Taiwania, **51**(2): 81-86, 2006

Pet Trade as Sources of Introduced Bird Species in Taiwan

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(Manuscript received 9 September, 2005; accepted 28 November, 2005)

ABSTRACT: Pet trade has dominated in contributing to exotic bird introductions into Taiwan. At least 290 exotic species of pet birds have been imported to Taiwan since 1994, of which 93 species have escaped from captivity and become introduced species, and 28 species have been found to breed in the wild. An estimated 32.1% of overall escaping rate was significantly higher than that suggested by Tens rule. Among 11 bird families which have at least one species breeding in the wild, the escaping rate was significantly higher for four families: Sturnidae, Timaliidae, Cacatuidae, and Pycnonotidae; and the breeding rate was significantly higher for only one family – Estrildidae. We suggest that these five families should be focused on, in future monitoring programs for risk assessment of invasive species.

KEY WORDS: Introduced bird species, Escaping rate, Invasive bird species, Pet trade, Pet bird.

INTRODUCTION

The introduction of exotic species has become a major threat to the maintenance of global biodiversity (Shigesada and Kawasaki, 2001). Economic damage associated with exotic bird invasions in the six selected nations (the United States, United Kingdom, Australia, South Africa, India, and Brazi) totals $2.4 billion per year (Pimentel et al., 2002). There are seven pathways contributing to the flow of exotic birds: aesthetic, biocontrol, cargo, domestic, food, game and pet. Among them, the pet trade has dominated in contributing to global bird introductions since 1970 (Kraus, 2003).

Based on Temple's (1992) estimation, in the Unites States, 38% of the exotics were pet birds that accidentally escaped from captivity. Pet species may have escaped captivity and become invasive. Two of the three invasive bird species found in Hong Kong are pet species: the sulphur-creased cockatoo (*Cacatua sulphurea*) which destroys ornamental trees, and the rainbow lorikeet (*Trichoglossus haematodus*) which damages ornamental trees and raids fruit groves (Yan, et al., 2001). Successful biological invasions involve a series of unique but nested stages: imported, introduced, established, and spread (Williamson, 1996). Imported species are exotic species that are brought into the country; introduced species are imported species that are found in the wild (feral) released but not yet breeding successfully, and established species are introduced species with a self-sustaining population and breeding successfully (Williamson, 1996).

The pet trade business in Taiwan has been expanding more recently. Although, pet bird species are the major component of the exotic bird species found in the wild in Taiwan (Severinghaus, 1999), no complete surveys on pet bird species have been conducted since 1996. Notably, when looking for potential bird invaders that will cause economic or ecological damage in Taiwan, the first approach would be to identify those introduced bird species and potential established species via the recent pet trade. Identification of such invasive species is the first step to allow us to target prevention of accidental or deliberate release against them. Therefore, the aim of this study is to compile a list of exotic bird species found in pet stores in Taiwan, and survey the field-records of presence and breeding of those exotic species to estimate their potential escaping and breeding rate in the wild of Taiwan.

MATERIALS AND METHODS

We define an exotic species as one that is recorded to have been transported and introduced free-living outside its naturally occurring geographical range (Cassey, 2002). Lost or

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migratory/passing species categorized as rare in Wang et al. (1991) are here classified as exotic species in the pet trade. The occurrences of exotic bird species found outside their normal migratory range and their normal migratory seasons in the wildernesses of Taiwan, are denoted as exotic species having escaped or been released from captivity. In this study, we have excluded 4 feral domesticated species: domestic fowls (*Gallus gallus*), domestic ducks (*Cairina moschata*), feral pigeons(*Columba livia*) and Bengalese finches (*Lonchura domestica*). Three escaping species that are not sold in pet stores and are possibly imported by zoo keepers (the Indian Peafowl, *Pavo cristatus*, Sacred Ibis, *Threskiornis aethiopicus*, and Greater Flamingo, *Phoenicopterus ruber*) were also excluded from our analysis. We gathered information on all species, following the species list in Clements (2000). For pet birds, we modify the stages of invasion as imported (sold in pet stores), escaped/or released, breeding, establishment, and spread, and only the first 3 stages were examined in this study because of a lack of population data for identification of successful establishment. The different stages were examined in a nested fashion, in that escaped/or released was examined using the set of all species found in pet stores, and breeding was examined using the subset of all escaping/or released species. This is because only escaping or released species can breed and become established. Field-records of presence and breeding of exotic bird species were based on data published by the Wild Bird Federation Taiwan (1999-2003) and by the Kaohsiung Wild Bird Society (1999-2003), and by Lin (2004).

A total of 146 pet stores in Taiwan were investigated during 2004 by a team of four persons with each one observing different families of birds. Twenty-six stores were surveyed in Taipei City and Taipei County, seven in Hsinchu City and Hsinchu County, five in Fengyuan City, 24 in Taichung City, nine in Chiayi City, 20 in Tainan City and Tainan County, 50 in Kaohsiung City and Kaohsiung County, five in Pingtong City.

One-sided binomial test was used to examine the escaping rate and breeding rate of each bird family (Hollander and Wolfe, 1973).

RESULTS

The number of exotic species found in pet stores have increased from 85 (Chi, 1995) to 261 (our 2004 survey) over the past 10 years (Table 1). The top three families with the most number of species sold in pet stores are Psittacidae, Estrildidae, and Sturnidae in the 2004 survey (Table 2).

A total of 272 different exotic species were found in the two surveys (our 2004 survey and Chi, 1995), and based on previous field-records, 18 additional exotic species of pet birds have escaped from captivity and been found in the wild, but not in these two surveys. Thus, a total of at least 290 species of exotic pet birds have been imported to Taiwan since 1994, 93 species have been recorded in the wild, and approximately one third of those escaping species have bred at some point (Table 3).

For those 290 imported species, the successful escaping rate was 32.1%, which was significantly higher than 10% (one-sided bionomial test, $P < 0.05$); and for those 93 escaping species, the successful breeding rate was 30.1%, which was also significantly higher than 10% (one-sided bionomial test, $P < 0.05$) (Table 3). There are 11 bird families which have at least one species breeding in wild of Taiwan. Successful escaping rate ranged from 9.8% to 100% for different families of birds; successful breeding rate ranged from 14.3 to 100%. Among those 11 bird families, notably, families Sturnidae, Timaliidae, Cacatuidae, and Pycnonotidae showed significantly higher escaping rate than the overall rate (one-sided bionomial test, $P < 0.05$). For breeding rate, only family Estrildidae demonstrated a significantly higher rate than the overall rate (one-sided bionomial test, $P < 0.05$). Family Sturnidae have both the greatest number of species successful in escaping from captivity and the greatest number of species breeding in the wild of Taiwan (Table 3).

Among those 28 introduced species with breeding records in the wild in Taiwan, the top four of the most common sold species (found in a greater number of stores in the 2004 survey) are the Java sparrow (*Padda oryzivora*), the yellow-fronted canary (*Serinus mozambicus*), the green-naped lorikeet/rain-bowlorikeet/Edward's lorikeet/red-collared lorikeet/ Michell's lorikeet (*Trichoglossus haematodus*), and the Javan myna (*Acridotheres javanicus*) (Table 4).

DISCUSSION

Risk assessments have generally focused on questions: what are the species characteristics that enable some species to have a high probability of colonizing, establishing, breeding populations, expanding geographic range and/or having an adverse effect on the environment? Many of these generalizations are taxon-specific (Kolar and Lodge, 2001). This focused, taxon-specific approach may become useful for identifying organisms from a particular taxon that have increased invasion risk.

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Table 1. Numbers of bird species found in pet shops in Taiwan.

	Our 2004 survey	Taipei Wild Bird Society's 1996 survey (Severinghaus, 1999)	Chi (1995)
Native Species	63 (19.4%)	34 (16.3%)	35 (28.9%)
Exotic Species	261 (80.6%)[ab]	169 (83.7%)[a]	85 (71.1%)[a]
Total	324	203	120

[a] not including domesticated species.
[b] including 5 identified supspecies.

Table 2. Numbers (%) of exotic species by bird family found in pet shops in Taiwan.

Family	Our 2004 Survey	Chi (1995)
Psittacidae[a]	111(42.5)	19(22.4)
Estrildidae	27(10.3)	14(16.5)
Sturnidae	17(6.5)	6(7.1)
Timaliidae	11(4.2)	6(7.1)
Cacatuidae	10(3.8)	7(8.2)
Fringillidae	10(3.8)	4(4.7)
Phasianidae	8(3.1)	7(8.2)
Muscicapidae	7(2.7)	5(5.9)
Emberizidae	6(2.3)	0
Zosteropidae	6(2.3)	0
Turdidae	6(2.3)	1(1.2)
Chloropseidae	5(1.9)	2(2.4)
Columbidae	4(1.5)	2(2.4)
Nectariniidae	4(1.5)	0
Ploceidae	4(1.5)	2(2.4)
Capitonidae	3(1.1)	0
Corvidae	3(1.1)	1(1.2)
Odontophoridae	3(1.1)	0
Alaudidae	2(0.8)	1(1.2)
Bombycillidae	2(0.8)	2(2.4)
Musophagidae	2(0.8)	0
Paridae	2(0.8)	2(2.4)
Pycnonotidae	2(0.8)	1(1.2)
Viduidae	2(0.8)	3(3.5)
Bucerotidae	1(0.4)	0
Irenidae	1(0.4)	0
Oriolidae	1(0.4)	0
Rhipiduridae	1(0.4)	0
Total	261	85

[a] including different identified supspecies

Identification of those taxa with higher probability of escaping or breeding is the first step to allow us to target prevention against them. In this study, we found that 11 bird families have at least one species breeding in wild, and among them, five families have significantly higher probabilities of escaping from captivity or breeding in the wild: Sturnidae, Timaliidae, Cacatuidae, Pycnonotidae and Estrildidae.

At least 19 exotic species of Sturnidae have been found in the wild; among them, two species (*Acridotheres javanicus* and *Acridotheres tristis*) have been recorded in more than one third of administrative units of Taiwan (Lin, 2001). Although species of Cacatuidae showed a significantly higher escaping probability, its breeding rate is not significantly higher than the overall rate and only four species have been found to breed in the wild in Taiwan. Lin (2005) attributed this low breeding rate of exotic species of Cacatuidae to the scarcity of tree cavities in urban areas available for them to nest. At least 4 exotic species of Pycnonotidae have been found in the wild of Taiwan, and all of them have native ranges in South-East Asia. Although only one species of Pycnonotidae has been found to breed in the wild, more species may be expected to breed in the wild of Taiwan considering their native distributions. Exotic species of Estrildidae demonstrated a

Table 3. Escaping numbers and breeding numbers of bird families which have at least one species breeding in the wild in Taiwan.

	Escaping		Breeding	
Family[a]	Escaping number of species/total number of species in the family (rate %)	P[b]	Breeding number of species/total number of species in the family (rate %)	P[b]
Sturnidae	19/23(82)	0*	8/19 (42.1)	0.185
Psittacidae	11/112 (9.8)	1	2/11 (18.2)	0.888
Estrildidae	10/29 (34.5)	0.46	6 /10(60)	0.048*
Timaliidae	8/14 (57.1)	0.047*	2 /8(25)	0.747
Ploceidae	7/7 (100)	0*	1 /7(14.3)	0.918
Fringillidae	7/12 (58.3)	0.055	1 /7(14.3)	0.918
Cacatuidae	7 /11(63.6)	0.031*	4 /7(57.1)	0.127
Pycnonotidae	4/5 (80)	0.039*	1 /4(25)	0.761
Corvidae	2 /3(66.7)	0.243	1 /2(50)	0.511
Emberizidae	1/6 (16.7)	0.902	1 /1(100)	0.301
Cuculidae	1/1 (100%)	0.321	1 /1(100)	0.301
Overall	93/290 (32.1)	0*	28/93 (30.1)	0*

[a] families with at least one species breeding in the wild of Taiwan; families with no species breeding in the wild of Taiwan were not shown here.
[b] probabilities computed under the one-sided binomial test of *Ho* ($p = p_o$) versus the alternative *Ha* ($p > p_o$), where $p_o = 0.321$ (escaping overall rate), or 0.301 (breeding overall rate) tested for each family, or $p_o = 0.1$ (tens rule) tested for overall rate.
* significant at $\alpha = 0.05$.

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Table 4. Numbers of stores which sold the exotic species with breeding records in the wild in Taiwan.

Family	Scientific Name	Number of stores in 2004 survey
Estrildidae	*Padda oryzivora*	125
Fringillidae	*Serinus mozambicus*	55
Psittacidae	*Trichoglossus haematodus* [a]	39
Sturnidae	*Acridotheres javanicus*	39
Psittacidae	*Eos bornea*	28
Estrildidae	*Estrilda melpoda*	23
Estrildidae	*Lonchura maja*	20
Sturnidae	*Acridotheres tristis*	19
Timaliidae	*Garrulax canorus*[b]	19
Cacatuidae	*Cacatua galerita*	18
Estrildidae	*Estrilda astrild*	16
Estrildidae	*Lonchura atricapilla*	16
Sturnidae	*Gracula religiosa*	14
Sturnidae	*Gracupica nigricollis*	12
Cacatuidae	*Cacatua alba*	10
Estrildidae	*Lonchura malabarica*	7
Sturnidae	*Acridotheres fuscus*	6
Corvidae	*Cyanopica cyana*	3
Sturnidae	*Aplonis panayensis*	3
Pycnonotidas	*Pycnonotus jocosus*	2
Cacatuidae	*Cacatua moluccensis*	1
Cacatuidae	*Cacatua goffini*	1
Emberizidae	*Paroaria coronata*	1
Ploceidae	*Ploceus aurantius*	0 [c]
Sturnidae	*Acridotheres burmannicus*	0 [d]
Cuculidae	*Eudynamys scolopacea*	0 [d]
Timaliidae	*Garrulax sannio*	0 [d]
Sturnidae	*Sturnus malabarius*	0 [d]

[a] including 5 identified subspecies
[b] subspecies from Mainland China
[c] imported species found in Chi (1995) survey of pet stores.
[d] imported species not found in 2004 and Chi (1995) surveys of pet stores but recorded in the wild in Taiwan.

significantly higher probability of breeding in the wild of Taiwan. Lee and Shieh (2005) found that two successfully established species of Estrildidae, *Lonchura maja* and *Lonchura malabarica*, were not commonly sold in pet stores with higher numbers of individuals (Lee and Shieh, 2005). This indicated that invasive potentials of species of Estrildidae might be more related to their environmental adaptability than to the imported numbers. Eight exotic species of Timaliidae have escaped from captivity, of which hwamei (*Garrulax canorus*) subspecies from mainland China have been found to be highly invasive because of interbreeding with subspecies of Taiwan (Lou et al. in Annual meeting of 2005 Animal Behavior and Ecology).

Previous success at invasion is a good indicator of whether an invader will succeed in a new place (Williamsons, 1996). We need to particularly cautious about two species, the white-rumped shama (*Copsychus malabaricus*) and village weaver (*Ploceus cucullatus*) because they have been found to be highly potential invaders in other countries (elibrary.unm.edu/sora/Condor/cooper/SGML/sab_009/sab_009.html, Behavior and Ecology, Lahti, 2003) although they have not yet been found breeding in the wildernesses of Taiwan.

Tens rule was first noted for British exotic species and was later demonstrated to cover a wider geographic array of exotic introductions (Williamson and Fitter, 1996). Tens rule suggested that 10% of exotic species imported to an area appear in the wild, 10% of those appearing in the wild establish self-sustaining populations, and 10% of established species become pestiferous. However, Kraus (2003) found that 32-100% of bird introductions appear to have established successfully. In Taiwan, we found the 32.1% of escaping rate, which is higher than the range Tens rule implies. This higher introduced rate may result from “prayer animal release”, which is a common feature of the religious culture in Taiwan, and birds are the major group of animals released (Severinghaus and Chi, 1999). Although the capability of breeding in the wild does not necessarily guarantee successfully establishing self-sustained populations, a breeding rate of 30.1% indicates a high probability of invasive potential, which is worthy of great attention.

In conclusion, we found a higher overall escaping rate of exotic bird species in Taiwan, and five families of bird species need to be focused on, in future monitoring research because of their significantly higher escaping rate or breeding rate in the wild.

ACKNOWLEDGEMENTS

This work was funded by National Science Council (NSC 92-3114-B-002-013). We thank Mr. W.-L. Chi, R.-S. Lin, the Wild Bird Federation Taiwan and the Kaohsiung Wild Bird Society for providing valuable information.

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臺灣引入鳥種與寵物販賣關係之探討

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(收稿日期：2005 年 9 月 9 日；接受日期：2005 年 11 月 28 日)

摘　　要

寵物貿易是臺灣引入鳥種的主因。從1994年起臺灣至少有290種外來寵物鳥種被引進入口，其中有93種逃逸野外成為引入鳥種，28種有在野外繁殖的紀錄。根據紀錄估計總逃逸率約為32.1%，此顯著的高於十分之一規則所建議的比例。有11科的鳥種有野外繁殖的紀錄，這11科鳥種中有四科的鳥種逃逸率顯著的高於總逃逸率，它們分別是椋鳥科、畫眉科、鳳頭鸚鵡科及鵯科；野外繁殖率顯著高於總繁殖率的只有梅花雀科。我們建議在未來的監測計畫中應針對這五科較具入侵潛力的鳥科做進一步入侵鳥種的風險評估。

關鍵詞：引入鳥種、逃逸率、入侵鳥種、寵物交易、寵物鳥。

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