ALIEN ARTHROPOD SPECIES DETERRED FROM ESTABLISHING IN THE GALÁPAGOS, BUT HOW MANY ARE ENTERING UNDETECTED?

Charlotte E. Causton, Carlos E. Zapata and Lázaro Roque-Albelo

INTRODUCTION

The greatest threat to the biodiversity of the Galápagos Islands is the introduction of alien organisms. The growth of tourism and associated migration of people to the islands in the last 20 years has brought about a dramatic rise in the number of accidental and intentional introductions. To date, 24 species of vertebrates, more than 500 plant species, and at least 300 invertebrate species have been introduced into the Archipelago (Snell *et al.* 1996; Mauchamp 1997; Peck *et al.* 1998, Tye in prep.). Many of these species feed on the native and endemic flora and fauna and, in some cases, may displace them. As a result of this, some Galápagos organisms that were common 20 years ago are now rare.

New species are arriving on a daily basis. To reduce the rate of new arrivals, it is imperative that measures are taken to prevent species from reaching the Archipelago, based upon the quarantine regulations established under the International Plant Protection Convention. In response to this, a task force, composed of representatives from the Galápagos National Park Service (GNPS), the Charles Darwin Research Station (CDRS), the National Institute of Galápagos (INGALA), and the Provincial Agricultural Office (DPA) (an annex of the Ministry of Agriculture) was formed in 1997 to find mechanisms to implement a much needed quarantine and inspection system for the Archipelago. The "Sistema de Inspección y Cuarentena para las Islas Galápagos" (SICGAL), proposed by Whelan (1995), recommends regulatory control and inspection points for mainland Ecuador and the Galápagos Islands. A monitoring system to detect the arrival of new organisms is proposed, as well as an environmental education program to increase the awareness of the general public and others of the impact of introduced species. This proposal also includes complementary tactics for reducing the number of introductions, such as increasing local farm production and building a waste disposal system.

Since the SICGAL proposal was written, a series of actions have been taken with the aim of reducing the number of introductions to the islands. The enactment in 1998 of the Law of the Special Regimen for the Conservation and Sustainable Development of the Province of the Galápagos and the general regulation for this law (January 2000) have given the islands some legislative support to implement a quarantine and inspection system.

Meanwhile, special regulations will be promulgated within the next six months to define the procedural framework of SICGAL, the implementation of fees for service, and the identification of offences and penalties for non-compliance. These regulations are particularly important, as the success of the system ultimately depends on the step-by-step inspection and monitoring procedures that will be identified by the law. On the other hand, the use of user fees in addition to revenue from 5% of the tourist entrance fees to the Galápagos National Park should ensure the sustainability of the system.

On May 31, 1999, a pilot quarantine control and inspection program, funded by USAID, was initiated in the Galápagos Islands. In the first year of this program, six Galápagos residents were accredited as inspectors and were responsible for checking incoming hand luggage and cargo in Baltra, Santa Cruz, San Cristóbal, and Isabela. Personnel numbers have increased to 38 inspectors in the second year, and inspection and control points are currently being set up in Guayaquil and Quito.

Complementary to this, a list of permitted and prohibited products, devised by stakeholders in a participatory process and approved by the Ecuadorian Service for Animal Health (SESA) and the PNG, has been published. Intensive education campaigns have produced TV and radio spots, leaflets, and posters with the aim of raising public awareness of the impact of introductions and the benefit of the new quarantine restrictions. Meanwhile, registers and forms for collecting all data relevant to the inspection process have been designed.

ALIEN SPECIES DETECTED BY SICGAL INSPECTORS

During the first seven-month period to December 1999, 33 arthropod species were detected during the inspection of personal baggage and commercial consignments of imported goods (Table 1). In addition to this, 90 plant and animal products (including a Cyperaceae sedge with roots, a rabbit, and a fighting cock!) were confiscated. Although inspection activities at this time were being carried out at a quarter of the capacity identified as necessary to implement the program in its entirety (only hand luggage and a limited amount of cargo were being inspected), the number of insects detected is an indication that additional species are being introduced through other unmonitored pathways.

Port of entry	Pathway	Order	Species	Common name
B	Flowers	Homoptera	unidentified	scale insect
B	?	Lepidoptera	unidentified	moth larva
B	Fruits	Diptera	*Drosophila* sp.	pomace fly
B	Vegetables	Coleoptera	unidentified	ladybird
B	Mango	Diptera	*Anastrepha fraterculus*	fruit fly
B	Fruits	Hymenoptera	*Tapinoma* sp.	ghost ant
B	Corn	Lepidoptera	*Helicoverpa zea*	corn ear worm
B	Vegetables	Hemiptera	unidentified	
I	Beans	Diptera	unidentified	
I	?		unidentified	
I	Dried Beans		unidentified	weevil
SC	Vegetables	Lepidoptera	unidentified	moth
SC	?	Hymenoptera	unidentified	ants
SC	Fruits	Diptera	unidentified	flies
SC	?	Lepidoptera	unidentified	moth
SC	Seeds		unidentified	
SC	Fruits	Acari	*Tetranychus urticae*	two spotted mite
SC	On cargo boat	Lepidoptera	*Thyrinteina arnobia*	geometrid moth
SC	Fruits		unidentified	
SC	Fruits		unidentified	
SC	Vegetables		unidentified	
SC	Cabbage		unidentified	
SC	Fruits	Lepidoptera	unidentified	moth
SC	Vegetables		unidentified	
SC	?		unidentified	
SC	Vegetables		unidentified	
SC	Melon	Orthoptera	unidentified	
SX	Vegetables	Diptera	unidentified	flies (several species)
SX	?	Coleoptera	unidentified	beetle larva
SX	On cargo boat	Lepidoptera	*Thyrinteina arnobia*	geometrid moth
SX	?	Diptera	unidentified	flies
SX	Vegetables		unidentified	
SX	Flowers	Lepidoptera	unidentified	moth larva
SX	Vegetables	Lepidoptera	*Spodoptera* sp	
SX	Corn		unidentified	

Table 1. Arthropods detected by SICGAL inspectors from June-December 1999 (Ports of entry: B = Baltra, I = Isabela, SC = San Cristóbal, SX = Santa Cruz)

Even more alarming is that some of these species are recognized pests on the mainland and in other parts of the world. Several species that have arrived in the last seven months are of particular concern. In September 1999, eggs and adults of a geometrid moth, *Thyrinteina arnobia* Stoll, were found on two different cargo boats delivering goods to San Cristóbal and Santa Cruz. This species was responsible for defoliating hectares of mangrove forests, primarily red mangrove (*Rhizophora mangle* L.), from August-September in the Guayas region of Ecuador ("El Universo," 11 August 1999).

The establishment of *T. arnobia* in the Galápagos is particularly worrying given that four species of mangrove trees are native to the Archipelago, including the red mangrove. Following its identification, inspectors were alerted to the importance of detecting further incursions of this species and periodic targeted monitoring has been carried out in the mangrove trees near the port of entry. Like many species of insect, *T. arnobia* flies towards lights and was probably attracted to the lights of the cargo boats in the port of Guayaquil. Movement of insects by boats was reported in the 1970s (Silberglied 1978), but with the increase in boat traffic (cargo ships and tourist vessels) this mode of transport has contributed to the introduction of insects to the Galápagos from the mainland and is responsible for the spread of species between the islands of the Archipelago.

The pathway with the highest number of introductions in the first seven months of the program was the importation of fruit and vegetable products (Table 1). Due to staff shortages, inspectors concentrate on checking fresh produce and this might explain why few insects were intercepted on other pathways. However, the increasing consumer demands of the Galápagos residents requires that a high number of perishable goods are imported every month, increasing the risk that arthropods associated with crops are imported (Zapata *et al.* in press). Some of the species that we were able to identify are known to be aggressive agricultural pests in other parts of the world.

Prior to approval of the permitted product list, corncobs were regularly imported with their outer leaves, providing a refuge for several unidentified Lepidoptera and Diptera, in addition to *Helicoverpa zea* (Boddie). Commonly known as the corn earworm or tomato fruit worm, this is a pest of corn, but has a greater impact on tomato crops. This is the first time that it has been reported in the Galápagos. *Helicoverpa zea* is polyphagous and could feed on native species. The greatest threat, however, is to agricultural crops. Tomatoes and corn form part of the basic diet of the Galápagos residents. Incentives and training are currently being offered to farmers to increase local agricultural production, with the aim of reducing imports from the continent and the risk of new incursions. The introduction of pests like *H. zea* could affect yield considerably.

Fruits are also important hosts of arthropods, including some of the most aggressive pests known in the world, such as scale insects (Homoptera) and fruit flies (Diptera: Tephritidae). On checking a shipment of mango fruits in October 1999, SICGAL inspectors found the majority infested with up to ten larvae of a fruit fly. This detection caused huge concern, as the introduction of fruit flies into the Galápagos could affect both local agricultural production and native plants. Many species are polyphagous, with some known to be pests on up to 200 species of plants (White and Elson-Harris 1992). Fortunately, the fly was identified as *Anastrepha fraterculus*, the only species of fruit fly already present in the Galápagos. It was believed to have been originally brought in on guava (Foote 1982, Harper *et al.* 1989).

NEXT STEPS

Many of the specimens collected by inspectors in the first year of the program could not be identified rapidly, since specialists were required to identify them. Others were submitted to the entomologists in poor condition. Quick identifications are needed to determine whether a species intercepted by inspectors is a newly arrived species that requires immediate action to be taken to prevent its establishment, or is one that is already present in the Galápagos. For this, a series of steps needs to be taken. Firstly, we need to expand the recently created CDRS reference collection to ensure that all species found in Galápagos are represented in the collection. Technical staff also need to be on hand for diagnostic services and, lastly, a network with international specialists should be set up for remote interception diagnostics.

Knowing what species are entering Galápagos will also enable us to find out which groups are introduced on a regular basis and which pathways require stricter controls. It will not give us an indication of the number of species that are entering undetected. To be able to determine how many species are able to evade the barriers at the ports of exit and entry to the Galápagos, a system will be set up in the Archipelago to monitor the arrival of new species. Contingency plans will be available in the event that a species that has been classified as a potential threat to the Galápagos manages to reach the Archipelago. With these measures and the stricter controls that will be provided by the inspectors and the regulations, the number of incursions should be reduced considerably.

CONCLUSIONS

Due to its isolation (1000 km from the closest land mass) and its recent colonization, the Galápagos Archipelago is fortunate to still have 96% of its original flora and fauna (Gibbs *et al.* 1999). Unfortunately, this biodiversity is now under threat from insects and other arthropods that are being detected in the increasing volume of imported fresh fruit and vegetables. Preventing new species entering Galápagos through the operation of the SICGAL inspection service is a small investment compared with the costs incurred by their effects on Galápagos biodiversity, agriculture, and human health, in addition to those involved in running control and eradication programs.

Achieving these goals requires a two-stage approach. An initial injection of funds is needed to train inspectors, run education programs, prepare procedures manuals, and construct inspection facilities and diagnostic laboratories. Once the system is set up, income generated from user fees and the tourist park entrance fees should cover maintenance costs, salaries, training, and communication campaigns. Multilateral and bilateral donor agencies such as the Global Environment Facility, Ted Turner's United Nations Foundation, UNESCO, and the Spanish International Cooperation Agency have recognized the threat of alien species and have begun to participate actively in the implementation of SICGAL. If all goes to plan, the quarantine and inspection system should be complete within the next four years and the influx of introduced species effectively controlled and monitored.

ACKNOWLEDGEMENTS

We thank Linda Pitkin (Natural History Museum, London) and Patricio Ponce (Ponficial Catholic University of Ecuador, Quito) for helping in the identification of the insect specimens, and Robert Bensted-Smith, Robert Ikin, Marc Patry, Alan Tye, Mark Gardner, and Charles and Caroline Catt for reviewing the manuscript. We would also like to thank USAID for the financial support to implement the pilot quarantine and inspection system.

LITERATURE CITED

Foote, R.H. 1982. The Tephritidae (Diptera) of the Galápagos Archipelago. Memoirs of the Entomological Society of Washington 10: 48-55.

Gibbs, J.P., H.L. Snell, and C.E. Causton. 1999. Effective monitoring for adaptive wildlife management: lessons from the Galápagos Islands. Journal of Wildlife Management 63 (4): 1055-1065.

Harper, J.D., J.S. Escobar, and G. Cereceda. 1989. Collection of *Anastrepha fraterculus* on Santa Cruz Island, the Galápagos Province, Ecuador. Florida Entomologist 72: 205-206.

Mauchamp, A. 1997. Threats from alien plant species in the Galápagos Islands. Conservation Biology 11: 260-263.

Peck, S.; J. Heraty; B. Landry; and B. J. Sinclair. 1998. Introduced insect fauna of an oceanic archipelago: the Galápagos Islands, Ecuador. American Entomologist (Winter): 218-237.

Silberglied, R.E. 1978. Inter-island transport of insects aboard ships in the Galápagos Islands. Biological Conservation 13: 273-278.

Snell, H.M., P.A. Stone, and H.L. Snell. 1996. A summary of geographic characteristics of the Galápagos Islands. Journal of Biogeography 23: 619-624.

Tye, A. In preparation. Invasive plant problems and requirements for weed risk assessment in the Galápagos Islands.

Whelan, P. 1995. Una propuesta para el establecimiento de un sistema de inspección y cuarentena para las islas Galápagos. Fundación Charles Darwin, Quito.

White, I.M. and M. Elson Harris. 1992. Fruitflies of economic significance: Their identification and bionomics. C.A.B. International, UK.

Zapata, C.E., C.E. Causton, and D. Cruz. In press. El sistema de implementacion y cuarentena para Galápagos: inicio de actividades. Informe Galápagos, Worldwide Fund for Nature and Fundación Natura, Quito.

Charlotte E. Causton, Charles Darwin Research Station, Galápagos, Ecuador (e-mail: causton@fcdarwin.org.ec). Carlos E. Zapata, Charles Darwin Research Station, Galápagos, Ecuador (e-mail: czapatae@fcdarwin.org.ec). Lázaro Roque-Albelo, Charles Darwin Research Station, Galápagos, Ecuador (e-mail: lazaro@fcdarwin.org.ec).