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Exotic Amphibians in the Pet Shops of Taiwan

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ABSTRACT: Pet trade is an important mechanism for introducing alien species. We surveyed a total of 434 pet shops in major cities of Taiwan and found 49 species of alien amphibians belonging to 14 families and 31 genera. Two of the alien species, *Rana catesbeiana* and *Kaloula pulchra*, have established in the fields and the other three, *Bufo marinus*, *Xenopus laevis*, and *Dendrobates auratus*, have invasion records in other countries. There were 16 CITES Appendix II species. The most frequently displayed species were the horned frogs, *Ceratophrys* spp. and the most abundant species was the American Bullfrog, *Rana catesbeiana*. We urge the authority of Taiwan establishing regulations on pet trade and enforcing the wildlife conservation law to reduce the risks of alien species invasions.

KEY WORDS: Alien species, Invasive species, Amphibians, Pet trade.

INTRODUCTION

Pet trade is an important mechanism for introducing alien species, which is one of the major causes for the recent loss of biodiversity (Diamond, 1984). As a useful rule of thumb, 10% of the introduced species become established, and 10% of those established become pests (Williamson, 1996). That is, for about every 100 species introduced, one will become pest. The economic and ecological damage caused by such pests can be enormous. For example, over time, more than 50,000 alien species have invaded U.S. ecosystems where they are responsible for an estimated $120 billion in both damage and control costs each year (Pimentel, 2002).

Unfortunately, exotic pet trade in Taiwan are largely unregulated or unmonitored. The lack of regulations often results in the release of domesticated exotic animals into the wild and poses a serious threat to local biodiversity and environments. Amphibians and reptiles, with comparatively few species listed on CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna), low transportation costs, and large profit margin, are traded more frequently than live birds and mammals. Nevertheless, how many exotic amphibian species have been imported and how high the chances that these species will establish in the wild in Taiwan are largely unknown.

In this study, we surveyed the pet shops in major cities of western Taiwan to investigate the number of exotic amphibian species and their relative trading frequency. We propose a list of exotic amphibian species with high risk of invasion for further control and management.

MATERIALS AND METHODS

Pet shops in northern (Taipei City and County); central (Taichung City and County, Changhwa, Nanto, and Yunlin counties), and southern Taiwan (Chayi, Tainan, Kaohsiung, Pingtung cities and counties) were investigated. Information about the pet and aquarium shops were obtained from the Yellow Pages and the shops were checked for amphibian trade at least once. Four seasonal surveys were performed in February-early May, mid May-mid August, late August-October, and November-December 2004 in northern Taiwan. Three seasonal surveys were carried in March-May, June-August, and September-November 2004 in central and southern Taiwan. An additional investigation in central Taiwan was

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performed in May-September 2005. Night markets that might involve amphibian trade were also surveyed. Some large pet shops were followed up in each seasonal survey. We recorded amphibian species and their quantities in each shop. For the unidentified individuals, characters of external morphology were recorded and photographs were taken if possible for further identification. Occasionally, the unidentified individuals were purchased for identification. Species names and taxonomy were based on the system of Frost (2004). Hybrid horned frogs (*Ceratophrys ornata* × *C. cranwelli* or *C. ornata* × *C. cornuta*) were treated as one species because the color patterns showed large variations among individuals and were hard to distinguish between species.

RESULTS AND DISCUSSION

A total of 434 pet shops in Taiwan were investigated. Proportion of the shops selling amphibians was 28% (70/254), 73% (58/80), and 31% (31/100) for northern, central, and southern Taiwan, respectively (Table 1). High proportion of the shops selling amphibians in central Taiwan was due to fact that the investigations were concentrated on aquarium shops, which often carried pet amphibians. Surveys in northern and southern Taiwan included pet shops selling terrestrial pets, such as reptiles or birds.

A total of 543 records including 190, 171, and 182 records from northern, central, and southern Taiwan (Table 1) were collected. At least 52 species of amphibians belonging to 2 orders, 15 families, 33 genera, from the pet shops were identified (Table 1, Appendix 1). Three species of the pet amphibians, *Hyla chinensis*, *Limnonestes kuhlii*, and *Rhacophorus arvalis*, are native to Taiwan and the rest are alien. The family Dendrobatidae had the highest number of species (10 species) as pets in Taiwan (Appendix 1). Hylidae, Leptodactylidae, and Mantellidae ranked second in number of species (6 species) as pets. The number of species and taxonomic diversity of the exotic amphibians in the pet shops (49 species; 14 families, 31 genera; Table 1) outnumbered those of native amphibians (32 species; 6 families, 10 genera) in Taiwan. Two species of the alien amphibians, Asian painted frog, *Kaloula pulchra*, and American bullfrog, *Rana catesbeiana*, have already established populations in Taiwan.

Original distributions of the pet amphibians are shown in Table 2. More than 1/3 of the pet amphibians were originated from South America (34%), followed by Central Africa (23%), North America (10%), and East Asia (10%). *Litoria caerulea* and *Ceratobatrachus guentheri* were the only species originated from Oceania and Pacific Islands, respectively.

Sixteen species sold in the pet shops are CITES Appendix II species (Table 3). These include all species of *Dendrobates*, *Epipedobates*, *Phyllobates*,

Table 1. Summary of the pet shops and the pet amphibian species in northern (N), central (C), and southern (S) Taiwan.

	N	C	S	Total
Shops investigated	254	80	100	434
Shops selling amphibians	70	58	31	143
Number of records	190	171	182	543
Number of species	35	28	26	52
Number of alien species	33	26	26	49
Number of genus	23	22	19	33
Number of alien genus	22	21	19	31
Number of family	11	13	10	15
Number of alien family	11	12	10	14
Number of species unique to the region	10	10	6	-

Table 2. Summary of original distribution of the pet amphibian species.

Original distribution	Number of family	Number of genus	Number of species	%
North Africa	1	1	1	1.6
Central Africa	5	9	14	22.6
South Africa	4	4	4	6.5
North America	4	5	6	9.7
South America	5	10	21	33.9
East Asia	6	6	6	9.7
Southeast Asia	5	5	5	8.1
South Asia	4	4	4	6.5
Europe	2	2	2	3.2
Oceania	1	1	1	1.6
Pacific Islands	1	1	1	1.6
Total			65*	100.0

* Forty-one species have single geographic distribution. Nine and one species have dual and triple geographic distributions, respectively.

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Mantella as well as the axolotl, *Ambystoma mexicanum*, and the red rain frog, *Scaphiophryne gottlebei*. Trade of these species supposedly was under the regulations of CITES and the domestic law (Wildlife Conservation Law), by which export permits or bred-in-captivity certificates were required.

Table 3. The CITES Appendix II amphibians sold in the pet shops.

Family/Genus	Species
Ambystomatidae	
Ambystoma	*mexicanum*
Dendrobatidae	
Dendrobates	*auratus, azureus, leucomelas, pumilio, reticulates, tinctorius, ventrimaculatus,*
Epipedobates	*tricolor, trivittatus*
Phyllobates	*lugubris*
Mantellidae	
Mantella	*aurantiaca, laevigata, madagascariensis, viridis*
Microhylidae	
Scaphiophryne	*gottlebei*

CITES: Convention on International Trade in Endangered Species of Wild Flora and Fauna.

The most frequently displayed species in the pet shops were the horned frogs, *Ceratophrys cranwelli* and the hybrid horn frogs (Table 4). They constituted more than 1/3 (38%, 209/543) of the total records (Table 4). American bullfrog, *Rana catesbeiana*, and African clawed toad, *Xenopus laevis*, ranked second (10%, 53/543) and third (8%, 41/543), respectively, in the frequency of occurrence. White's treefrog, *Litoria caerulea*, Chinese fire-bellied newt, *Cynops orientalis*, Llanos frog, *Lepidobatrachus llanensis*, and Sambava tomato frog, *Dyscophus guineti*, were also seen frequently (Table 4). However, the newly metamorphosed American bullfrogs was the most abundant species in the pet shops. They were sold as food for the aquarium fish, arowana (*Osteoglossum*).

A few large pet shops usually covered the whole variety of pet amphibian species in a region. Many smaller shops carried only the popular species, such as the horned frogs, American bullfrogs, or African clawed toads. Furthermore, some small venders might not display pet amphibians in shops all the time. For example, 30 pet shops selling amphibians were observed during the first survey (March-May) in southern Taiwan, however, only 19 and 15 of these shops carried pet amphibians in the second (May-August) and the third (September-November) surveys, respectively.

New arrivals and turnover of pet amphibian species in the shops were high. In northern Taiwan, 13 (in 24 shops), 24 (in 30 shops), 24 (in 22 shops), and 9 (in 6 shops) species of pet amphibians were observed in the four seasonal investigations; 15, 8, and 1 new species of amphibians not recorded in previous surveys were found in the second, third, and fourth survey, respectively. In southern Taiwan, 14 (in 30 shops), 14 (in 19 shops), and 20 (in 15 shops) species of pet amphibians were found in the three seasonal surveys; 4 and 8 extra species of amphibians were added in the second and third surveys, respectively. The highest number of amphibian species in pet shops occurred from May to October in northern Taiwan and from September to November in southern Taiwan.

Table 4. The amphibian species frequently occurred in the pet shops.

Family/Species	Frequency of occurrence	Percentage (out of 543)
Salamandridae		
Cynops orientalis	25	4.6
Hylidae		
Hyla chinensis	12	2.2
Litoria caerulea	31	6.3
Leptodactylidae		
Ceratophrys sp. (hybrid)	73	13.4
Ceratophrys cranwelli	136	25.0
Lepidobatrachus laevis	16	2.9
Lepidobatrachus llanensis	24	4.4
Microhylidae		
Dyscophus guineti	21	3.9
Pipidae		
Xenopus laevis	41	7.6
Ranidae		
Rana catesbeiana	53	9.8

Amphibian species sold in pet shops of one region might not occur in the shops of other regions. We found 35, 28, and 26 species of pet amphibians in northern, central, and southern pet shops, respectively (Table 1). However, 10 (28%), 10 (36%), and 6 (23%) species of amphibians were unique to the pet shops in northern, central, and southern Taiwan, respectively (Table 1). For example, *Ambystoma mexicanum*, *Bufo marinus*, *B. terrestris*, *Kaloula pulchra*, and *Pipa pipa* occurred in the northern pet shops only. *Triturus marmoratus*, *Tylototriton verrucosus*, *Bufo viridis*, *Hemisus marmoratus*, *Hyla gratiosa*, *Mantella laevigata*, *Mantella madagascariensis*, and *Rhacophorus arvalis were found only in the central pet shops. Dendrobates pumilio*, *D. reticulatus*, *D. ventrimaculatus*, *Boophis marojezensis*, *Megophrys nasuta*, and *Phrynomantis microps* occurred only in shops of southern Taiwan. The uniqueness of pet amphibian species in a region indicates that each region has its own suppliers. We also found that there were pet amphibian keepers who bred the amphibians in captivity and re-sold them to the pet shops.

Many amphibians have toxic skin secretions and are potentially harmful to humans. Species in the genera *Bufo*, *Dendrobates*, *Epipedobates*, *Phyllobates*, *Mantella*, and *Kaloula*, produce highly toxic skin compounds, such as bufodienolides and dendrobatid alkaloids (Flier et al., 1980; Daly et al.,

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1987; Daly, 1998), which are fatal if substantial amount are ingested. However, the source of many chemicals that occur in amphibian skin appears to be the arthropods in their diets, particularly ants (Caldwell, 1996). The pet amphibians, which were bred in captivity and fed with artificial food (e.g. wingless fruit flies), may be less or non-toxic. Because source of the pet amphibians was usually unknown, the potential harm by the toxic pet amphibians could not be ignored.

Some of the exotic amphibians on the pet market of Taiwan have high potential of becoming invasive species. Marine toad, *Bufo marinus*, and American bullfrog, *Rana catesbeiana*, are on the top 100 of the world's worst invasive alien species list (Lowe et al., 2000). African clawed toad, *Xenopus laevis*, and green poison-arrow frog, *Dendrobates auratus*, also have records of invasion. The former has been reported in North America, South American, and Europe (Tinsley and McCoid, 1996), and the latter has invaded Hawaii (McKeown, 1996). In fact, American bullfrog has been found in the fields of Taiwan for more than 15 years (Lue et al., 1990) and Asian painted frog, *Kaloula pulchra*, was first seen in southern Taiwan in 1998 (Y. R. Young personal communication). However, population biology and effects of these invasive amphibians on local ecosystems remain largely unknown (Liang, 2005). We urge the authority of Taiwan establishing regulations on amphibian (as well as other animal) pet trade and enforcing the law of wildlife conservation to reduce the risks of alien species invasions and the associated economic and ecological costs.

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Appendix 1. Amphibian species traded in the pet shops of Taiwan.

Taxa/Scientific Name	Common Name
Urodela	
Ambystomatidae	
Ambystoma mexicanum	axolotl
Salamandridae	
Cynops orientalis	Chinese fire-bellied newt
Triturus marmoratus	marbled newt
Tylototriton verrucosus	crocodile newt
Anura	
Bombinatoridae	
Bombina orientalis	oriental fire-bellied toad
Bufonidae	
Bufo marinus	marine toad
Bufo terrestris	southeastern toad
Bufo viridis	European green toad
Dendrobatidae	
Dendrobates auratus	green poison frog
Dendrobates azureus	blue poison frog
Dendrobates leucomelas	yellow-banded poison frog
Dendrobates pumilio	flaming poison frog
Dendrobates reticulatus	reticulated poison frog
Dendrobates tinctorius	dyeing poison frog
Dendrobates ventrimaculatus	Amazonian poison frog
Epipedobates tricolor	phantasmal poison frog
Epipedobates trivittatus	three-striped poison frog
Phyllobates lugubris	lovely poison frog
Hemisotidae	
Hemisus marmoratus	mottled shovel-nosed frog
Hylidae	
Agalychnis callidryas	red-eyed tree frog
**Hyla chinensis*	common Chinese tree frog
Hyla gratiosa	barking tree frog
Litoria caerulea	White's tree frog
Phrynohyas resinifictrix	Amazon milk frog
Phyllomedusa hypochondrialis	orange-legged leaf frogs
Hyperoliidae	
Kassina maculata	spotted running frog
Leptodactylidae	
Ceratophrys sp.	hybrid horned frog
Ceratophrys calcarata	Colombian horned frog
Ceratophrys cornuta	Amazonian horned frog
Ceratophrys cranwelli	Cranwell's horned frog
Lepidobatrachus laevis	Budgett's frog
Lepidobatrachus llanensis	Llanos frog
Mantellidae	
Boophis marojezensis	Madagascar bright-eyed frog
Mantella aurantiaca	Madagascan golden frog
Mantella laevigata	arboreal mantella
Mantella madagascariensis	painted mantella
Mantella viridis	green mantella
Mantidactylus pulcher	Tsarafidy Madagascar frog
Megophryidae	
Megophrys nasuta	Malayan horned frog
Microhylidae	
Dyscophus guineti	Sambava tomato frog
Kaloula pulchra	Asiatic painted frog
Phrynomantis microps	Accra snake-necked frog
Scaphiophryne gottlebei	red rain frog
Scaphiophryne marmorata	marbled rain frog
Scaphiophryne madagascariensis	Madagascar rain frog
Pipidae	
Pipa pipa	Surinam toad
Xenopus laevis	African clawed toad
Ranidae	
Ceratobatrachus guentheri	Gunther's triangle frog
**Limnonectes kuhlii*	Kuhl's wart frog
Pyxicephalus adspersus	African bull frog
Rana catesbeiana	American bull frog
Rhacophoridae	
**Rhacophorus arvalis*	farmland green tree frog

*: Native species of Taiwan

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臺灣寵物店販售的外來兩棲類

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摘　　要

寵物交易是引進外來種的一個重要管道。本研究調查臺灣西部都會區 434 家水族寵物店販售之兩棲類，共發現 49 種外來兩棲類，分屬於 14 科 31 屬。其中，美洲牛蛙（*Rana catesbeiana*）及亞洲錦蛙（*Kaloula pulchra*）兩外來種已在臺灣野外建立族群；另外三種：海蟾蜍（*Bufo marinus*）、非洲爪蟾（*Xenopus laevis*）及綠箭毒蛙（*Dendrobates auratus*）則有入侵其他地區的紀錄。此外，還發現 16 種華盛頓公約附錄二列名的兩棲類。寵物店最常販售的兩棲類是角蛙（*Ceratophrys* spp.），而販售數量最多的則是美洲牛蛙的幼蛙。我們呼籲相關單位儘速建立寵物交易的管理辦法，並加強執行野生動物保育法，以減低外來種入侵臺灣的風險。

關鍵詞：外來種、入侵種、兩棲類、寵物交易。

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