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Secretariat, CFCS
c/o University of the Virgin Islands
USVI Cooperative Extension Service
Route 02, Box 10,000
Kingshill, St. Croix
US Virgin Islands 00850

Or from

CFCS Treasurer
P.O. Box 506
Isabella, Puerto Rico 00663

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TRADE IN PET, AQUARIUM, AND TERRARIUM SPECIES AS A SIGNIFICANT SOURCE OF INVASIVE ALIEN SPECIES IN THE WIDER CARIBBEAN REGION

Ulrike Krauss, Invasive Species Coordinator, Forestry Department, Ministry of Agriculture, Lands, Forestry, and Fisheries, Union, Saint Lucia. Telephone: 758-468-5646; Email: ulrike.krauss@gmail.com.

ABSTRACT

A wide range of pets, including aquarium and terrarium species, as well as associated organisms, are available via numerous formal, informal, poorly-regulated, or even illegal outlets. Once present in a country, escapes and even deliberate releases are likely to occur. If freed pets become established in the area, they frequently turn invasive. In the Caribbean, internet trade easily eludes proper procedures, and the sheer volume of exotic pets kept, traded, or released in Florida represents a threatening source for invasive alien species (IAS) for the Wider Caribbean Region (WCR). The negative impact can be via predation, competition, habitat alteration, hybridization, vectoring of animal pathogens or parasites (aggravated by shared facilities in trade hubs), zoonoses, and interference with human activity or infrastructure. These mechanisms have led to extinctions of previously rare endemic species in the WCR and continue to threaten others. Examples of IAS originating from the pet trade span across terrestrial, marine, and freshwater species, including plants and live feed for the aquarium trade, as well as bird seeds. Aquatic organisms and increasing outbreaks of zoonoses are particularly problematic. Only a few international standards address risks of invasions associated with the pet trade and only for specific taxa, that is, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the International Plant Protection Convention (IPPC), and the World Organisation for Animal Health (OIE). This gap is now being addressed by an ad hoc Technical Expert Group under the Convention of Biological Diversity (CBD). Existing and incipient preventative tools include pre-importation measures (i.e., importation bans and post-importation measures) that focus on the prevention of release/escape or reproduction of IAS. Their successful deployment invariably involves close collaboration between the government and the private sector, coupled with public involvement and broad-based awareness-raising.

PET TRADE AS AN IAS PATHWAY WITH MULTIPLE SERIOUS IMPACTS

Pets, including aquarium and terrarium species, are animals kept for personal amusement or companionship. Pet-keeping has become popular across the WCR, with particularly the urban young being increasingly interested in exotic and/or unusual pets. A survey by John (2001) indicated interest by Saint Lucias in keeping the native boa (*Boa constrictor*), the red-kneed tortoise (*Geochelone carbonaria*), iguana (native and alien), and local pigeons and doves as pets. Throughout the WCR, Florida (United States) is a prolific source of IAS, including pets and associated taxa, given the sheer volume of species traded through this hub and the number of animals and ornamental plants released there into the wild (Simberloff et al. 1997). Pet feed, such as exotic plant seeds, crickets (Orthoptera), and viable brine shrimp (*Artemia franciscana*), can also exhibit invasive behavior once discarded. Brine shrimp are even marketed online as complete science experimental kits (Figure 1), with some companies offering global shipping.
Growing globalization has been accompanied by the mushrooming of one-stop shopping centers and malls at the expense of specialist retail outlets where expert advice is available. In today’s urban areas, a wide range of pet species and accessories, including plants and live feed, are sold in markets, garden centers, and supermarkets. On small Caribbean islands, where total pet trade volume is often below critical mass for specialist commercialization; internet trade; and informal breeding by private individuals for sale, trade, and exchange, are of importance. These pathways are poorly regulated and law enforcement is often impractical. This is complicated by the fact that suppliers often misidentify the species provided (SCBD 2010). In fact, internet trade has brought an almost unlimited variety of exotic life forms within the universal reach by a mouse-click: aquatic rarities, insects, molluscs, exotic mammals, ornamental plants and seeds, together with their parasites, pests, and pathogens. Because many of these organisms are known to be potentially invasive if set free, internet trade represents a marked risk as source of illegally imported alien species.

Once an alien species has been introduced to a new country, there is no such thing as zero risk of escape or release (SCBD 2010). Pets can escape accidentally or be released deliberately because their owners no longer can or want to look after them. Owners often underestimate the longevity or requirements for space and care. Misguided sympathy makes matters worse when animals are released into nature reserves in an attempt to provide them with a comfortable habitat. If conditions are conducive and the released species survives, it may affect the native biodiversity at the most vulnerable locations of highest conservation value, where potential damage is greatest. Examples of a range of devastating impacts exist across Caribbean terrestrial, marine, and freshwater ecosystems and encompass:

- **Predation** Feral cats (Figure 2) and dogs have a severe impact on the indigenous terrestrial fauna of many countries. Even waterfowl and marine turtles fall victims in coastal areas. Feral cats are one of the main biological factors causing the decline and extinction of birds and small reptiles. Of the 625 birds threatened globally because of IAS, cats are responsible for 174 cases (BirdLife International 2008a). Of the 134 bird species that are confirmed to have gone extinct since 1500, 71 cases are attributed to IAS, with nearly half of the (34) to cats (BirdLife International 2008b).

  In the Caribbean Sea, the Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) is a ferocious predator of unsuspecting coral fish. The spectacularly decorative lionfish is an attraction in many private and public aquaria in the New World. Its insatiable appetite for other fish, large size, and venomous spines render it an expensive and challenging pet. Deliberate releases and accidental escapes have been blamed for the Caribbean invasion (Betancur-R. et al. 2011; Schofield 2010).
While domestic cats are popular pets worldwide, feral cats are one of the main factors causing the decline and extinction of birds and small reptiles. The red-eared slider \((Trachemys scripta elegans, \text{Figure 3})\) preys on small waterfowl, fish, amphibians, and invertebrates. Its robustness is a two-edged sword: this uncomplicated terrapin enjoys great popularity, particularly as a first pet for inexperienced children; at the same time, its remarkable ability to adapt to a range of climates and to invade novel habitats renders it a top IAS. Between 1989 and 1997, over 52 million red-eared sliders were exported from its North American origin to foreign markets. Given its longevity (up to 40 years) as well as invasive and destructive history, imports of \(T. scripta elegans\) into the European Union have been banned. Numerous Caribbean countries have been impacted (GISD 2010).
Competition with native fauna for food and habitat. The omnivorous red-eared slider feeds on plants and animals alike, thereby competing with native terrapins. Its basking behavior (Figure 1) impacts nesting water birds: if nests get pushed into the water, eggs are killed.

The tropical macroalga *Caulerpa taxifolia* is a popular aquarium ornamental. A cold-tolerant aquarium strain, which is believed to have been discarded from a Monaco aquarium, is now highly invasive in Europe, smothering other algal species, sea grasses, and sessile invertebrate communities in the Mediterranean Sea by a combination of competition and toxicity (Lowe et al. 2000).

Modification of native flora: Herbivorous feral pets can alter floral composition directly through feeding pressure or propagule dissemination, or indirectly either through impacting native herbivores or through rough competition by accessory plants and feed (GISD 2010).

The lionfish impacts herbivorous fish populations to the extent that the marine floral composition is altered (Lesser and Slattery 2011). In Hawaii, 37% of the major weed species are dispersed by introduced birds. Parrots may fly up to 30 miles in the course of a day, spreading invasive plants high into the rain forest (Fox 2011). These include infamous *Miconia, Clidemia*, and *Ficus* species. Hanson and Mason (1985) published a list of 435 plant species believed to have been introduced into the United Kingdom as bird feed with viable seeds. Australia learned from that experience, making gamma-radiation of bird seeds compulsory to release imports from quarantine.

Hybridization can eliminate genetic uniqueness of island endemics, as is the case with green iguanas (*Iguana iguana*), a popular pet of South and Central American origin, which has given rise to fertile offspring with the Lesser Antillean Iguana (*Iguana delicatissima*) in the French West Indies, diluting the gene pool of *I. delicatissima* (Rodrigues in press). The same risk is looming on Saint Lucia, where efforts are underway to eradicate the alien green iguana while its population is still spatially separate from the Saint Lucian iguana (*Iguana cf. iguana*), whose taxonomy is still poorly defined (Morton and Krauss 2011).

Vectoring of animal pathogens or parasites: The fungus *Batrachochytrium dendrobatidis* causes chytridiomycosis in at least 12 amphibian families, leading to death within 10 to 18 days. Chytridiomycosis has brought endemic Caribbean species, for example, the mountain chicken (*Leptodactylus fallax*), to the verge of extinction (Daltry 2009). The pathogen is thought to have been spread principally thought the pet trade, for example, with Africa clawed frogs (*Xenopus* spp.).

Of the 134 bird species that are confirmed to have gone extinct since 1500, 16 are being attributed to diseases caused by introduced pathogens (BirdLife International 2008b). At least 10 native Hawaiian bird species went extinct due to avian malaria, which was introduced by early settlers with their pet birds that possessed co-evolved resistance to the malaria parasite, *Plasmodium relictum* (Lowe et al. 2000). In the insular Caribbean, tests for two viral diseases, avian influenza and Newcastle disease, are performed on imported wild birds, but only 30% of countries implement quarantine for imported birds (FAO 2011).
Zoonoses: Several reptiles are known to be carriers of Lyme disease, heartwater, babesiosis, and *Salmonella* bacteria, and have been linked to cross-infection in other domestic or farm animals and to zoonoses, that is, disease transmission from animals to humans (SCBD 2010). In fact, most newly emerging infectious diseases are zoonoses that often have their origin in the international trade of wild animals, particularly those taken directly from the wild.

In 2003, 40 people in the United States contracted Monkey Pox from African rats imported as pets from the wild via cross-infection of indigenous prairie dogs housed in the same facility. Severe Acute Respiratory Syndrome (SARS) is caused by a coronavirus associated with the trade in small carnivores, especially civets. A 2003 outbreak killed at least 774 people worldwide and cost tens of billions of US dollars (SCBD 2010).

These examples illustrate how stores and trading hubs create unnatural opportunities for animals from different parts of the world to meet and exchange parasites and pathogens. This was also the case when avian influenza was reported in a Surinamese parrot, sending alarm signals to veterinarians and conservationists throughout the world (Associated Press 2005). In reality, the healthy animal had been taken to the United Kingdom and housed in the same quarantine facility with pet birds from Asia that were carriers of the H1N1 viral strain and passed the deadly infection to the South American bird.

**Interference with human activity and infrastructure:** The burrowing habit of the green iguana renders it a nuisance species in urban Florida. Also, at the Puerto Rico airport, they are reported to be posing a collision hazard on the runway (Morton and Krauss 2011).

Water thyme (*Hydrilla verticillata*), an aquarium ornamental plant native to Asia and Africa, grows vigorously at the water surface, excluding sunlight from other plants and reducing aquatic plant and animal biodiversity in many countries. The dense mats also affect commercial and recreational activities.

**International Regulatory Framework and Multilateral Environmental Agreement**

Only a few international standards address risks of invasions associated with the pet trade and only for specific cases:

- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)** regulates the trade of endangered animals and plants. A permit system and genetic barcoding aid in monitoring their movement, the focus is on endangered species, not invasives.

- **International Plant Protection Convention (IPPC), with its International Sanitary and Phytosanitary Measures (ISPMs),** applies to organisms that are plant pests, including some weedy plants. However, taxa that do not impact plant health are not within the ISPM remit.

- **World Organisation for Animal Health (OIE) develops standards to minimize the transfer of zoonotic diseases by restricting the movement of live animals and fish.** In 2010, OIE published a review on animals as invasive species that goes far beyond OIE’s original veterinary mandate (Pastoret and Moutou 2010).
Although the pathway of introducing alien species as pets (aquarium and terrarium species) remains a gap of national and international regulatory frameworks, some recent initiatives try to close this gap, most notably, the ad hoc Technical Expert Group (AHTEG) of the Convention of Biological Diversity (CBD), and the Working Group on E-commerce of Specimens of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) that is developing a toolkit to monitor the sale/purchase of CITES-listed species on the internet.

**AVAILABLE AND INCIPIENT MANAGEMENT TOOLS**

Prevention is the approach of choice, with two principal avenues: (1) prevention of species importation and (2) prevention of release or escape. The latter can further be subdivided into prevention of release and prevention of reproduction (Table 1).

National legislation is required to regulate pre-import steps and reduce the risk of escape/release post-introduction. However, when a country restricts imports of a species, this could be challenged by other countries questioning whether this would be in agreement with the SPS Agreement of the World Trade Organization (WTO). Thus, the decision of whether or not to permit the importation of a species must be science-based. Risk assessments are the main tool to determine the risk of an imported species becoming invasive. In the Americas, the invasive species thematic network (I3N) of the Inter-American Biodiversity Information Network (IABIN) developed a user-friendly Analysis of Invasion Tool and Vector Analysis Pathways Tool covering terrestrial vertebrates, fish, and vascular plants, along with a climate matching module (http://i3n.iabin.net/tools/web_tools.html). A number of countries have developed their own modules, based on national priorities (Simons and De Poorter 2009).

As important as solid legislation is, trade restrictions are unpopular with both public and commercial enterprises. Furthermore, bans do not encourage the improvement of practices and may become counterproductive if they are not efficiently enforced. Thus, current best practices on managing the pet trade as an IAS pathway invariably involve collaboration between the government, the private sector, and experts who conduct science-based and transparent risk assessments. In fact, many initiatives are driven by self-regulation and voluntary measures that also aid the professional image, thereby creating a win-win situation. Policy-makers could support the partnership by incentivizing safer pet trade and ownership practices. Various taxation and polluter-pays models are available to fund interventions, but have not yet been adequately exploited (Perry and Farmer 2011).
Table 1: Preventative measures to manage the pet trade as pathway for invasive alien species

<table>
<thead>
<tr>
<th>Tool</th>
<th>Pre-importation</th>
<th>Post-importation: Prevention of Release/Escape or Reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Assessment</td>
<td>I3N IABIN Risk Assessment tool for aquatic and terrestrial animals</td>
<td>Amnesty to register and keep individuals of recently prohibited species that were procured prior to prohibition, even if not through the official channels</td>
</tr>
<tr>
<td>Black lists of prohibited species</td>
<td>Not comprehensive but case-specific (e.g., prohibition of civet imports as a precaution against SARS outbreaks) Monitoring prime online auction sites to remove illegal items</td>
<td></td>
</tr>
<tr>
<td>White lists indicate species that may be imported</td>
<td>Import is prohibited until risk assessment shows import is of no concern (e.g., EU white list for aquaculture)</td>
<td></td>
</tr>
<tr>
<td>Customer licensing and record-keeping</td>
<td>Green lists provide information on species that require a license to deter casual pet ownership CITES toolkit offers standard for development of electronic permit system for international wildlife trade</td>
<td>Animal labeling; unique characteristics Amnesty days for existing keepers to register Obligation to microchip pets and maintain license as effective releases prevention Requirement of CITES-listed species to be identified using DNA barcoding</td>
</tr>
<tr>
<td>Public awareness and stakeholder involvement, including • Voluntary measures by private sector • Public-Private Partnerships (PPPs)</td>
<td>Influences demand and increases the effectiveness of pre-import risk assessment of live animals May precede formal risk assessment and regulations, especially where capacity is low Self-regulation paralleling regulatory framework Animal inspections, transport measures Proper quarantine, sanitation, and pest control practices</td>
<td>Ecology and potential risk awareness, (e.g., recognition aids by Center for Aquatic and Invasive Plants, University of Florida) Post-import inspections, acclimation, and quarantines (e.g., US National Reptile Improvement Plan Housing, packaging, and handling (e.g., FAO Biosecurity Toolkit) Triploids or Same-Sex Stores Spay &amp; neuter programs Voluntary codes of conduct, Codes of Ethics Care sheets Public education/technical support campaigns (e.g., Habitatatitude and BD-free phibs) Training Hazard Analysis Critical Control Point (HACCP)-based approaches</td>
</tr>
<tr>
<td>Re-homing programs</td>
<td></td>
<td>Re-homing of unwanted pets</td>
</tr>
<tr>
<td>Pet-sitting programs</td>
<td></td>
<td>Pet-sitting services to assist keepers</td>
</tr>
<tr>
<td>Non-viable feed propagules</td>
<td>Gamma radiation of bird seeds compulsory to release quarantined imports in Australia</td>
<td>Canned crickets are now widely available as alternative to live food</td>
</tr>
</tbody>
</table>

Public-Private-Partnerships (PPPs) work best when coupled with public awareness campaigns and involvement of local communities. The development of voluntary codes of conduct (VCoCs), as well as certification schemes, are instrumental in both self-regulating the industry and raising public awareness (Reaser 2011). In the Caribbean, Anguilla (Connor 2008) and the Bahamas (BEST Commission 2003), in their National Invasive Species Strategies (NISS), have adopted identical VCoCs for the following:

- Zoos and Aquaria
- Farms (agricultural and aquacultural)
- Pet Stores, Breeders, and Dealers
- Pet Owners
- Veterinarians

This is also exemplary in terms of regional harmonization.

Once a species has been imported for the pet trade, a risk of escape/release has been created. The magnitude of this risk, however, can be manipulated. VCoCs have been used to involve the private sector in awareness-raising of their clientele, thereby reducing the risk of pets being released or abandoned. For example, the Ornamental Fish International (OFI) publishes care sheets (OFI has 190 members in 44 countries worldwide and is committed to the OFI Code of Ethics). Similarly, the Ornamental Aquatic Trade Association (OATA) in the United Kingdom prints the statement that “ornamental fish and plants bought for aquariums and ponds must never be released into the wild” on over 2 million fish retail plastic bags annually. Two campaigns by the Pet Industry Advisory Council (PIJAC) in the United States have excellent outreach, also via the internet (Habitattitude at http://www.habitattitude.net/ and BD-free ‘Phibs at http://www.pijac.org/projects/project.asp?p=26). The Marine Aquarium Council (MAC) is an international association of conservation organizations, the aquarium industry, public aquariums, hobbyist groups, and government agencies. MAC promotes responsible and sustainable marine aquarium trade and the certification of best practices. MAC’s Handling, Husbandry, and Transport (HHT) International Standard ensures segregation from uncertified organisms, optimal health, and proper documentation during export, import, and retail sales. Organisms sold as MAC-certified must be handled only by MAC Certified professionals, facilities, exporters, and retailers. This is very similar to the Hazard Analysis Critical Control Point (HACCP)-based approaches.

Once a pet species has been freed, early detection and rapid response are essential if eradication is to prevent a full-fledged invasion. Free hotlines and/or bounties encourage reporting of sightings. Recording Invasive Species Counts (RISC) of the Non-Native Species Secretariat (NNSS) in the United Kingdom enables anyone to submit an observation/record, including uploading photos, of an animal or plant listed by the experts as invasive. The Aquatic Plant Information Retrieval System (APIRS) database at the Institute of Food and Agricultural Sciences, University of Florida (UF/IFAS) provides free information on aquatic weeds. After successful eradication, restoration is often attempted. Because eradication of aquatic organisms is nearly always impossible, containment in a certain area or watershed may be an option.
CONCLUSIONS AND FUTURE DIRECTION

Much work remains to be done in bringing the management level of the pet trade, including aquarium and terrarium species, to the standards of most other major IAS pathways. One well-recognized weakness lies in the international legislative framework, which is presently being addressed through a CBD AHTEG. However, numerous tools are already available for prevention, as well as mitigating a negative impact. Many of these are applicable to the WCR, some even spear-headed by the WCR. Their successful deployment invariably involves collaboration between the government and the private sector, coupled with public education and involvement. The joint development of VCoCs, as well as certification schemes, are instrumental in self-regulating the industry and raising public awareness.

REFERENCES


