

# On-line trade of aesthetic exotic organisms: sword of Damocles?

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*Exotic organisms introduced into non-native ecosystems may invade and affect the native biodiversity, which might lead to serious ecological, economic and sociological threats. Among the various pathways of introduction of non-native species, on-line pet trading is the most recently emerged method which facilitates rapid introduction of exotic species. Though on-line trading has become an influential factor for the growth of world economy in the current scenario, its role in the introduction of exotic species and their subsequent consequences in countries like India is least studied. In this article we delineate the role of on-line trading in importing alien species to our doorsteps, which can cause serious threats to India's biodiversity and economy in near future. Our web survey revealed that 910 varieties of exotic fishes and 14 exotic animals are being sold through unregulated on-line trading in India. The number of exotic species recorded in this survey is not conclusive and may be the tip of the iceberg when compared to the ground reality in the country. Our interaction with the local people exposed that most of the sellers and buyers are naïve about the consequences of introducing these species into our native ecosystems. Our extensive field survey revealed that most of the exotic fishes were maintained in open tanks and no regulations were adopted to curtail their escape during maintenance of tanks, rains and floods. Greater abundance and biomass of *Pterygoplichthys pardalis* than the native edible fishes in freshwater ecosystem in Madurai, Tamil Nadu, South India is an example of invasion of ornamental fish into the wild. Bringing policy-level changes, multidimensional approaches to regulate on-line trade of exotic species will pave the way for protecting the native ecosystem from encroachment of exotic organisms.*

**Keywords:** Aquarium trade, biodiversity, exotic organisms, invasion, on-line trade.

THE International Union for Conservation of Nature and Natural Resources (IUCN) defines invasive species as an alien species which becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity. Being the first phase in the process of invasion, introduction is facilitated by the movement of a species to a previously unoccupied area by the same or related species from its natural range assisted by external intervention<sup>1-3</sup>. The external intervention may be a natural phenomenon which enables extended dispersal across previously inaccessible borders, or by anthropogenic activity of commodity exchange and transportation across the globe<sup>4,5</sup>. Easier access to on-line trading portals and better

transportation of products could make this new pathway of exotic species introduction as dreadful as intentional introduction, and accelerate the spread and increase the odds of directed invasion<sup>6-8</sup>. The increase in the clutch of invasion inadvertently reduces the native species diversity. The ecological and economic losses caused by introduction of exotic organisms have been well documented<sup>9-13</sup>. Commercial trade of ornamental plants, fishes and other small animal pets are fortified due to increasing demands of hobbyists. Aquarium fish trade is predominantly capitalized on freshwater fishes, which makes up 90% of the trade<sup>14</sup>. About 26% of exotic freshwater fishes that invaded and established in the natural waters of USA has been introduced mainly through aquarium fish trade<sup>14</sup>. Nearly 100 species of aquarium fishes have been documented as introduced species in North American freshwater ecosystems via aquarium fish trade, of which up to 40 species have established populations<sup>15,16</sup>. In Florida, USA, at least 47% of negative effects imposed on the environment is rendered by the plants introduced for ornamental purpose<sup>17</sup>. Much recently, a focused mode of

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species introduction has evolved with the on-line trading of living organisms. This pathway is directed as the consumers mostly prefer exotic species that are not available in their own locality for ornamental or leisurely purposes. On-line trading can be a much focused mode of species introduction and more effective than the earlier studied pathways<sup>15,18–20</sup>. Reports exist on the negative consequences to the ecosystem and economy of the country on freshwater<sup>21,22</sup>, marine<sup>23,24</sup> and terrestrial<sup>12,13</sup> ecosystems. Many of the exotic species introductions have backfired and caused irreparable damage to the introduced ecosystem. However, the trend of introducing new, exotic species into the ecosystem is still increasing progressively. India being a vast country with innumerable bioresources across different terrains, there is a higher risk involved even in a controlled and conscious introduction of exotic species<sup>23</sup>. The objective of the present study is to report the role of on-line pet trade in exotic species introduction.

### Survey of exotic plants and pets sold on-line

To find out the number of exotic plants and pets sold on-line in India, we surveyed on-line trading sites specialized in this niche. Google search engine was used to survey the number of on-line aquariums and pet shops using the key words 'Aquariums in India', 'Online pet shops' and 'Exotic plants and fish in India for sale'. From the Google search results, the number of on-line shops selling exotic pets (viz. ornamental fishes, aquatic plants and other small animal pets) was surveyed state-wise. The results show that nine states/Union Territories (Andhra Pradesh, Chandigarh, Gujarat, Karnataka, Kerala, Maharashtra, New Delhi, Tamil Nadu (TN) and West Bengal) in India had on-line shops to market aesthetic exotic organisms. The total number of aquatic plants, fishes and small animal pets was recorded. Field survey was also carried out to observe the exotic pets and their upkeep in farms and commercial pet shops at Madurai, TN, South India. This was mainly intended to study whether any instructions are provided to the hobbyists regarding maintenance, reselling and releasing of exotic pets into the ecosystem. A case study is also reported regarding the establishment and invasion of an exotic aquarium fish *Pterygoplichthys pardalis* at Vandiyur Lake, Madurai.

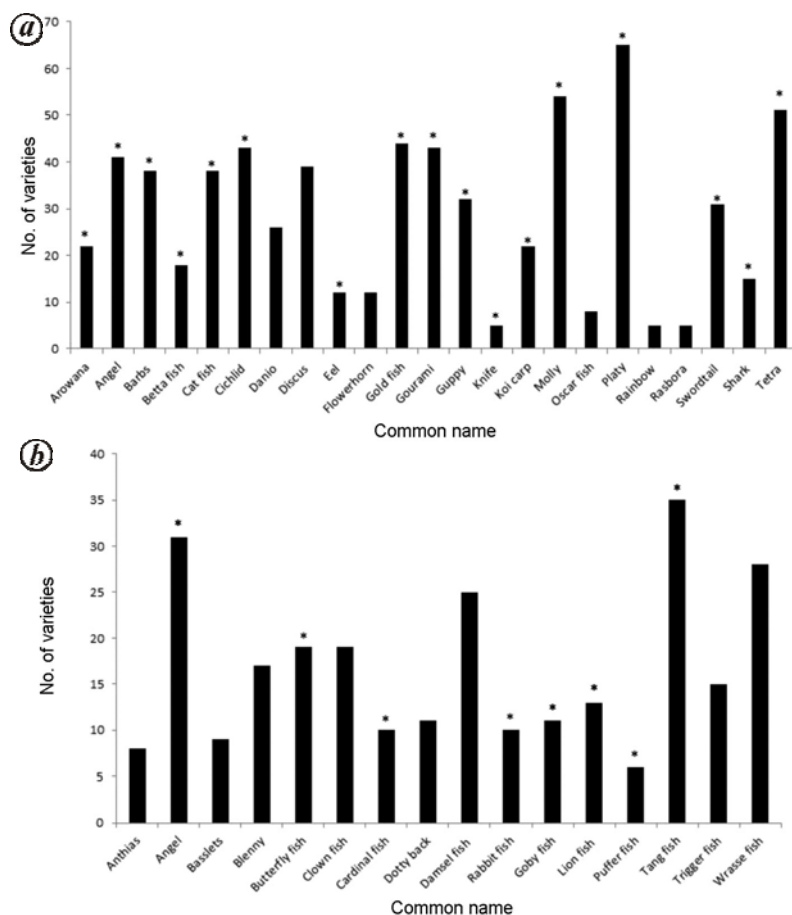
### Exotic aquatic plants and their availability in on-line stores

We found that 12 shops were involved in the marketing of aquatic plants through on-line trade, out of which 10 shops were selling aquatic plants along with exotic fishes and 2 shops were selling aquatic plants exclusively. About 15–25 plants were being sold at the price of hun-

dred to several hundred Indian rupees and they were delivered through courier service. Sixty-two exotic aquatic species of various cultivars and hybrids were sold through on-line stores. The morphological differences between the same species make them a different commercial entity for selling with a different name. More than 3000 terrestrial ornamental plants, including herbs, shrubs and trees are available through on-line shopping in India. We have postponed the survey of the plant species in our study due to the non-availability of resources and put our case forward with evidences collected from the on-line trading of aquarium plants, fishes and small animal pets.

### Exotic ornamental fish and their availability in on-line stores

Totally there were 21 on-line shops selling aesthetic exotic fishes all over the country, out of which 14 were selling both marine and freshwater fishes. Four shops were dedicated for selling exotic marine organisms and three for freshwater fishes. The fishes were identified by their common name(s). A total of 65 genera of freshwater fishes and 66 genera of marine fishes were found available in on-line shopping websites, comprising nearly 910 varieties of fishes (Appendix 1), with several fishes having invasive episodes in various countries (Figure 1). Different species of fishes are sold under the same common name. So, deducing the specific genus and name from the common name would be misleading. Thus, all the possible genera that can be linked to the respective common name were given (Appendix 1). Several shops were selling carnivorous, omnivorous and piscivorous fishes. Carnivorous fishes such as Arowana, Flowerhorn and Lionfish are becoming more popular among hobbyists. In marine organisms, sea anemones, star fish, crabs, shrimps, and eels were also sold in some shops. Flowerhorn and Arowana were sold as 'Vasthu fish', believed to bring luck and prosperity. Arowana was usually sold from several hundreds to lakhs of rupees depending on its size. For Flowerhorn fish, its hump and colour determine its price and demand. Cichlid fish was most prevalent due to 88% availability in the surveyed shops, followed by angelfish (82%) and goldfish (76%). Arowana and Flowerhorn were ranked at fourth and ninth place respectively, based on their availability in our survey. Among marine fishes, butterfly, tang and clown fishes were ranked in ascending order based on their availability (Table 1). Among the available websites, only 21 were involved in actual trading through on-line transactions. The remaining traders use the websites to provide information on prices and availability along with species profile. In addition, web directories and classifieds also provided information on local aquarium, pet shops and suppliers.



**Figure 1.** a, Marine and Brackish water fishes. b, Common freshwater fishes and their varieties marketed through on-line trade in India. Fishes with reported invasion episodes are marked as (\*).

### Exotic small animal pets and birds available in on-line stores

We have recorded 11 on-line shops selling exotic small animal pets in India. Lesser number of pet animal species were marketed on-line compared to the available plants and fishes. Thirteen exotic small animals were recorded which commonly included Rabbits, Guinea pig and Hamsters. Many uncommon pets were also recorded, viz. small primates like cotton top tamarin, marmosets, fox squirrels, hedgehogs, and reptiles like iguana and red belly salamanders (Table 2). Twenty-seven bird species were recorded in the surveyed shops, with lovebirds, pigeons and parrots being common.

### Condition in local aquarium

We visited local fish farms and aquariums to analyse the control measures adapted to contain the exotic organisms. In fish farms, exotic fishes were maintained in open cement tanks (Figure 2 a and b) and these tanks had open outlets for drainage (Figure 2 c). These open outlets end into small channels which are ultimately connected to the main drainage canals. Exotic fishes were observed in

these channels and canals. Juveniles of goldfish and black molly were common in these channels (Figure 2 d). The carnivore fishes Arowana (Figure 2 e) and flowerhorn were also maintained in the open tanks. Even a moderate amount of rainfall would be sufficient for these tanks to over flow and cause the fishes and their juveniles to escape. Exotic garden plants, birds and pet animals were also sold in these farms. We found that no proper measures were adopted to prevent the exotic species from escaping.

We also found that unmarketed plants (not part of this survey) were allowed to grow in the gardens (Figure 2 g). They are another group of potential invaders that could invade the adjoining ecosystem when their propagules and dispersal mechanisms are favoured by natural and non-natural sources. Exotic birds (Figure 2 h) were also common in most of the shops in Madurai.

### A case study on bioinvasion of *Pterygoplichthys pardalis*

Here we present a case study to support our view that escaping aquarium pets may cause adverse impacts on native ecosystems. We conducted a detailed and systematic

**Table 1.** Probability of invasion based on the propagule pressure (rank based on number of shops marketing a particular fish) of various freshwater fishes and marine organisms marketed through on-line trade in India

Fresh water fishes				Marine organisms			
Common name	Shops selling the fish	Total shops surveyed	Rank	Common name	Shops selling the organism	Total shops surveyed	Rank
Cichlid	15	17	1	Butterfly	13	18	1
Angel	14	17	2	Tang	11	18	2
Gold	13	17	3	Clown	10	18	3
Tetra	13	17	3	Damsel	9	18	4
Arowana	12	17	4	Trigger	8	18	5
Barb	11	17	5	Rabbit fish	8	18	5
Molly	10	17	6	Lionfish	8	18	5
Shark	10	17	6	Cardinal	7	18	6
Gourami	10	17	6	Gobies	7	18	6
Koi carp	10	17	6	Wrasse	6	18	7
Cat fish	9	17	7	Anthias	6	18	7
Discus	8	17	8	Puffer	6	18	7
Flowerhorn	7	17	9	Blenny	5	18	8
Guppy	7	17	9	Shrimp	5	18	8
Zebra	7	17	9	Anemone	4	18	9
Betta	6	17	10	Dottyback	4	18	9
Loach	6	17	10	Dragonet	3	18	10

**Table 2.** Common name, family and invasion status of small pet animals being sold in India through on-line trade

Common name	Family	Invasion status (other parts of the world)
Angora rabbit	Leporidae	No record
Rabbits	Leporidae	Invaded
Guinea pigs	Caviidae	Invaded
Hamsters (Chinese, Syrian, Russian Dwarf)	Cricetidae	No record
White mouse	Muridae	No record
Gerbil	Muridae	No record
Cotton top tamarin	Callitrichidae	No record
Hedgehogs	Erinaceidae	Invaded
Marmoset	Callitrichidae	Invaded
Iguana	Iguanidae	Invaded
Dwarf buffalo	Bovidae	No record
Dwarf goat	Bovidae	No record
Red Belly salamander	Salamandridae	No record
Fox squirrels	Sciuridae	No record

study after noticing a recurring occurrence of *P. pardalis* in the catches from the Vandiyur Lake, Madurai. This mesotrophic lake is located in the suburbs of Madurai city (9°55'N; 78°09'E) at an altitude of 126.3 m amsl. Its total surface area is 231.58 ha with depth ranging from 2 to 12 m. Our data on bioinvasion of *P. pardalis* were based on 30 catches made by fishermen during the study period (from 9 January to 20 February 2010). Its abundance and biomass in the fish catches from the lake varied daily and widely. However, it occurred consistently in all day catches and quantitatively exceeded all other edible fishes both in abundance and biomass. For instance, it exceeded 2 tonnes against 70 kg of edible fishes in biomass in the last catch dated 20 February 2010 before summer season. Abundance of other edible fishes averaged  $121.5 \pm 2.04$  (mean  $\pm$  SE) against  $171.6 \pm 31.33$  no./catch for 30 days sampling

period. Biomass of other edible fishes averaged  $22.9 \pm 2.26$  wet weight/kg/catch compared to  $326.1 \pm 59.52$  kg for *P. pardalis* and the difference was statistically significant ( $t = 5.173$ ;  $P < 0.001$ ). It clearly shows the negative impacts of this aquarium fish on fish culture in terms of diminished production of edible fishes. As this invasive species is non-edible or does not hold any known secondary values, its unmarketable biomass after harvest is being discarded on the shoreline (Figure 2f), where it is not even scavenged by piscivorous birds or carnivores. *P. pardalis* introduced as a pet has now become a pest.

## Conclusion

There are several reports on invasion ecology regarding the escape and establishment of aesthetic exotics in the

world. The Global Invasive Species Database reveals that 39 episodes of plant, 11 episodes of fish, 7 episodes of pet animal and 2 episodes of bird invasions have resulted from initial introduction as an aesthetic organism. It is evident that on-line trading could be a potent vector for the introduction of exotic species in India. Reports are already available regarding the presence of exotic ornamental fishes in Indian rivers<sup>25–27</sup>. Several ornamental fishes such as *Barbus tetrazona* (tiger barb), *Betta splendens* (Siamese fighter), *Epalzeorhynchus frenatus* (rainbow shark), *Hyphessobrycon eques* (serpae tetra), *Labeotropheus fuelleborni* (Fuelleborn's cichlid), *Oreochromis niloticus* (Nile tilapia), *Phractocephalus hypophthalmus* (iridescent), *Poecilia latipinna* (sailfin molly) and *Pterygoplichthys pardalis* (tank cleaner) have been reported in freshwater ecosystems of Uttar Pradesh, India with high invasion potential<sup>28</sup>. Our case study also clearly indicates the negative consequences of exotic aquarium fish *P. pardalis* on fish culture at Madurai.

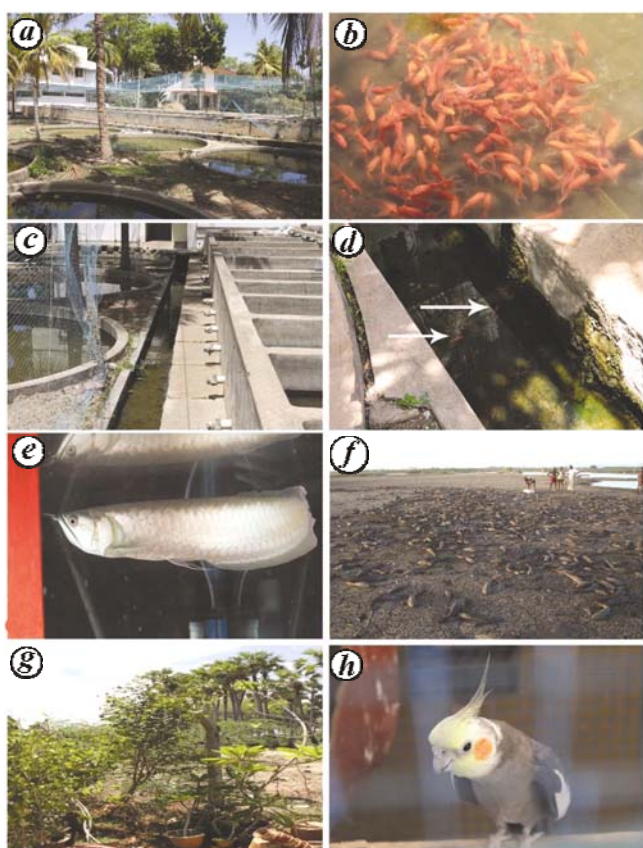
Small pets like iguanas and hedgehogs are now being sold in India, while there are reports regarding invasion at their introduced ranges at South Florida, Hawaii and New

Zealand. These small mammals and reptiles can collapse forest ecosystems and cause a heavy loss in species diversity if introduced in the wild.

We may have underestimated the impacts of introduced species into natural areas because these places are less intensively managed and studied than other agricultural and human-generated habitats<sup>29</sup>. These exotic species can cause huge economic loss<sup>9,11</sup> and severely upset the structure and function of the ecosystem<sup>23,30,31</sup>, and thus pose a substantial threat to the introduced ecosystem. Predicting the potentiality of introduced species is much complicated due to multiple factors playing a crucial role in determining their composition, abundance and diversity at various levels<sup>32</sup>. Predicting specific negative consequences and estimating their probability could be the central aspect of risk assessment<sup>33</sup>. Research on identifying the introduction pathways is a powerful tool for the management of alien species<sup>34</sup>. Policies and control efforts targeting pathways could be an effective way of addressing the present problems<sup>35</sup>. In India, studies on ecological impacts of exotic species and their introduction pathways are limited. Most of the available resources regarding species introduction and their impacts are mainly from developed countries. The developed countries contribute major research in biological invasions<sup>36</sup>, whereas such studies in the developing and biodiversity-rich countries like India are either insufficient or lacking<sup>37</sup>.

The knowledge gap between ecologist, resource managers and politicians creates confusion on effective conservation and management of natural populations from problematic invaders<sup>38</sup>. Such of gaps must be overcome and necessary policies are needed for managing these intentional introductions in a holistic way. A single-dimensional approach from a single platform cannot be effective in controlling these invaders, since multidimensional approaches from ecologists, bioresource specialists, academicians, politicians and public are needed for the planning and execution of any effective management strategies against these invasive species.

We must be open to taking lessons from accumulating experiences by other countries in tackling the invasive species<sup>39</sup>. Consolidation of gained information from collective experiences<sup>40</sup>, sharing the information across countries and continents, and comparative field analysis play a rudimentary role in the management of exotic and invasive species<sup>41</sup>. A managed database (Delivering Alien Invasive Species Inventories for Europe – DAISIE) was compiled by European countries for the management of biological invasions. The United States Department of Agriculture (USDA) and North Carolina State University, USA, developed a web application software for screening the sale of illegal NIS (non-indigenous species) using the internet<sup>42</sup>. Generation of basic scientific data by adopting research framework and policies with standardized methodology is the need of hour in India<sup>43</sup>.



**Figure 2.** *a*, An overview of an aquarium farm. *b*, Gold fishes maintained in an open tank. *c*, Open tank drainage outlet ending into a channel. *d*, Escaped juvenile fish seen in the channel. *e*, New arrival Arowana (the 'Vasthu' fish). *f*, Discarded unmarketable biomass of an aquarium fish *Pterygoplichthys pardalis*. *g*, Unmarketed plants establishing their population along the edges of the farm. *h*, A cockatiel.

**Appendix 1.** Common name and their corresponding genus of the available freshwater and marine fishes available through on-line trade in India

Common name	Genus
Freshwater fishes	
Cichlid	<i>Aequidens, Apistogramma, Aulonocara, Astronotus, Cichlasoma, Geophagus, Heros, Mikrogeophagus, Mesonauta, Nannacara, Papiliochromis, Pseudotropheus, Hemichromis, Rocio</i>
Angel	<i>Pterophyllum</i>
Gold	<i>Carassius</i>
Tetra	<i>Aphyocharax, Astyanax, Boehlkea, Gymnocorymbus, Hemigrammus, Hyphessobrycon, Megalamphodus, Moenkhausia, Nematobrycon, Paracheirodon, Phenacogrammus, Prionobrama, Pristella, Thayeria</i>
Arowana	<i>Osteoglossum, Scleropages</i>
Barb	<i>Puntius, Barbonymus</i>
Molly	<i>Poecilia</i>
Shark	<i>Balantiocheilus, Epalzeorhynchus, Luciosoma, Labeo</i>
Gourami	<i>Belontia, Macropodus, Pseudosphromenus, Trichopsis, Parasphaerichthys, Trichogaster, Trichopodus, Osphronemus</i>
Koi carp	<i>Cyprinus</i>
Cat fish	<i>Acanthicus, Corydoras, Hypancistrus, Hypostomus, Pterygoplichthys, Synodontis</i>
Discus	<i>Symphysodon</i>
Flowerhorn	Hybrid
Guppy	<i>Poecilia</i>
Zebra	<i>Danio</i>
Betta	<i>Betta</i>
Loach	<i>Botia, Nemacheilus, Schistura, Pangio, Acantopsis, Yunnanilus.</i>
Marine fishes	
Butterfly	<i>Amphichaetodon, Chaetodon, Coradion, Chelmon, Chelmonops, Forcipiger, Hemitaenichthys, Heniochus, Johnrandallia, Parachaetodon, Prognathodes, Roa</i>
Tang	<i>Acanthurus, Ctenochaetus, Naso, Paracanthurus, Prionurus, Zebrasoma</i>
Clown	<i>Amphiprion, Premnas</i>
Damsel	<i>Amblyglyphidodon, Chrysiptera, Chromis, Dascyllus, Pomacentrus</i>
Trigger	<i>Balistapus, Melichthys, Rhinacanthus, Sufflamen, Xanthichthys</i>
Rabbit fish	<i>Siganus</i>
Lionfish	<i>Pterois</i>
Cardinal	<i>Apogon, Cheilodipterus, Pterapogon, Sphaeramia, Zoramia</i>
Gobies	<i>Eviota, Elacatinus, Cryptocentrus, Gobiodon, Lythrypnus, Paragobius</i>
Wrasse	<i>Cirrhilabrus, Labroides, Pseudocheilinus, Wetmorella</i>
Anthias	<i>Anthias, Nemanthias, Pseudanthias</i>
Puffer	<i>Arothron, Canthigaster, Tetraodon</i>
Blenny	<i>Ecsenius, Meiacanthus</i>
Shrimp	<i>Lysmata, Rhynchocinetes</i>
Anemone	<i>Anemonia, Stichodactyla, Macroactyla, Entacmaea</i>
Dottyback	<i>Pictichromis, Pseudochromis, Pseudoplesiops, Manonichthys</i>
Dragonet	<i>Synchiropus</i>

In the last few years, *P. pardalis* invasion has been reported sporadically in the major water bodies and rivers in TN. The recreational practice of collecting exotic species and their subsequent escape or release pose a significant threat to the local ecosystem and livelihood of the people depending on it. The greater number of exotic species that are sold on-line can be directly correlated with the higher chances of escape or release into the wild, thus exponentially increasing the chances of invasion. The previously known pathways of species introduction have proved to be catastrophic and surely on-line trade of exotic organisms is like a 'sword of Damocles', unless we establish control over such sale of exotic species and prevent similar introductions.

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