number of times the species occurred on the Top 10 list) and total number of specimens imported live for trade of the 26 species that comprised the 10 most imported, non-native amphibian and reptiles into Texas, USA each year 2002–2008. Source: USFWS LEMIS database.

Scientific Name	Common Name	Frequency of Occurrence	Total Imported
Litoria caerulea	Green Tree Frog	7	121,485
Takydromus sexlineatus	Asian Grass Lizard	6	58,517
Gehyra mutilata	Stump-tailed Gecko	5	58,295
Gekko gecko	Tokay Gecko	5	35,797
Hemidactylus sp.	Hemidactylus sp.	4	54,438
Python regius	Ball Python	4	41,075
Gekko vittatus	Lined Gecko	4	20,050
Ptychozoon kuhli	Kuhl's Flying Gecko	4	19,990
Hymenochirus curtipes	Western Clawed Frog	3	154,848
Physignathus cocincinus	Chinese Crested Dragon	3	22,962
Litoria infrafrenata	White-Lipped Treefrog	3	21,218
Agalychnis callidryas	Red Eyed Treefrog	3	18,696
Cuora amboinensis	Malayan Box Turtle	3	7,167
Polypedates leucomystax	Asian Brown Treefrog	2	15,098
Hemidactylus platyurus	Flat-tailed House Gecko	2	9,829
Python curtus	Blood Python	2	7,889
Rana erythraea	Green Paddy Frog	1	10,694
Hymenochirus sp.	African Clawed Frog	1	7,310
Hyperolius concolor	Hyperolius Concolor	1	6,840
Python reticulatus	Reticulated Python	1	7,036
Sceloporus malachiticus	Green Spiny Lizard	1	3,870
Litoria sp.	Litoria	1	2,595
Iguana iguana	Common Green Iguana	1	2,210
Basiliscus plumifrons	Green Basilisk	1	3,620
Megophrys sp.	Horned Frog	1	6,002
Varanus salvator	Common Water Monitor	1	6,545

amphibians and reptiles imported alive per year accounted for 65.84% (SD = 8.29) of the total imports (Table 7). Included in the top 10 lists were familiar pet species such as the Western Clawed Frog (*Hymenochirus curtipes*), Green Tree Frog, Ball Python (*Python regius*), and Tokay Gecko (*Gekko gecko*). Interestingly, the Asian Grass Lizard (*Takydromus sexlineatus*) appeared on the top 10 list six times.

Informal visits to large chain pet stores revealed that the lizard is available through these venues which could account for their import in such large numbers. An average of 153 (SD = 37.13) taxa per year were recorded in the LEMIS database, but only 26 taxa were in the annual top 10 imported species list for the period of the dataset. These results demonstrated that relatively few taxa were consistently traded in large quantities, even though many species were available.

FIGURE 2. States in the USA where we detected dealers of amphibians and reptiles with commercial Internet sites. Not shown are 13 international dealers that were willing to sell and ship to customers in Texas, USA.

Internet-based pet trade.—We polled 101 Internet pet dealer sites based in USA and 13 based internationally. The top three USA states housing dealers were California (21), Texas (15), and Florida (10; Fig. 2). Of the taxa available for purchase online, 72% (n = 779) were non-native. Multiple dealers offered the same taxa for sale and each time the taxa appeared for sale, we recorded it as an instance. Of all instances, 85.08% were non-native amphibian or reptile species. Snakes were the most common (55.89%), followed by lizards (28.32%), amphibians (10.42%), turtles (5.26%), and crocodilians (0.10%). A total of 42 taxa occurred more than 10 times in the dataset, echoing the trade pattern of live imported specimens (Table 8). The top ranked species, Ball Python (n = 481), ranged in price from $20 to $15,000 (n = 481). Numerous color variants of Ball Pythons were reported, and this trait drove the price of the animal. Other boas and pythons were traded online, including two subspecies of the Boa Constrictor (*Boa constrictor ssp.*; n = 187), Reticulated Python (*Broghammerus reticulatus*; n = 76), and the Burmese

TABLE 8. Popular non-native amphibian and reptile taxa traded live as pets on the Internet and prices (USD) from dealer website polls, February 2008. The species are ranked by number of instances (number of times the taxon was identified for sale as a unique item).

Common Name	Scientific Name	Instances	Minimum	Maximum	Average Price	Mode
Ball Python	*Python regius*	481	$ 20.00	$ 15,000.00	$ 1,716.54	$ 2,500.00
Leopard Gecko	*Eublepharis macularius*	198	$ 15.00	$ 5,500.00	$ 337.07	$ 100.00
Panamanian Boa	*Boa constrictor imperator*	83	$ 30.00	$ 15,000.00	$ 1,524.57	$ 100.00
Reticulated Python	*Broghammerus reticulatus*	76	$ 45.00	$ 10,000.00	$ 1,782.69	$ 2,000.00
Honduran Milksnake	*Lampropeltis triangulum hondurensis*	67	$ 35.00	$ 950.00	$ 208.08	$ 200.00
Boa Constrictor	*Boa constrictor*	56	$ 55.00	$ 7,500.00	$ 1,061.16	$ 300.00
Central Bearded Dragon	*Pogona vitticeps*	49	$ 15.00	$ 745.00	$ 195.25	$ 250.00
Red Tailed Boa	*Boa constrictor constrictor*	48	$ 45.00	$ 8,500.00	$ 1,066.98	$ 325.00
California Kingsnake	*Lampropeltis getula californiae*	47	$ 22.00	$ 200.00	$ 62.98	$ 40.00
Burmese Python	*Python molurus bivittatus*	42	$ 22.00	$ 2,300.00	$ 438.05	$ 150.00
Crested Gecko	*Rhacodactylus ciliatus*	29	$ 40.00	$ 365.00	$ 127.62	$ 75.00
Pueblan Milksnake	*Lampropeltis triangulum campbelli*	28	$ 20.00	$ 176.00	$ 64.86	$ 60.00
Nelson's Milksnake	*Lampropeltis triangulum nelsoni*	25	$ 35.00	$ 292.00	$ 101.86	$ 75.00
Green And Black Poison Dart Frog	*Dendrobates auratus*	23	$ 26.00	$ 70.00	$ 40.09	$ 30.00
Florida Kingsnake	*Lampropeltis getula floridana*	22	$ 22.00	$ 161.00	$ 76.95	$ 45.00
Bullsnake	*Pituophis catenifer*	22	$ 25.00	$ 600.00	$ 166.91	$ 145.00
Columbian Rainbow Boa	*Epicrates cenchria cenchria*	21	$ 125.00	$ 15,000.00	$ 1,620.89	$ 135.00
Rosy Boa	*Lichurana trivirgata*	21	$ 50.00	$ 3,000.00	$ 287.29	$ 100.00
Red Blood Python	*Python brongersmai*	21	$ 65.00	$ 22,500.00	$ 1,764.76	$ 65.00
Dyeing Poison Frog	*Dendrobates tinctorius*	20	$ 35.00	$ 125.00	$ 72.75	$ 50.00
Eastern Sand Boa	*Gongylophis colubrinus loveridgii*	19	$ 45.00	$ 349.00	$ 112.89	$ 55.00
Carpet Python	*Morelia spilota*	19	$ 50.00	$ 12,500.00	$ 1,800.53	$ 200.00
Red Footed Tortoise	*Chelonoidis carbonaria*	18	$ 75.00	$ 505.00	$ 204.00	$ 85.00
Sinaloan Milksnake	*Lampropeltis triangulum sinalaoe*	18	$ 25.00	$ 500.00	$ 142.65	$ 150.00
Panther Chameleon	*Pardalis pictus*	16	$ 30.00	$ 357.00	$ 251.60	$ 250.00
African Spurred Tortoise	*Geochelone sulcata*	15	$ 60.00	$ 800.00	$ 168.77	$ 65.00
Brooks' Kingsnake	*Lampropeltis getula brooksi*	15	$ 35.00	$ 700.00	$ 195.00	$ 200.00
Green Tree Python	*Morelia viridis*	15	$ 225.00	$ 1,200.00	$ 517.00	$ 325.00
Strawberry Poison Dart Frog	*Dendrobates pumilio*	14	$ 50.00	$ 325.00	$ 144.50	$ 130.00
Woma Python	*Aspidites ramasayi*	13	$ 250.00	$ 2,800.00	$ 975.55	$ 750.00
Pacman Frog	*Ceratophrys ornata*	13	$ 9.50	$ 66.00	$ 21.23	$ 15.00
Common Green Iguana	*Iguana iguana*	13	$ 7.50	$ 4,500.00	$ 367.77	$ 35.00
Savu Island Python	*Liasis mackloti*	13	$ 35.00	$ 400.00	$ 182.46	$ 250.00
Dumeril's Boa	*Acrantophis dumerili*	12	$ 115.00	$ 579.00	$ 274.45	$ 275.00
Monocled Cobra	*Naja kaouthia*	12	$ 33.00	$ 715.00	$ 344.67	$ 575.00
New Caledonia Bumpy Gecko	*Rhacodactylus auriculatus*	12	$ 60.00	$ 600.00	$ 216.58	n/a
Fat-Tailed Gecko	*Hemitheconyx caudicinctus*	11	$ 39.00	$ 700.00	$ 231.00	$ 50.00
Thayer's Kingsnake	*Lampropeltis mexicana thayeri*	11	$ 45.00	$ 850.00	$ 175.73	$ 100.00
Green Tree Frog	*Litoria caerulea*	11	$ 10.00	$ 40.00	$ 21.91	$ 20.00
Amazon Tree Boa	*Corallus hortulanus*	10	$ 20.00	$ 534.00	$ 149.33	$ 30.00
Tokay Gecko	*Gekko gecko*	10	$ 6.00	$ 48.00	$ 18.30	$ 6.00
Madagascar Day Gecko	*Phelsuma madagascariensis*	10	$ 40.00	$ 116.00	$ 71.30	n/a

Python (*Python molurus bivittatus*; n = 42). Non-native venomous snakes were traded online, but only the Monocled Cobra (*Naja kaouthia*) occurred more than 10 times. Non-native lizards traded online were primarily Leopard Geckos (*Eublepharis macularius*; n = 198) and Bearded Dragons (*Pogona vitticeps*; n = 49). Relatively few tortoises and zero non-native turtles were sold online within our dataset. The Red-footed Tortoise (*Chelonoidis carbonaria*) and African Spurred Tortoise (*Geochelone sulcata*) were the only species of testudinids with more than 10 instances. Only three anurans were commonly sold online: the Dyeing Poison Frog (*Dendrobates tinctorius*), the Strawberry Poison Dart Frog (*Dendrobates pumilio*), and Green Tree Frog *(Litoria caerulea).*

TABLE 9. The most popular non-native amphibians and reptiles traded live as pets at herpetological expositions in Texas, USA from February 2008–February 2009 with instances (number of instances that we encountered the species for sale) and price (USD). The modal price reflected better the typical market value because mean prices were often skewed by a few very expensive specimens.

Common Name	Scientific Name	Instances	Minimum	Maximum	Average Price	Mode
Ball Python	*Python regius*	196	$ 12.00	$ 25,000.00	$ 760.11	$ 500.00
Reticulated Python	*Broghammerus reticulatus*	143	$ 80.00	$ 15,000.00	$ 2,792.83	$ 2,500.00
Boa Constrictor	*Boa constrictor*	118	$ 20.00	$ 12,000.00	$ 499.21	$ 350.00
Bearded Dragon	*Pogona vitticeps*	91	$ 20.00	$ 400.00	$ 144.76	$ 175.00
Leopard Gecko	*Eublepharis macularius*	35	$ 20.00	$ 1,200.00	$ 185.51	$ 25.00
Poison Dart Frog	*Dendrobates* sp.	26	$ 40.00	$ 175.00	$ 66.54	$ 50.00
California Kingsnake	*Lampropeltis getula californiae*	25	$ 35.00	$ 125.00	$ 64.17	$ 50.00
Honduran Milksnake	*Lampropeltis triangulum hondurensis*	24	$ 55.00	$ 500.00	$ 214.58	$ 375.00
Red Footed Tortoise	*Chelonoidis carbonaria*	18	$ 15.00	$ 250.00	$ 121.39	$ 100.00
Coastal Carpet Python	*Morelia spilota*	18	$ 75.00	$ 350.00	$ 163.78	$ 125.00
Green Tree Python	*Morelia viridis*	15	$ 75.00	$ 850.00	$ 355.00	$ 375.00
Burmese Python	*Python molurus bivittatus*	14	$ 50.00	$ 1,600.00	$ 267.14	$ 85.00
Uromastyx	*Uromastyx* sp.	13	$ 35.00	$ 75.00	$ 52.31	$ 50.00
Brooks' Kingsnake	*Lampropeltis getula brooksi*	12	$ 20.00	$ 225.00	$ 90.83	$ 75.00
Savannah Monitor	*Varanus exanthematicus*	12	$ 15.00	$ 40.00	$ 24.08	$ 20.00
Argentine Black-and-White Tegu	*Tupinambis merianae*	11	$ 30.00	$ 125.00	$ 92.73	$ 125.00
Pacman Frog	*Ceratophrys ornata*	10	$ 10.00	$ 70.00	$ 26.00	$ 30.00
Thumbnail Poison Dart Frog	*Dendrobates quinquevittatus*	10	$ 50.00	$ 125.00	$ 92.00	$ 125.00
Leopard Tortoise	*Geochelone pardalis*	10	$ 95.00	$ 250.00	$ 129.00	$ 100.00
Arizona Mountain Kingsnake	*Lampropeltis pyromelana pyromelana*	10	$ 12.00	$ 350.00	$ 180.78	$ 95.00

Trade at expositions.—Amphibian and reptile expositions are public events coordinated by private individuals, trade associations, or herpetological societies. Animal breeders and pet supply merchants typically pay a fee to the organizer for the right to sell to the public in the trade show. Admission was charged to the public for every show we attended and ranged from $8 to $15. All shows were held on weekends and lasted for two days. One show was marketed as a "hot show" that included venomous reptiles for sale. A legal waiver had to be signed before entry to the venomous show. Four shows were promoted by individuals, one by the North American Reptile Breeders (NARBC), and one by the East Texas Herpetological Society (ETHS).

The top ranked species was the Ball Python (n = 196) and was marked for sale from USD $12.00 to USD $25,000.00 (Table 9). Rarity of specific color variants determined price. Other species of boas and pythons were common at expositions and included the Reticulated Python (n = 143), Boa Constrictor (n = 118), and Burmese Python (n = 14). The most common lizards at expositions were Bearded Dragons (n = 91) and Leopard Geckos (n = 35). Species of lizards attaining larger adult size available at expositions included the Savannah Monitor (*Varanus exanthematicus*) and the Argentine Black-and-White Tegu (*Tupinambis merianae*). Poison dart frogs in the genus *Dendrobates* had the greatest frequency of occurrence of all amphibians at the expositions with a total of 36 instances. Trade of all species of *Dendrobates* is restricted by CITES and most dealers remarked that their specimens were produced in captivity. Red-footed Tortoises (*Chelonoidis carbonaria*) and Leopard Tortoises (*Geochelone pardalis*) were common testudinids at expositions and sold as hatchlings.

Of the 560 survey respondents at expositions, 419 individuals reported owning at least one or more non-native herptile pet, totaling 838 (76.81% of total). Respondents listed the sources of their non-native pets as captive bred (71.24%; n = 597), unknown (17.66%; n = 148), farm reared (5.97%; n = 50), and wild caught (5.13%; n = 43). Of 419 respondents who listed non-native amphibians and reptiles as pets, 49.65% (n = 208) listed that they purchased live specimens at expos, while 36.51% (n = 153) listed they purchased the specimens at brick-and-mortar pet stores, 12.17% (n = 51) shopped online, and 1.67% (n = 7) acquired the specimens through rescue. Dry good purchases reported by respondents fell into three categories; brick-and-mortar pet shops 64.22% (n = 269), expos 18.18% (n = 76), and online 17.60% (n = 74).

We made phone calls to the 822 stores listed by the TDC as "pet store." Twenty-nine (3.53%) of the shops we contacted had live reptiles and/or amphibians for sale. This percentage may be an understated because any establishment registered as a pet store, including feed stores, grooming salons, and dry good only suppliers, were included in the TDC listing of "pet Store." An e-mail was sent to the owner of each store,

TABLE 10. Non-native species established in the continental United States (Krause 2009) documented in the commercial trade in Texas January 2002–June 2008. Trade categories include; Import (WE), Export (E), Food (F), and Pet trade (P).

	Scientific Name	Common Name	State where Established	Trade Categories
Anurans				
	Osteopilus septentrionalis	Cuban Treefrog	FL	E, P
	Xenopus laevis	African Clawed Frog	AZ, CA	E, WE, P
Lizards				
	Agama agama	African Rainbow Lizard	FL	E, WE, P
	Ameiva ameiva	Giant Ameiva	FL	E, WE
	Anolis (Norops) sagrei	Brown Anole	AL, FL, GA, LA, SC, TX	E, P
	Anolis chlorocyanus	Hispaniola Green Anole	FL	E
	Anolis equestris	Knight Anole	FL	E, P
	Aspidoscelis montaguae	Giant Whiptail	FL	E
	Basiliscus vittatus	Brown Basilisk	FL	E, WE, P
	*Calotes versicolor**	Variable Bloodsucker	FL	
	Chamaeleo calyptratus	Veiled Chameleon	FL	E, WE, P
	Chamaeleo jacksonii	Jackson's Chameleon	CA, FL	E, WE, P
	Chondrodactylus bibronii	Bibron's Sand Gecko	FL	E, WE, P
	Cnemidophorous lemniscatus	Rainbow Whiptail	FL	E
	*Ctenosaura pectinata**	Mexican Spiny-tailed Iguana	FL, TX	
	*Ctenosaura similis**	Gray's Spiny-tailed Iguana	FL	
	Cyrtopodion scabrum	Rough-tailed Gecko	TX	WE
	Gekko gecko	Tokay Gecko	FL	E, WE, P
	Hemidactylus frenatus	Common House Gecko	FL, TX	P
	Hemidactylus mabouia	Wood Slave	FL	E, WE
	Hemidactylus platyurus	Asian Flat-tailed House Gecko	FL	WE
	Hemidactylus turcicus	Mediterranean Gecko	AL, AZ, AL, CA, FL, GA, KS, LA, MD, MS, MO, NE, NM, OK, SC, TX, UT, VA	E, P
	Iguana iguana	Green Iguana	FL	E, F, WE, P
	Leiocephalus carinatus	Northern Curly-tailed Lizard	FL	E
	Leiocephalus schreibersii	Red-sided Curly-tailed Lizard	FL	E, WE
	Leiolepis belliana	Butterfly Lizard	FL	E, WE, P
	*Mabuya multifasciata**	Brown Mabuya	FL	
	Phelsuma madagascariensis	Madagascar Day Gecko	FL	P
	Tarentola annularis	Ringed Wall Gecko	FL	E, WE
	Tarentola mauritanica	Moorish Gecko	CA, FL (?)	E, WE, P
	Tupinambis merianae	Argentine Black-and-White Tegu	FL	E, WE, P
	Varanus niloticus	Nile Monitor	FL	E, WE, P
Snakes				
	Acrochordus javanicus	Javanese File Snake	FL	E, WE
	Boa constrictor	Boa Constrictor	FL	E, WE, P
	Python molurus	Indian Python	FL	WE, P
Crocodilians				
	Caiman crocodilus	Spectacled Caiman	FL	E, WE, P

* listed in USFWS LEMIS database for import, but no specific epithet is listed.

but only four respondents started the electronic survey and only two finished. It was difficult to get information from two large franchised pet stores that operated throughout the USA. Employees answering phones at their locations were not authorized to give e-mail addresses and managers were often unavailable. Both companies sell live reptiles and amphibians, but we were unable to get a representative from either corporation to complete the online survey. An annual report published online by PetSmart©, detailed that only 2% of their total net sales for 2008–2009 were generated from the sale of live pets including fish, amphibians, reptiles, and birds (PetSmart 2009. Annual Report. Available from http://phx.corporate-ir.net/ [Accessed 14 October 2010]).

Trade in established invasive species.—We documented live trade in 36 species of known, non-native, invasive reptiles and amphibians (two anurans, 30 lizards, three snakes, and one crocodilian) in Texas (Table 10; Crother et al. 2008, Kraus 2009). Three species considered invasive in Texas persisting in the trade were the Brown Anole (*Anolis sagrei*), Mediterranean Gecko (*Hemidactylus turcicus*), and Common House Gecko (*Hemidactylus frenatus*). It was possible the Mexican Spiny-tailed Iguana (*Ctenosaura pectinata*) was involved in the import trade in Texas, though records in the LEMIS database were only defined to genus *Ctenosaura*.

Non-native amphibian and reptile meat trade.—A total of 34 import shipments of non-native amphibians and reptiles were coded as meat or soup for commercial trade. Two of the shipments were identified as "Non-CITES Reptile" (13 kg), one as Indus Valley Bullfrog (*Hoplobatrachus tigerinus*, 7,960 kg), one as Crocodile (one kg), and 30 as Common Iguana (*Iguana iguana*, 469.74 kg plus 2,696 individuals). From 2002 through 2008, no non-native reptile or amphibian meat was exported from Texas.

DISCUSSION

Patterns revealed.—Two overarching patterns were revealed by our analyses. First, the number of species and subspecies in the trade was large; more than 1,100 identifiable taxa were documented. Species in the commercial trade originated from anywhere in the world and trade is largely unregulated. The large number of species in the trade reflects a global network of collectors accessing a broad species pool from many habitats on several continents. Our results indicate that the number of species and subspecies traded has increased during the past decade, likely due to their availability through expos and Internet-based sales. A previous study of the reptile trade in Texas by Jester (1992) only considered native species. Using similar methods, Ceballos and Fitzgerald (2004) reported 70 species and subspecies of non-native turtles in the trade in Texas during 1995–2000; we documented at least 129 taxonomic entities from 2002–2008. We did not consider 16 taxa reported by Ceballos and Fitzgerald (2004) because they were only traded in non-commercial categories including scientific and educational exchanges for zoos and aquariums. Thus our study documents a potential increase of 75 taxonomic entities of turtles in the trade since 2000. We suggest the difference in non-native species of turtles in the trade may be due to their availability through the Internet trade, which grew considerably in the past decade. No studies thoroughly documented trade in other non-native taxa in Texas, but we suggest the same trend of increasing species availability as a result of trade on the Internet is plausible.

Second, our data show that only a few species remained popular in the trade through time. This trend is supported by analysis of the top 10 traded species by year; eight species were in the top 10 during four of the seven years in our dataset. Species making the top 10 list of live imports included common amphibians and reptiles that were not expensive when on sale to the public at expositions. These species are also commonly sold at chain pet stores. Popularly imported species when encountered at herpetological expositions sold for USD $10–20, implying a commercialization scenario similar to that outlined for hatchling turtles by Reed and Gibbons (2002). They suggested the driver of pet turtle trade at the retail level is sale of inexpensive pets sold to novice keepers, rather than expensive pets to more experienced hobbyists. Species encountered in the greatest frequency at herpetological expositions and via the Internet were higher priced, genetic color variations produced in captivity. The Ball Python was the most common non-native species offered for sale to the public; the top species by instance online and at herpetological expositions. This species varied in price from USD $12 for a wild phase to USD $25,000 for an Axanthic Spider Morph. These results suggest the sale of inexpensive pets takes place locally of imported species while the sale of more expensive specimens takes place at expositions and via online retailers. This trend is additionally supported by our findings from survey respondents at reptile expositions who noted that the majority of the amphibian and reptiles pets that they owned were produced in captivity in the USA.

Our results show an interesting paradox, in that the LEMIS database clearly shows the international trade is largely composed of wild-caught specimens (Smith et al. 2009) but our surveys showed 71% of respondents kept captive-bred specimens. Our surveys were restricted to individuals attending amphibian and reptile expositions where the majority of specimens sold were captive-bred in the USA. The specimens imported in large numbers that are presumably wild-caught are common low-cost pet species that were not the focus of herpetoculture expositions. Presumably, these species are mostly traded through commercial pet stores. Future research identifying the proportion of wild-caught and captive-bred specimens marketed to different user-groups would provide important information relevant to developing wildlife trade policies.

International trade.—The trade in products is an important indicator of the level of trade in non-native species. Information is readily available from USFWS, but not commonly assessed at the state level. While we focused on the demand for live animals because of the additional risks associated with establishment of non-native species, our paper is an overall assessment of trade of all sorts. In some cases, like crocodiles, tegus, turtles, and some snakes, the demand for skins and food is the driver of the use of the species. In both situations, take from the wild for skins, and take from the wild for pets, native populations are impacted. The only wildlife description code common to every taxonomic category was "LIV" indicating that the specimen was imported alive either for the pet trade, as food for other animals, or to eventually be consumed. It was not possible to determine the percentage of the trade comprised of live specimens by comparing it to the other categories because the units of trade are different. Similarly, it was

impossible to determine the source (wild, captive, farm-reared) of animals that were traded as products.

Lizards occurred in more trade categories than any other group, followed closely by crocodilians. Lizards and crocodilians were traded as boots, shoes, handbags, watchbands, small and large leather products, and more. Amphibians were more likely to be traded for meat, as in the case of the Indus Valley Bullfrog, which was imported for human consumption. It should also be noted that much of the meat trade is known to be conducted via interstate commerce, for which no reporting exists.

We noted annual variation in numbers of imported live specimens, but there was not a temporal trend. The trade also varied by taxon group. No live crocodiles were imported for commercial trade during the period of our dataset and turtle imports were fairly constant. We attribute this to existence of state and federal regulations on both crocodilians and turtles that influence trade in these groups. Imports of other taxonomic groups showed large fluctuations among years. Trade in anurans varied the most, rising from 16,754 individuals in 2002 to 133,621 in 2007 and back down to 50,564 in 2008. These fluctuations were primarily due to the import of the African Clawed Frog, a species that did not occur in the dataset for 2002, but 60,600 and 76,423 were imported in 2006 and 2007, respectively. Increases in this particular species should be of concern because of the dangers of ranavirus and chytrid; pathogens affecting native populations of amphibians (Raverty and Reynolds 2001; Robert et. al 2007). Because interstate regulations are not in place to restrict movement of specimens after they are imported, Texas could be considered a source for introduction of pathogens as live animals are dispersed.

The export of live, non-native amphibians and reptiles from Texas was difficult to analyze despite our use of multiple data sources. Our analysis showed that between 2002 and 2008, 949,901 live, non-native specimens were imported to Texas, but 562,378 live, non-native specimens were exported. It was not possible to disentangle the proportions of specimens imported to be re-exported from that produced in captivity and exported. An export shipment could consist of specimens recently imported for resale to the international market or could be made up of specimens originating from a captive breeding colony within the United States. Other studies have also been limited in the ability to quantify export data (Reed and Gibbons 2002; Schlaepfer et al. 2005), indicating that reporting systems need to be changed to distinguish exports from re-exports. Because specimens are not marked individually, it is impossible to determine the origin and destination of individual live animals.

Invasive species in trade.—We paid extra attention to live specimens in the trade during our study because of the link between pet trade and invasive species. We found that species currently invasive in Texas and the United States persist in the live amphibian and reptile trade because they are generally not regulated. Our analyses revealed 36 species known to be invasive in the United States persisting in the trade from 2002–2008. Similar analyses for other states may reveal these and other species not native to many regions of North America are actively traded. The problem with live animal trades and risk of non-native species invasions is that it is difficult to predict which species will become invasive in any given habitat and introductions are often irreversible (Rejmanek and Richardson 1996; Kraus 2009). In 2008, a bill was introduced to the United States House of Representatives (HHR 669) entitled, "Nonnative Wildlife Invasion Prevention Act" proposing that a species-by-species list of non-natives permissible for trade be created. If passed, the bill would have ended the trade in most non-native animals in the USA. Groups including the Pet Industry Joint Advisory Council (PIJAC) and United States Amphibian and Reptile Keepers (USARK) quickly disseminated information regarding the bill to their members. The USARK took the issue on by hiring a Washington, D.C. lobbyist, educating legislators, and organizing a letter writing campaign in opposition of the bill. The primary argument against the bill focused on the economic losses that would be incurred by small family businesses whose source of income is linked to the trade. Non-native captive bred reptiles are in demand, and businesses producing and selling such specimens would be in jeopardy if this legislation passed. The bill failed to pass the House twice, in 2008 and in 2009.

Policies in some states in the USA focused on snakes, particularly large constrictors that were considered dangerous and known invasive species (Reed 2005). In 2007, the USFWS posted a Notice of Inquiry (RIN 1018-AV68) to gather biological and economic information about domestic trade in large constrictors in the United States to determine if it would be appropriate to include them in the list of injurious wildlife under the Lacey Act. If the logic applied to the case of these large constrictors were extended to other taxa, commercial trade in many species would be questionable because many traded species have life-history characteristics that would make them potentially likely to be invasive, and some are also potentially dangerous to humans. Currently the only non-native amphibian or reptile species regulated by the Lacey Act is the Brown Treesnake. We documented importation of *Boiga* sp. into the United States, but it could not be determined which species were imported because several members of the genus are known to be desirable as pets.

Recommendations.—Shortcomings of the USFWS reporting system have previously been pointed out and include allowance of multiple codes for the same taxonomic entity, partial codes, and generalized codes. Schlaepfer et al. (2005) noted that non-identified shipments could include imperiled species or non-natives known to be invasive. Ceballos and Fitzgerald (2004) recommended that precise information on origin of specimens is needed to understand impact of the trade on wild populations as well as to achieve accurate monitoring. We avoided some of these problems by cross-referencing our database queries and developing criteria for estimating the total number of taxa. However, partial codes, generalized codes, and poor nomenclature posed problems that impeded our ability to precisely identify the number of species and subspecies in the trade. We recommend that vague entries in trade databases such as "Non-CITES Reptile or Amphibian", "Reptile", or "Amphibian" not be permissible for commercial shipments. Utilization of the Taxonomic Serial Number (TSN) provided by the Integrated Taxonomic Information System, would be a positive step towards clarifying identities of species in the trade, but recommendations to adopt the TSN have yet to be implemented (Gerson et al. 2008).

Benefits of standardized nomenclature for traded species would enable more complete analysis of trade data and enhance the ability of inspectors to identify species in shipments. Standard nomenclature is also needed to develop enforceable criteria for the level of taxonomic identification required for different types of shipments. Gerson et al. (2008) claimed that through the adoption of the TSN system, traders would be forced to become more knowledgeable and forthcoming about the taxonomic status of species traded. It is unrealistic to expect commercial traders to keep up with changes in current scientific nomenclature. Government agencies and NGOs should work together to develop standard names or TSN codes that commercial traders are required to use for reporting. This requirement would improve trade monitoring systems and reduce confusion caused by reporting old and new names for the same species. The problem of importing regulated species under false names would still exist as well as incorrect identifications. Nevertheless, trade monitoring systems would be greatly improved if the TSN coding system were adopted or standardized genus and species names were required for commercial trade shipments.

Our results indicated the growing role of Internet-based sales of live animals in the pet trade. It is increasingly important to monitor Internet trade, as the use of e-commerce has created a global market for wildlife and their products. The pet trade is very risky for species invasion problems because the number and suite of species used as pets changes over time and the magnitude of the pet trade overall is growing. In contrast, the number of species used for food and skins is relatively stable. Kraus (2009) draws interesting correlations between the pathway of introduction of an invasive species with geographic region of the introduction noting pet trade is the most common pathway for live, non-native reptiles and amphibians to be introduced to North America. When considering these factors combined with our results showing that Internet and exposition trade in live, non-native species is flourishing in Texas, it is clear that management should focus on specimens that are traded live for pets.

Our study is among the first to use multiple data sources at the national level, state level, data on Internet-based trade, and targeted interviews to reveal detailed patterns of trade among a large number of genera, species, and subspecies of amphibians and reptiles. Our approach could be used as a template for assessing trade in non-native species in other states, especially those with a high volume of documented dealers, breeders, or enthusiasts. We showed that much trade persists in known invasive species and others that must have the potential to become invasive. Continued monitoring of species involved in trade and quantities imported is critical in developing management strategies for all species traded live but also conservation practices for those traded as products.

Acknowledgments.—We would like to acknowledge TPWD for supporting this project, Circee Peters at USFWS for her help in obtaining LEMIS records, and Rachel Blodgett for her diligent work gathering Internet data.

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