

Risks associated with maritime routes to and within Galapagos¹

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Ships provide a transport medium for organisms that could pose a direct risk for Galapagos or a risk due to diseases that they might carry. Marine species may be transported in the hulls and ballast water while invertebrates, disease-vector insects, and vertebrates can travel as stowaways onboard ships or within food products, ornamental plants, or equipment that is being transported (Table 1). Also, some organisms are intentionally carried on board, such as pets or ornamental plants.

Table 1. Introduction pathways of invasive species by ships.

Introduction pathway	Organism transported
Ship in general	Reptiles, amphibians, rats, and other vertebrates; terrestrial invertebrates
Hull and anchor locker	Marine invertebrates, algae
Ballast water	Marine invertebrates, algae
Food (including live seafood)	Marine and terrestrial invertebrates, diseases
Ornamental plants and flowers*	Soil invertebrates, snails, aphids, scale insects, ants, disease vectors and the associated diseases
Standing water	Mosquitoes
Pets*	Birds and other vertebrates, diseases
Attraction to lights	Moths and other insects
Cargo, containers, and passenger luggage	Terrestrial invertebrates, reptiles, amphibians, and other vertebrates

* Intentional introduction

There is little information regarding species that have been transported to Galapagos in ships due to the fact that inspections have not been obligatory nor have they been carried out systematically (Zapata, 2007). For Galapagos, the most probable vectors for invasive species are international yachts and cargo ships, due to the frequency in which they arrive (approximately 20 and 85 times per year, respectively; Cruz *et al.*, 2007). For ships that travel to Galapagos directly from other countries, there is the additional risk of transporting species that are not yet found in continental Ecuador. In this article, we identify the principal vectors for invasive species associated with maritime routes and provide a few examples of incursions that have occurred in Galapagos.

¹ Taken from Cruz *et al.*, 2007.

Transport of marine organisms

Ships are the principal vectors for marine organisms. They can transport communities of species in the hull, the propeller and anchor lockers, on the exposed surfaces of water pipes on ships with a metal hull, and in the ballast water (Carlton, 1989). Species can also be transported as live seafood for consumption.

Currently there are no regular inspections of the hulls of the ships that travel to Galapagos and it is not known if invasive marine organisms are entering the archipelago. However, inspections were carried out for the arrivals of the M/N Discovery in 2006 and 2007. These inspections discovered various barnacles, one bivalve species of the Veneridae family that could have been discarded from the food supplies, and green filamentous algae Chlorophytas (Table 2) (GNPS, 2006).

International ships could potentially introduce diverse marine species because their routes connect the archipelago to different parts of the world, including the Baltic, northeastern and northwestern Atlantic, the Caribbean, the northeastern, southeastern, and southern Pacific, and Australia. Numerous marine species have been introduced to these regions and from these regions to others (Coles *et al.*, 1999; Hewitt, 2002). It is believed that the Caribbean is the greatest potential source of invasive species, followed by the northeastern Atlantic and the northeastern Pacific. All of these regions have an environment that is significantly similar to Galapagos ecosystems, suggesting that invasive species that arrive in Galapagos from these areas have a greater chance for survival and establishment.

Some invasive species with a high probability of being transported to Galapagos are: the sea star *Asterias amurensis*; the barnacle *Chthamalus proteus*; the mollusk *Mytilopsis sallei*, and the alga *Undaria pinnatifida*. Characteristics common to all of these species include colonization at high densities, modification of native communities, and potential to cause extensive and costly damage to marine equipment, ships, and the mariculture (NIMPIS 2002; Global



Photograph: Mandy Trueman

Invasive Species Database).

Transport of terrestrial invertebrates and plants

Terrestrial invertebrates can be transported to and spread throughout Galapagos by being attracted to the lights on ships, in ornamental plants, on pets, in food products or wood, in fresh water containers, or simply as stowaways (Table 1).

The transport of terrestrial invertebrates in ships has not been well documented in Galapagos, although there are a few examples (Table 2). In the first visit of the international cruise ship M/N Discovery, 16 invertebrate species were found without conducting an exhaustive search (Roque-Albelo *et al.*, 2007). Of these, at least 11 insect species and two families are not registered in Galapagos and represent a risk to the islands if they are introduced and become successfully established. The majority of the insects collected were moths (Lepidoptera) found on deck, probably attracted to lights. Although the ship carries out measures to diminish the risk of transporting insects, 58 live individuals and 17 species of insects were found in the third visit of this ship in April 2007 (Azuero *et al.*, 2007).

Table 2. Introduction pathways reported for organisms transported to Galapagos in ships.

Introduction Pathway	Type of ship	Transported organisms
Hull	International cruise ship	Marine invertebrates (barnacles and a bivalve of the Veneridae family), green algae Chlorophytas
Attraction to lights	International cruise ships and local tourist boats	Moths (Lepidoptera), flies and mosquitoes (Diptera), wasps and ants (Hymenoptera), scale insects and aphids (Heteroptera), crickets (Orthoptera), lacewings (Neuroptera), beetles (Coleoptera), cockroaches (Blattoidea), wasp parasites (Strepsiptera)
Ornamental plants	International cruise ships, international yachts, local tourist boats	Ants, scale insects, snails, soil invertebrates (millipedes, isopods, wood lice, worms, silver fish)
Intentional introduction	International yacht	Monkey, plants, dogs
Stowaways onboard	Local tourist boats, fishing boats, cargo ships	Rats, cockroaches, ants, wasps, iguanas
Stowaways in luggage	Local tourist boats	Reptiles: lizards
As pets	Cargo ships, international yachts	Cats and dogs

A study carried out in 2002 showed that local tourist boats can also be important dispersal agents for insects between islands, including moths, flies, mosquitoes, wasps, and ants, among others (Roque-Albelo *et al.*, 2006, Roque-Albelo *et al.*, this document). The transfer of endemic Galapagos species between islands by local tourist boats could interfere with normal evolutionary and biogeographical processes, while the transport of aggressive invasive species aids their dispersal, increasing the impact on the archipelago.

Ornamental plants provide an effective medium for transporting terrestrial invertebrates, including ants, fitophagous insects and plant disease vectors, snails, and soil invertebrates. A large number of ships that visit the Galapagos Islands or work in the Galapagos Marine Reserve have live plants onboard. Examples of invertebrate species transported to Galapagos on plants onboard international ships include ants and scale insects (Roque-Albelo *et al.*, 2007; D. Arana, SESA-SICGAL, pers. com.). Invertebrates have also been transported to Galapagos on local tourist boats that travel to continental Ecuador or Panama for general maintenance. In 2006, five invertebrate species were found in potted plants recently bought for local tourist boats (F. Bersosa, CDF, pers. com.). These ornamental plants, in addition to being associated with insects or pathogens, could also pose problems themselves, as they are

known to be invasive plants in other parts of the world. Occasionally, visitors to Galapagos have given plants as gifts to members of the local community.

Given their small size, invertebrates can hide in food, in other products taken to the islands, or in standing water, as is the case with mosquitoes (Lounibos, 2002). The abundance and diversity of terrestrial invertebrate species (37 species) found in the permanent traps used on the M/N Discovery indicate that one could encounter invertebrates at any moment (Roque-Albelo *et al.*, 2007). This is especially the case for cargo ships where there is much disorder and the food products are not transported in sealed containers.

Transport of vertebrates

Vertebrates can be transported on ships as stowaways. They can also be intentionally introduced to Galapagos. In addition to being a threat due to the impact that they can have as plague species themselves, they can act as vectors for diseases that could affect both humans and native animals.

In an analysis of the transport of rats to and among the Galapagos Islands in 1991, rats were found on 3 of the 42 local tourist boats (7%), 2 of 7 fishing boats (29%), and 1 cargo ship (Calvopiña, 1991). According to Zapata (2007), there is no compliance with the "Procedure for Fumigation during Maritime Transport from

the Continent to the Province of Galapagos" established in 2005² and there is still a need to describe in greater detail the procedures for fumigation and rat extermination for boats. It is known that until recently, some cargo ships used cats to capture rats (D. Arana, SESA-SICGAL, pers. com.).

Other vertebrates that have arrived in Galapagos as stowaways include reptiles. During seasons of high densities of green iguanas (*Iguana iguana*) in Guayaquil, this species has successfully boarded cargo ships, aided by the lack of mechanisms to isolate the ships from possible intrusions (R. Rivera, SESA-SICGAL, pers. com.). There are documented instances of green iguanas being transported to Galapagos (D. Arana, SESA-SICGAL, pers. com.). Meanwhile, a lizard *Eumeces inexpectatus* from the southeastern United States was discovered in the luggage of a tourist on San Cristóbal (Saavedra, 2006). Although their origin and transport pathways have not been confirmed, some introduced species, such as geckos and the frog *Scinax quinquifasciatus*, could have arrived in Galapagos by ship (Tapia *et al.*, 2000).

There have been cases where travelers on boats have gone onshore illegally with pets, such as dogs and a monkey, and instances when these animals have been given to local residents as gifts (D. Arana, SESA-SICGAL, pers. com.). There are also reports of pigs and other domestic animals being introduced via boats (D. Arana, SESA-SICGAL, pers. com.).

Conclusions and recommendations

Given the scarcity of data it is difficult to conduct a complete analysis of the species transported to and among the Galapagos Islands by ships. However, with the evidence in Galapagos and other countries, it can be shown that ships provide introduction pathways for both invasive marine and terrestrial species. With the current increase in the number of cargo ships and private yachts traveling to and among the Galapagos Islands, the rate of introductions is predicted to increase unless an effective biosecurity system is implemented.

Compared with the damage produced by invasive species and the associated costs, the investment in prevention is low and, as such, the prevention of more introductions via the maritime pathway should be considered high priority. The following measures are recommended as a way of lowering the risk of dispersal of both plants and animals via ships:

1. Update and approve the procedures for the fumigation of boats, based on the recommendations of Zapata (2007), expanding the procedures to cover all of the possible entrance routes for invasive marine and terrestrial species.
2. Provide training sessions on best practices for transportation operators, certified fumigation companies, and inspectors of SESA-SICGAL, among others.
3. Establish a data registry on the movement of ships to and among the Galapagos Islands, including the origin of the ship, its fumigation status, sanitary conditions, and last port of departure.
4. Limit access ports, both on Galapagos and the mainland, with the goal of concentrating and improving the inspection capacities of SESA-SICGAL, at the same time minimizing potential entrance routes for exotic species.
5. Avoid the movement among islands of international ships and other boats not registered in Galapagos.
6. Strengthen the inspection of mediums of transport and cargo and ensure sufficient infrastructure.
7. Design a monitoring system for early detection of invasive marine species and strengthen the monitoring system of invasive terrestrial species.
8. Develop contingency plans for rapid response to the introduction of high risk species.

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