



Risks associated with current and proposed air routes to the Galapagos Islands¹

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There is ample evidence demonstrating that animal and plant species can be transported by aircraft in both cargo and personal luggage of passengers and crew, as well as elsewhere inside the aircraft. If they successfully colonize the islands, some of these exotic species will pose a danger to humans and to the biodiversity of Galapagos, due to their potential for disease transmission or aggressive invasiveness. Beyond the potential danger for human health and negative impacts on both the environment and the local economy, exotic species require extremely expensive eradication or long-term control programs if eradication proves impossible.

There are numerous records of species entering the Galapagos Islands in luggage and cargo. In 2006, data from the Quarantine Inspection System for Galapagos (SICGAL) show that **1022** infested products were confiscated at the airports, as well as other products that are not allowed entry into Galapagos. Moreover, an assessment of inspection effectiveness² shows that current control activities do not prevent entry of species from outside Galapagos. The actual rate of interception by inspectors is **1** interception for every **8230** entries of individual plants and invertebrates.

Although cargo and luggage have been shown to be significant means of introducing exotic species into Galapagos, the extent to which airplanes themselves are potential vehicles for carrying new species to the islands has not been thoroughly evaluated. The goal of this analysis was to determine the potential of aircraft as vectors for exotic species that pose a high risk to Galapagos. Results of Phase 1, the assessment of the increase in air traffic over the last few years, are outlined in the previous article, "*Air traffic to Galapagos is Increasing.*"

Risks associated with current commercial flights

Invertebrate monitoring at the airports has demonstrated that despite the initiation of an insect fumigation system for commercial airlines in November 2005, an average of 0.71 invertebrates per inspected airplane

The introduction of harmful exotic species can endanger human health, have negative impacts on biodiversity, and result in very expensive eradication or long-term control programs when eradication proves impossible.

arrived during the first half of 2006. It is estimated that at least **779** invertebrates entered by aircraft during that period (Table 1). A total of **30** live invertebrates were collected in commercial airplanes between July and December 2006, 22 at the Baltra airport and 20 in San Cristóbal. An additional **2** insects were collected from the military's logistical airplane in Isabela. In Baltra, **72%** of inspected airplanes had insects present. The 19 live invertebrates encountered included spiders, crickets, flies, and 3 mosquitoes, 1 of which was full of blood. In San Cristóbal, invertebrates were found on 35% of the commercial airplanes; none were found on the 3 charter flights that were inspected. The 11 live insects collected included ants, cockroaches, flies, and 2 mosquitoes. All of the insects collected were found in the holds of the aircrafts, except for one mosquito found in the cabin. The logistical airplane inspected in Isabela had a cockroach and a moth³.

The risk of introducing live invertebrates into Galapagos is expected to increase during the rainy season, when invertebrates are typically more abundant. However, the SESA-SICGAL inspections reported here were conducted during the cool season when insect activity is lower. The risk of transporting invertebrates to the Galapagos is also predicted to increase whenever any species increases its population on the mainland. For example, in January 2007, there was an outbreak of crickets around the Guayaquil airport resulting in many stowaways on airplanes to Baltra⁴.

In Baltra, 72% of inspected airplanes had insects present.

Table 1. Live invertebrates found in airplanes checked in Baltra, San Cristóbal, and Isabela.

Airport	Airline	No. of airplanes inspected (No. with invertebrates)	Live invertebrates	
			Number	Order: common name
Baltra	TAME	11 (6)	5	Arachnidae: spider (1) Diptera: mosquito (1) Orthoptera: cricket (3)
	AEROGAL	11 (10)	14	Arachnidae: spider (3) Diptera: fly (7) Diptera: mosquito (2) Hymenoptera: wasp (1) Orthoptera: cricket (1)
San Cristóbal	TAME	10 (3)	4	Diptera: fly (2) Hymenoptera: ant (2)
	AEROGAL	10 (4)	7	Blattaria: cockroach (1) Coleoptera: beetle (1) Diptera: mosquito (2) Hymenoptera: ant (2) Orthoptera: cricket (1)
	Charter flights (2 by ICARO)	3 (0)	0	
Isabela	Military Logistical	1 (1)	2	Blattaria: cockroach (1) Lepidoptera: moth (1)

Source: Cruz JD & Causton C (2007)¹

Risks associated with current and new routes of private flights to the Galapagos

The principal risk associated with permitting flights from international airports or Ecuadorian airports other than those with SICGAL infrastructure is that they connect Galapagos to places with species that have not yet been reported in the archipelago. This increases the probability of new invasive species reaching the islands. Private or charter flights that arrive directly from other countries¹ create new and dangerous routes for the introduction of invasive species that are not yet present in mainland Ecuador and therefore not a risk from domestic commercial flights or cargo ships. The map in Figure 1, showing current and proposed routes to the Galapagos Islands and the distribution of some high risk species, demonstrates the ease of transporting species to Galapagos that are alien to mainland Ecuador and the archipelago.

Further, opening new airports in the Galapagos will connect islands that have had no direct link to mainland Ecuador or other countries, facilitating the arrival and establishment of introduced species. The construction of an airport on Isabela for airplanes arriving directly from the mainland increases the risk of introduction and range of dispersal of new exotic species. As the largest of the Galapagos Islands (>50% of the total land area), Isabela has the largest proportion of endemic species and, therefore, the potential consequences of the introduction and establishment of invasive species are significant. Isabela is also located close to the most pristine island, Fernandina, and could provide a steppingstone for invasive species to reach that island. Presently, it is less likely that introduced species will become established on these islands because they must disperse from San Cristóbal or Baltra.

Flights directly from other countries and opening new airports in the islands will create new, dangerous routes for the arrival of invasive species, which could influence the unique evolutionary processes of the Galapagos biota.

Risks associated with initiating night flights to Galapagos

We know of no environmental assessments of the impacts of landing strip lights or air activity on biodiversity in Baltra or the nearby islands¹. Increasing flight schedules to include night flights is expected to increase the diversity of invasive species potentially transported to Galapagos, such as species of mosquitoes and moths. Moreover, lighting of airports and aircraft will attract more insects, increasing the probability of accidentally introducing them into airplanes and transporting them to the Galapagos. Night flights will also increase vehicle traffic between Puerto Ayora and the Itabaca Canal, with the associated risk of increasing the probability of negative impacts on night birds, which are often affected by lights⁵.

Other risks

In addition to the risk of introducing highly aggressive invasive species, flights may interfere with evolutionary processes in Galapagos. The interesting, unique island species have often resulted from slow evolutionary processes related to genetic isolation and adaptive radiation. Introduction of a mainland species with phylogenetic affinities to endemic Galapagos species could influence the speciation process and the uniqueness of the Galapagos biota.

Organisms posing a high risk for the Galapagos

Some examples are given below of high-risk species that could reach the Galapagos via aircraft. These species could cause significant impacts on the natural ecosystems and potentially damage sustainable development in the archipelago.

Disease vector insects

There is a risk of disease vectors entering and affecting human beings and the biodiversity of Galapagos. So far, the Galapagos remain free of these kinds of diseases, with the sole exception of dengue fever, transmitted by the *Aedes aegypti* mosquito, introduced in 2001. The route of introduction has not been determined. An international workshop in 2000 on threats to Galapagos birds identified **11** serious diseases that have not yet reached the Archipelago⁶.

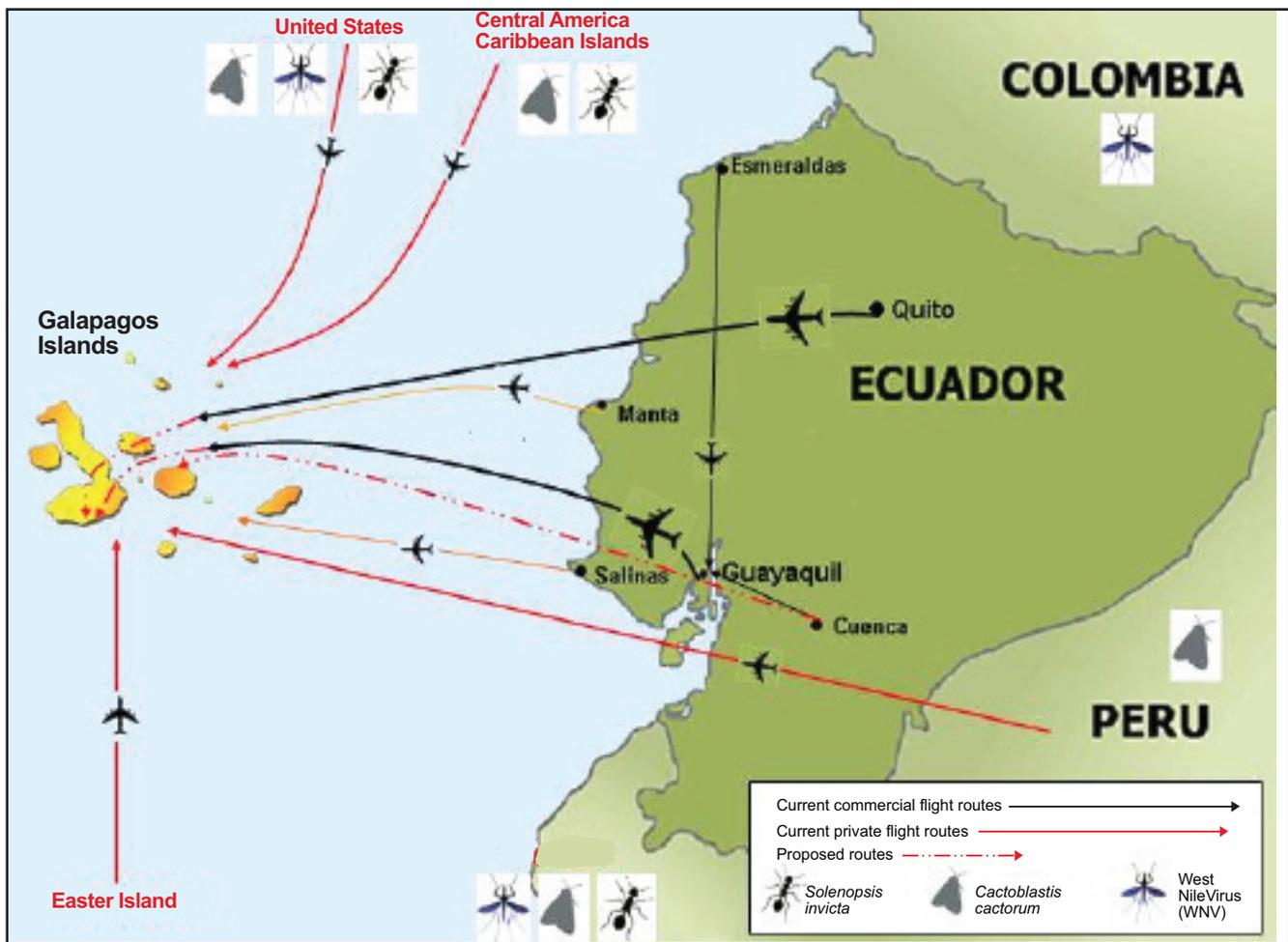
Introduction of the West Nile Virus (WNV) into Galapagos is of special concern because it would affect both the biodiversity (birds and reptiles) and human beings. A risk analysis by a team of experts examining potential methods of transport of WNV to Galapagos determined that aircraft is the method that poses the greatest risk⁷. There is currently the risk for WNV to enter the islands via private flights from countries with the disease (Fig. 1). At this time, WNV has not been reported in Ecuador, but its presence is documented in Colombia⁸.

Other invertebrates

According to Rogg,⁹ there are at least 53 high-risk species for the Galapagos that could still enter the islands on aircraft from mainland Ecuador. The number of invasive species that could be introduced from other countries is much higher.

The West Nile Virus (WNV) is one of the most alarming diseases that have not yet reached Galapagos; however, aircraft represent the method of transport of greatest risk.

Figure 1. Current and proposed flight routes to Galapagos and distribution of some invasive species posing a high risk for the Galapagos



Source: Cruz JD & Causton C. (2007) ¹

In addition to the risk from domestic commercial flights, international routes¹ provide entryways for other species known to be invasive in other parts of the world, which could have the same or even greater impacts in Galapagos. For example, species such as the fire ant, *Solenopsis invicta*, identified as one of the world's 100 most invasive organisms¹⁰, has a high probability of being transported in international airplanes (Fig. 1). This ant could affect human health and alter native invertebrate and vertebrate communities, either as a predator or simply by killing other species with its sting.

Another species of great concern for Galapagos is the cactus-boring worm, *Cactoblastis cactorum* (Lepidoptera). This species could be introduced into the Galapagos via its adult phase, a night moth attracted by lights. The ecological consequences of introducing *C. cactorum* into the islands could be very serious. This species could quickly destroy the populations of *Opuntia* cactus, one of the signature plants of Galapagos.

At least 53 high-risk species could enter the islands on aircraft from mainland Ecuador; the number is much higher from other countries.

Vertebrates

Animals stowing away on aircraft are not limited to invertebrates, but can also include reptiles, amphibians, and other vertebrates¹¹. One example is the spread of the invasive brown tree snake from Guam Island. This snake can wrap itself around plane wheels or get into holds, and has been reported to have been introduced via airplanes flying to Hawaii and other islands of the Pacific, Singapore, Taiwan, and Australia. This snake has not only affected biodiversity as a predator of birds, but has also affected local economies. The annual losses resulting from damage to electrical systems in Guam are estimated at some US\$ 4 million¹².

Conclusions and recommendations

There are many invasive species, such as snakes, insects, and viruses, that have not yet reached the Galapagos Islands and could be introduced via aircraft.

Despite the insect fumigation system being applied, invertebrates are still reaching Galapagos via airplanes. Records of organisms detected in cargo and

luggage indicate that commercial flights and their cargo are already vectors for introduced species. The risk of introducing new species will increase with the increase in the number of commercial flights to Galapagos and the incorporation of proposed new routes and schedules, including night flights.

Both the occasional arrival in the Galapagos Islands of private flights directly from other countries and non-inspection of charter or private flights from mainland Ecuador bring the risk of transporting invasive species and diseases from other countries, which are not yet found in mainland Ecuador.

Based on the high risk of introducing invasive species to Galapagos with an expansion of flights, it is considered critical to minimize routes to the archipelago. It is also important to consider a substantial increase in the resources required to strengthen SICGAL and ensure a stable legal framework for its effective operation.