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# *DRAFT* CHYTRIDIOMYCOSIS MANAGEMENT PLAN FOR THE LESSER ANTILLES REGION: MINIMISING THE RISK OF SPREAD, AND MITIGATING THE EFFECTS, OF AMPHIBIAN CHYTRIDIOMYOSIS.


**Dominican mountain chicken frog (*Leptodactylus fallax*) with chytridiomycosis.**

**EXECUTIVE SUMMARY OF THE DRAFT CHYTRIDIOMYCOSIS MANAGEMENT PLAN FOR THE LESSER ANTILLES REGION: MINIMISING THE RISK OF SPREAD, AND MITIGATING THE EFFECTS, OF AMPHIBIAN CHYTRIDIOMYOSIS WORKSHOP, 21-23 MARCH 2006.**

The threat of chytridiomycosis to amphibian biodiversity throughout the Caribbean region is great. The issue needs to be communicated to all groups in society, including government, scientific community, farmers, hunters and general public.

The disease first emerged in the Lesser Antilles in 2002, when a fatal epidemic affecting the mountain chicken frog (*Leptodactylus fallax*) in Dominica was recognised. This epidemic has since decimated the mountain chicken frog population on Dominica.

The mountain chicken frog is endemic to the Lesser Antilles and, following the onset of the chytridiomycosis epidemic, has been reclassified as critically endangered by the World Conservation Union (IUCN).

There are many other amphibian species endemic to the Lesser Antilles and, although the potential effect of chytridiomycosis on these other species is unknown, the disease should be considered an imminent threat to the survival of all endemic amphibians in the Caribbean.

There is a high risk that chytridiomycosis will spread to other islands in the Lesser Antilles and to the wider Caribbean region. The disease is already known to be present in Puerto Rico (where it is thought to have brought about the extinction of at least one species of frog). The only Caribbean Island known to be free of the disease is Montserrat; the infection status of other Caribbean islands is unknown.

The likeliest route of chytridiomycosis introduction to other islands is via the inadvertent arrival of infected amphibians in shipments of fresh vegetables and fruits. Soil contamination of produce is an additional potential route of introduction.

A series of simple measures, such as washing produce prior to shipment and immersing bananas in water at the point of importation, were identified as likely to be highly effective in greatly reducing the risk of disease spread and these should be instated at ports throughout the region.

In the past, a variety of amphibian species has been deliberately introduced to islands across the region. This activity must be stopped.

The introduction of chytridiomycosis via dirty footwear, clothing and equipment must also be considered and addressed. Until and unless there is proof that contaminated footwear, clothes and equipment cannot carry viable zoospores, the precautionary principle should be adopted. Therefore, methods to minimise the possibility of disease importation via this route should be introduced. Simple precautions, such as increasing public awareness and ensuring footwear and equipment are cleaned prior to, or on arrival onto, islands, should be put in place.

Mitigation measures are essential in islands, such as Antigua, that operate as hubs for international travel and trade.

Measures adopted to prevent the introduction of amphibian chytridiomycosis to Caribbean Islands will also reduce the likelihood of the introduction of other potentially-catastrophic amphibian diseases, such as ranavirus disease.

In Dominica, there has been a highly successful public awareness campaign (as part of a Darwin Initiative-funded amphibian conservation programme) to inform the public about the threat of chytridiomycosis to frogs, to discourage actions that might spread the disease and to encourage conservation actions. This campaign has included educational visits by Ministry of Agriculture and Environment staff to schools, farms and the local community. A similar publicity campaign should be conducted across the Lesser Antilles region.

While there is a high degree of political and public concern about the chytrid issue in Dominica, this stems from the threat this disease poses to a charismatic and iconic species for the nation. In islands where the amphibian species are smaller, with no obvious social or economic significance, the challenge to raise political and public concern based on protection of biodiversity alone will be greater. Caribbean island governments that are signatories to the Convention on Biological Diversity, however, have policy obligations to protect their native amphibians.

A rapid and sensitive molecular test with a high degree of specificity is available to detect the causative agent of chytridiomycosis (the fungus, *Batrachochytrium dendrobatidis*). This test can be conducted in a molecular diagnostic laboratory established for this purpose in Roseau, Dominica.

Nation states within the Lesser Antilles are urged to conduct chytridiomycosis surveillance and amphibian population monitoring programmes and to establish early warning systems for the rapid detection of the incursion of the disease into their islands.

Montserrat is the only Caribbean island known to be free from chytridiomycosis. Also, Montserrat is the only country, other than Dominica, with mountain chicken frogs; a species known to be highly susceptible to chytridiomycosis and which is being decimated by this disease in Dominica. It is, therefore, extremely important that all practical measures are taken to keep the disease out of Montserrat.

In particular, efforts must be taken to reduce the risk to Montserrat from the accidental importation of infected amphibians within agricultural produce. Montserrat receives regular deliveries of bananas from Dominica and frogs have been found within these boxes.

Although Dominica is known to be positive for the amphibian chytrid, the status of all other Caribbean Islands (with the exception of Montserrat, which is known to be currently free of infection) is unknown. Unless otherwise known, therefore, islands should be considered to be positive when regarding their exports, and negative when regarding their imports.

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## 1. INTRODUCTION

This report is the outcome of an international workshop held at the Holy Redeemer Retreat House, Eggleston, Dominica, 21-24 March 2006 (see Appendix 1). The workshop was funded by the UK Government's Darwin Initiative for the Survival of Species and was convened by the Ministry of Agriculture, Government of Dominica. The workshop was a response to the catastrophic collapse of the mountain chicken frog (crapaud) population on Dominica following the emergence of chytridiomycosis on the island. Delegates to the workshop included government representatives, forestry officers, veterinarians, conservation scientists, herpetologists, experts in the management of amphibian conservation breeding programmes and representatives of non-governmental organisations concerned with nature conservation.

The objective of the workshop was to produce a *Draft* Management Plan to minimise the risk of spread of chytridiomycosis to other Caribbean islands, and to limit the impact of the disease should it do so, across the Lesser Antilles region of the Caribbean. In the plan, we also sought to identify knowledge gaps that limit the ability to mitigate the spread and impact of the disease in the region and to build a consensus across the Lesser Antilles to protect Caribbean biodiversity from the effects of chytridiomycosis. The Draft Plan will be circulated to representatives of Governments in the region (including those Governments represented and those not represented at the workshop) for information, comments and input.

This Draft Plan identifies the most likely factors underlying the emergence of chytridiomycosis in the Lesser Antilles, the likely routes of spread between and within islands and the threats this could present to the biodiversity of the region. Preventative measures and early surveillance systems for chytridiomycosis emergence were identified, and a programme of further research was devised to provide information required to inform a Final Management Plan. Urgent measures for the conservation of the mountain chicken frog were endorsed. The programme identified in the Plan is long-term and so this version is just the beginning. A further international workshop will be held in 2008 to review the status of chytridiomycosis and amphibian biodiversity on Dominica and other Lesser Antilles islands, to take into account the results of further research and to develop a Final Management Plan for the region.

## 2. AMPHIBIANS IN THE CARIBBEAN

The Caribbean is one of the world's biodiversity hotspots and this is demonstrated by the diversity of the Amphibian fauna of the region. There are at least 158 species of frog in the West Indies (excluding Trinidad & Tobago), with several single-island endemics (Schwartz & Henderson, Amphibians & Reptiles of the West Indies, 1991). About 79% (at least 125) of the West Indian species belong to the genus, *Eleutherodactylus.* Only one species of caecilian (legless serpentine amphibians) is known from the Caribbean – this is found in Trinidad.

Many of the frogs, *e.g.* the Eleutherodactylids, are terrestrial, and do not go through a tadpole stage: by the time the eggs hatch the offspring are already miniature replicas

of the parents. Of the amphibians that do have a larval (tadpole) stage, two species (in the *Leptodactylus* genus) do not require water to breed, one of which (the mountain chicken – see below) even provides parental care to its offspring. The tadpoles of the highly aquatic Suriname (or Pipa) toad (*Pipa pipa*) from Trinidad develop in the skin tissue of the mother's back, before bursting out and emerging as miniature replicas of the adult frogs.

### 2.1. Lesser Antilles

The islands in the Eastern Caribbean from Sombrero in the north to Grenada in the south form the Lesser Antilles. The islands have a common geological origin and faunal similarity. With the exception of Barbados all of the islands are of volcanic origin and were formed between 23 and 5 million years before present (bp). The younger islands of the Lesser Antilles, such as Dominica, have high mountains that trap moisture from the trade winds. These islands are characterised by high rainfall, distinct montane habitats, luxuriant vegetation, and are often home to specialised endemic amphibians and reptiles. Older islands are more eroded and are often flat and arid.

The Lesser Antilles is comprised of the following 27 islands or island groups: Sombrero, Anguilla, St. Martin, St Barts, Saba, St Eustatius, St. Kitts, Nevis, Barbuda, Antigua, Redonda, Montserrat, Guadeloupe (Basse Terre and Grand Terre), Les Saintes (Terre de Haut, Terre de Bas), La Désirade, Marie Galante, Dominica, Martinique, St. Lucia, Barbados, St. Vincent & Grenadines, Grenada, Cariacou and Petite Martinique.

As the islands were never connected to the mainland, amphibians have colonised the islands from South America and the Greater Antilles. It appears that only frogs have managed to do so. Other amphibians (salamanders, newts and caecilians) apparently could not cross the ocean barrier between the American continents and the Antilles. Being oceanic, the Lesser Antillean islands have rather few frog species. The amphibian fauna of selected islands in the Lesser Antilles is presented in Table 1.

Throughout the Lesser Antilles, four families and 12 species of amphibian are represented from the following five genera: Bufo (1 species), Colostethus (1 species), Eleutherodactylus (7 species), Leptodactylus (2 species), Scinax (1 species). Across the region, only three species of amphibian occur on more than one island: *Bufo marinus* (10 islands, to which it was introduced to all 10), *E. johnstonei* (18 islands, including 5 islands where it was introduced), *E. martinicensis* (8 islands, including 1 island where it was introduced).

The Dendrobatidae and Leptodactylidae are the only naturally occurring frog families, while members of the Bufonidae and Hylidae are introduced. The Dendrobatidae are the infamous poison arrow frogs and their relatives. The Leptodactylidae includes the ditch frogs *Leptodactylus* that are among the largest frogs in the world, and whistling frogs *Eleutherodactylus*, which are among the smallest frogs.

**Table 1. Amphibian Species of Selected Eastern Caribbean Islands**

| Island | Species |
|---|---|
| Antigua/Barbuda | *E. johnstonei* (both islands), *E. martinicensis*, *Bufo marinus* (Antigua) (I) Cuban tree frog (I – see text) |
| Barbados | *E. johnstonei*, *Bufo marinus* (I) |
| Dominica | *E. amplinympha* (E), *E. martinicensis*, *Leptodactylus fallax*, *E. johnstonei* (I), |
| Grenada | *E. johnstonei, E. Euphronides* (E), *Leptodactylus validus, Bufo marinus* (I) |
| Grenadines | *E. johnstonei* (I), *Leptodactylus validus* |
| Montserrat | *E. johnstonei, Leptodactylus fallax, Bufo marinus* (I) |
| St. Lucia | *E. Johnstonei* (I), *Bufo marinus* (I), *Scinax ruba* (I) |
| St. Vincent | *E. johnstonei, E. shrevei, Leptodactylus validus, Bufo marinus* (I) |
| St. Kitts & Nevis | *E. johnstonei, Bufo marinus* (I) |

(I) = Introduced, (E) = Endemic

## 2.2. Dendrobatidae

The poison arrow frogs are represented in the Lesser Antilles by a single recently described species *Colostethus chalcopis* endemic to the montane forests of Martinique.

## 2.3. Leptodactylidae

2.3.1. *Eleutherodactylus* (whistling frogs)

There are over 500 species of whistling frog, genus *Eleutherodactylus*. They are amongst the smallest frogs in the world. All species are less than 60 mm in total length with most being on average between 20 and 30mm. Seven species of whistling frog are known to occur in the Lesser Antilles. Many are single-island endemics (found on one island and nowhere else in the world).

Most of the whistling frogs found in the Lesser Antilles are to some extent arboreal. Males can often be observed or heard at night calling from leaves and branches or from bromeliads. An exception is the stream whistling frog from Guadeloupe that, as its common name suggests, is aquatic in streams. Although called whistling frogs, not all species produce whistle-like calls. Calls can be low grunts, loud barks, raspy screeches or insect-like chirps.

Reproduction is through direct development. Whistling frogs do not have a tadpole stage, but instead the adults lay their eggs on land. For this they choose humid

microhabitats, like spaces under rocks and rotting vegetation. After emerging from the eggs the young are almost miniature replicas of the adults, although with tiny tails that are quickly absorbed within a few hours of hatching.

Most of the islands in the Lesser Antilles contain one species of whistling frog. The Grenada whistling frog *Eleutherodactylus euphronides* is endemic to Grenada. It is moderately common in montane forest but the population may be declining due to habitat loss from agriculture and competition from a recently introduced species of whistling frog.

The Saint Vincent whistling frog *Eleutherodactylus shrevei* is endemic to Saint Vincent. Although not uncommon in montane forest, the population might be declining due to habitat loss through agriculture.

Guadeloupe is home to four species of whistling frog, two of which are endemic. The Guadeloupe stream whistling frog *Eleutherodactylus barlagnei* is endemic to the rainforest streams of Basse Terre Island, Guadeloupe. Although moderately common, this species is declining as stream quality is threatened by pollution (pesticides and domestic sources) and the clearing of forest for agriculture. The second endemic whistling frog is the Guadeloupe whistling frog *Eleutherodactylus pinchoni*. In contrast to the stream whistling frog, *E. pinchoni* is terrestrial in the rainforest of Basse Terre Island, Guadeloupe. This moderately common frog appears to be declining due to habitat loss from agricultural encroachment.

Dominica is home to three species of whistling frog. *Eleutherodactylus amplinympha* is endemic to Dominica and predominantly occurs in montane forest and elfin woodland, especially in the transition zone between the two habitats on the slopes of the northern, central and southern mountain ranges. Fortunately the rugged topography of Dominica's interior ensures that montane forest habitat of *E. amplinympha* is largely secure.

Martinique's Whistling Frog *Eleutherodactylus martincenis* occurs on a number of islands in the Lesser Antilles including Dominica, Guadeloupe, Antigua, Martinique and St Martin. It is common in wet and dry forest in both lowland and montane areas. Although this species appears to be declining due to habitat loss, pesticides and introduced predators, overall it is not seriously threatened.

The most widespread whistling frog in the Lesser Antilles is Johnstone's Whistling Frog *Eleutherodactylus johnstonei.* This species occurs across most of Lesser Antilles. Within the Lesser Antilles it is unclear which populations are native, though it is known to have been introduced to Dominica, Jamaica, Venezuela, Trinidad, and Guyana. Johnstone's Whistling Frog prefers disturbed habitats and is an extremely common frog whose range distribution and population size appears to be expanding. There are no major threats to this adaptable and invasive species.

*2.3.1.1. Threats to Eleutherodactylid frogs*

In the Lesser Antilles the range and population size of many native whistling frogs is decreasing, as suitable habitat in low-lying and coastal areas is lost. In contrast, the invasive Johnstone's Whistling Frog may actually benefit from increased agriculture

and development in coastal areas, as this species prefers disturbed habitats. For example, Johnstone's Whistling Frog was recently introduced into Dominica and appears to be rapidly expanding its range by colonising disturbed areas bordering the island's major roads.

On mountainous islands inaccessible montane and cloud forests are often less perturbed than low-lying and coastal areas. Dominica's montane forest and elfin woodland is largely unaffected by agriculture and development. Dominica's rugged topography limits development of the interior. Thus in the Lesser Antilles habitat loss does not appear to be a major threat to most montane species of whistling frogs, such as Dominica's *Eleutherodactylus amplinympha*.

Introduced species have had a devastating effect on the reptiles of the Lesser Antilles and may represent a threat to whistling frogs. Introduced animals may prey on or compete with native amphibians. The omnivorous opossum (or Manicou), from South America, has become widespread on Dominica and is known to feed on frogs. Eurasian black and brown rats are thought to eat whistling frogs, as do feral cats and dogs, and mongoose. It is important to note that all of these mammals are relative newcomers to the Lesser Antilles, and whistling frogs may not have had sufficient time to evolve appropriate avoidance or defence behaviours.

In the Lesser Antilles Johnstone's whistling frog may represent a threat to native species of whistling frogs through competitive replacement. Johnstone's' whistling frog was been widely introduced within the Lesser Antilles and its range is still expanding. Johnstone's whistling frog may have entered Dominica with hurricane relief supplies following hurricane David in 1979. In Dominica, St Vincent and Grenada there is only minimal overlap in ranges between the introduced Johnstone's whistling frog that favours disturbed habitat and native whistling frogs which favour undisturbed habitat. In contrast in Guadeloupe and Martinique, where the distribution of the two whistling frog species overlap in disturbed habitats, the vocalisation of the introduced Johnstone's whistling frog is more intense than that of the native *E. martinicensis*. It has been speculated that Johnstone's whistling frog may be able to out-compete native species only in disturbed habitat.

Other threats to whistling frogs include pollution, natural catastrophic events, climatic change and disease. Whistling frogs occupying areas in and around farmland and may be exposed to agrochemicals, such as the highly toxic and persistent herbicide Paraquat. Certainly stream pollution appears to be threatening the Guadeloupe Stream Whistling frog. Amphibians are especially sensitive to environmental pollution as their moist, porous skin makes them vulnerable to water-borne toxins and infections.

The Lesser Antilles is subject to two natural catastrophic processes: hurricanes and volcanic eruption. Both can cause a great amount of damage to whistling frog habitat that may take decades or centuries to recover.

Volcanic eruptions have occurred throughout the geological history of the Lesser Antilles, as recently as 30,000 bp there was a massive eruption in Dominica more violent as the famous Krakatau eruption. The eruption of the Montserrat volcano in 1995 is endangering the mountain chicken *Leptodactylus fallax* and other components of the islands fauna, as large areas or rainforest has been destroyed. The effect of this

eruption on Montserrat's whistling frogs *E. martinicensis* is unclear.

The population of mountain chickens in Dominica has catastrophically declined from 2002 following a major confirmed outbreak of the fungal disease chytridiomycosis. It is unclear if this disease will affect whistling frogs in the Lesser Antilles.

Five of the 7 whistling frog species in the Lesser Antilles are listed by the IUCN as Endangered: *E. euphronides, E. shrevei, E. barlagnei, E. pinchoni*, and *E. amplinympha*. The endangered whistling frogs are all single-island endemics that are experiencing a decline in the extent and quality of their habitat. Only two species are currently not of conservation concern: *E. martinicensis* is listed by the IUCN as Near Threatened and *E. johnstonei* is listed as being of Least Concern. *Eleutherodactylus martinicensis* occurs on a number of islands and locations, although there is a decline in the extent and quality of its habitat. Johnstone's whistling frog is very common and adaptable with an increasing range and population.

So why protect whistling frogs? How would the environment change is they went extinct? Whistling frogs feed on insects, some of which may be pest species, and they probably have important ecological roles in terrestrial ecosystems. Whistling frogs are prey for other important animals in the Lesser Antilles such as snakes, *e.g.* Antillean Racers *Alsophis*. Also many whistling frogs are single-island endemics. For example *Eleutherodactylus amplinympha* is found on Dominica and nowhere else in the world and it is important that these unique and rare frogs are protected.

### 2.3.2. *Leptodactylus* (ditch frogs)

There are thirty-seven (37) species of frogs in the genus *Leptodactylus*, most of which are found in the Central and South American mainland. Only four members of this genus are native to Caribbean islands: *Leptodactylus albilabris* (which is found in the Dominican Republic, Puerto Rico, the British Virgin Islands and in the U.S. Virgin Islands), *L. nesiotus* (which is found in Trinidad & Tobago), *L. validus* (which is found in Trinidad & Tobago, Grenada and in St Vincent and the Grenadines) and *L. fallax* (which is found in Dominica and Montserrat).

#### *2.3.2.1. The Mountain Chicken (Leptodactlyus fallax)*

The mountain chicken (*Leptodactylus fallax*) is the largest amphibian in the Caribbean and it has been described as the second largest frog in the Western Hemisphere. The species was originally classified as *L. dominicensis*, but was re-classified to its current name *L. fallax* in 1926. This frog has several common names, including Dominican white-lipped frog, mountain chicken, and, in Dominica only, as the crapaud (kwapo in Kwéyòl language). The mountain chicken *Leptodactylus fallax*, is now classified as critically endangered and is currently restricted to the islands of Dominica and Montserrat.

##### *2.3.2.1.1. Distribution*

The original range of the mountain chicken comprised the six mountainous islands in the centre of the Caribbean island chain, and included islands from both the Leeward and Windward groupings. From north-to south, the species' natural range was St.

Kitts, Montserrat, Guadeloupe, Dominica, Martinique and St. Lucia. There are reports of "unsuccessful" attempts to introduce the species to Jamaica and Puerto Rico.

Over time, due to a combination of habitat loss, introduction of alien predators (viz. mongoose, cats, dogs) and hunting, the species became extirpated from four of the islands in its range, and now only occurs on parts of Montserrat and Dominica, where until recently, the frog was still heavily hunted (possibly the fourth most heavily hunted game species on Dominica).

In 1999, it was estimated that the species' distribution range on Montserrat had fallen to less than 17 $km^2$ in area. Over 10% of the species' original (1995) habitat in Montserrat has been destroyed by scorching pyroclastic flows, and heavy volcanic ash falls.

*2.3.2.1.2. Biology*

*Leptodactylus fallax* is the second largest frog in the Western Hemisphere, and is able to attain a body length of about 20 cm (SVL), and a weight of over 700g (1½ lb). However, it appears that the frogs on Montserrat attain a greater body length and weight than their counterparts in Dominica, and these differences have been attributed to over-hunting of the species on Dominica.

The frog is generally brown and tan in colour, with dark stripes on the hind legs, blotches on the sides, and occasionally warts on the back. The coloration lends itself to good camouflage. The mountain chicken is a stout-bodied animal, with powerful hind legs, being able to jump up to 8ft in a single jump.

The males are generally smaller but more brightly coloured than the females, and possess a spur on each of the forelegs, which is presumably used in mating. It is believed that these frogs can live up to about 12 years, and can reach breeding age at about 3 years.

The mountain chicken does not require water for breeding. Foam nests are made, in which the female deposits eggs that are fertilized by the male.

The eggs hatch into tadpoles, which remain in their foam nests for several weeks until and even after they fledge. The female parent provides a relatively high level of parental care guarding the nest, replenishing the foam to keep the tadpoles moist, and feeding the tadpoles with unfertilized eggs.

Breeding usually takes place during the annual "dry season", with nesting extending into the rainy season. Males begin vocalizing from around mid-February, and this behaviour may be initiated by rains.

It is estimated that between 20 and 24 tadpoles develop in a nest, and these develop at different rates of growth

The mountain chicken is generally nocturnal in nature, usually hiding in the animal's burrow during the day. And while most vocalization takes place at night, it is not

uncommon to hear males calling during the day.

Males and females have separate burrows, but mating occurs in the male's burrow, and the female eventually guards the nest. Nests are "built" on the ground, in moist soil, under large rocks, in rotten tree stumps, and even in areas modified by human activity.

*2.3.2.1.3. Habitat*

Wide range of habitats, from sea level to rain forest, and including gardens, plantations, in populated areas, scrub, in valleys, stony hillsides bordering streams and ravines. The frog can be raised and bred captivity.

*2.3.2.1.4. Diet*

*Leptodactylus fallax* is a voracious, "sit-and-wait" forager that feeds on a wide variety of items, with individual frogs having an average of 4-5 prey items in their diet. Vegetation and soil are also consumed, but possibly accidentally.

The frog's diet comprises of vertebrates (including at least one other frog, snakes, lizards, and mammals) as well as invertebrates, such as insects, millipedes, snails and slugs, centipedes, spiders, and both terrestrial and aquatic crustaceans. Schwartz and Henderson also note that bats are also occasionally eaten by these frogs.

A study of the diet of the mountain chicken on Dominica was made by Garnett Brooks Jr. of the College of William and Mary, by analysing the gut contents of 397 frogs collected between December 1965 and December 1966. The results of the year-long study are contained in an article by Brooks (An analysis of prey consumed by the anuran, *Leptodactlyus fallax*, from Dominica, West Indies.1982 Brooks, G.R. *Biotropica* **14(4):** 301-309); a summary of the findings is shown in Table 2, below.

**Table 2. Prey items found in the stomachs of mountain chicken frogs, Dominica.**

| Faunal Group | | Remarks | % of Frogs w Food Item |
|---|---|---|---|
| Insects | Orthoptera | Crickets, grasshoppers | **64** |
| | Coleoptera | Beetles (at least 6 families) | **27** |
| | Hymenoptera | *e.g.* ants | 8 |
| | Dermaptera | | 2 |
| | Lepidoptera | Butterflies & moths (adults, larvae) | 4 |
| | Hemiptera | | 1 |
| | Phasmid | Stick Insect (6" / 154mm specimen found) | <1 |
| | Unidentified | | 4 |
| Millipedes | | At least 3 species | **40** |
| Centipedes | | At least 2 species; (9-14 cm long) | 6 |
| Arachnids | | Spiders | ≤0.5 |
| Snails & Slugs | Gastropods | At least 4 species snail, 1 species slug | **22** |
| Decapods | | 2 spp. Crabs, Shrimp (*Macrobrachium)* | 5 |
| Vertebrates | Tink Frog | Gounouj (*Eleutherodactylus martinicensis* (?)) | 12 |
| | Lizards | Zanndoli (*Anolis oculatus)* | 1 |
| | Snakes | ≥least 2 spp: *Typhlops* (D/ca), *Alsophis* (Mni) | 1 |
| | Mammals | Possibly house mouse | ≤1 |

There are no records of cannibalism occurring among *Leptodactylus fallax*, even though the adults prey on adult tink frogs (*Eleutherodactylus sp*) which are about the size of the *Leptodactylus* froglets.

*2.3.2.1.5. Predators*

It is believed that the Boa constrictor (*Boa constrictor nebulosa*) preys on adult and juvenile mountain chicken and possibly the *Alsophis* snakes prey on the froglets. In habituated areas, dogs and cats are believed to prey on adult and juvenile frogs. Whilst it is possible that owls are potential nocturnal predators of the mountain chicken, dietary analysis of owl pellets has found no evidence of mountain chicken remains.

2.3.3. *Leptodactylus fallax* in Caribbean cultural heritage

In its current home range, the mountain chicken is considered to be more than just another species of frog, and has even been granted some status, in the form of national symbolism.

- A "crapaud" features prominently on the top right-hand quadrant of the official Coat of Arms of the Commonwealth of Dominica;

- At least three places in Dominica are named after the frog, viz. Crapaud Hall, Crapaud Jupa, and Crapaud City in the city of Roseau (after a physically challenged man)

- The meat is considered a delicacy both on Montserrat and on Dominica, and is an important element of these islands' local Creole cuisine. Reference to the "tasty frogs' legs that taste like chicken" used to appear regularly in tourism promotion materials for both Montserrat and Dominica

- The "national dish" of Dominica is still mountain chicken, although this will have to be reviewed, in light of the current legal and conservation status of the frog

- One indigenous Caribbean Bank, one guest house, and one other business place in Dominica have all adopted the Crapaud as their logo/emblem; and

- A pair of Crapauds features on the crest of Dominica's highest institution of learning, the Dominica State college

- The bank referred to is popularly referred to as the "Crapaud Bank" by Dominicans

- Reference to the Crapaud is also made in local Dominican folk songs, and is the subject of at least three Kwéyòl proverbs on the island:

    (a) *Kwapo di sé mannyè i asiz ki fè tout fanm enmen'y.* (Crapaud says that it's because of the way he sits that's why all women love him)

(b) *Kwapo pa ka vanté soup-yo*. (Crapaud don't fan their own soup)

(c) *Sé lanng kwapo ki twayi kwapo*. (It's Crapaud's tongue that betrayed his own self)

- The physical attributes of the mountain chicken have even been used to describe parts of the human anatomy, or certain human activities: *e.g.*

  (a) *Djèl-ou plat kon djèl kwapo* (Your lips are as "flat" as those of a Crapaud);

  (b) *Bonda'w plat kon bonda kwapo* (Your buttocks are as "flat" as those of a Crapaud), or *Kwapo Pa ni bonda* (Crapaud does not have buttocks).

  (c) *Wen'w kon wen kwapo* (Your waist is like that of a crapaud, *i.e.* said to a person with a slim-waist)

  (d) *Ou ka asid kon kwapo* (You are sitting like a Crapaud)

## 2.4. Amphibian Fauna on Islands with Representatives at the Workshop

### 2.4.1. Antigua

In Antigua, the Early Indians used pendants with images of *E. martinicensis* as a good will token. *Bufo marinus* was historically introduced to Antigua as a species to predate agricultural pests. Recently, a species of Cuban tree frog has been found in Antigua. This is thought to have been accidentally introduced with ornamental plants imported from Florida (the frog being an established invader of Florida). Species identification and assessment is still underway for this newly introduced species.

### 2.4.2. Dominica

Four species of amphibian are found in Dominica. One species, *E. amplinympha*, first identified in 1994, is endemic and occurs only at high elevations (*e.g.* Morne Trois Pitons, Freshwater Lake, Morne Diablotin). Two other species are native: *E. martinicensis* and *L. fallax*. The fourth species, *E. johnstonei*, is thought to have been introduced to Dominica with hurricane relief goods after Hurricane David in 1979.

### 2.4.3. Grenada

There are four amphibian species in Grenada: two native (one of which is endemic) and two introduced. The endemic Grenada frog *E. euphronides* is limited to areas of mountainous forest above 2500 feet above sea level and appears to be adversely affected by hurricanes. The native ditch frog (*Leptodacylus vallidus*), however, is widespread and has increased its range subsequent to the last hurricane. There are two introduced amphibian species in Grenada: the cane toad (*Bufo marinus*) and the whistling frog (*E. johnstonei*), each of which is very common. Johnstone's whistling frog is locally known as "the tree frog". It was introduced to Grenada in the 1800s and it now occurs all across the island, including in *E. euphronides* habitat. In contrast to

the endemic Granada frog, the introduced tree frog is favoured by environmental disturbance, such as that caused by hurricanes. Research is currently underway (led by researchers from Milwaukee) to determine if there is competitive replacement of *E. euphronides* by *E. johnstonei*.

2.4.4. St Lucia

Although St Lucia no longer has any native amphibians, there are three introduced species: *E. johnstonei, B. marinus* and *Scinax ruba*. The mountain chicken frog (*L. fallax*) used to be a native of St Lucia and there are reports that this species was extant on the island within living memory, possibly as recently as circa 1979/1980.

## 3. AMPHIBIANS AND LEGISLATION

Apart from specific legislation to protect the mountain chicken in Dominica, amphibians have very limited legal protection in the Lesser Antilles. For example, in Antigua, the Animals Protection Act protects all animal species from "abuse", but there is no specific legislation protecting or governing amphibians. In contrast, wild birds are specifically protected under Antiguan legislation. In other countries, there is no protection at all for amphibians.

In Dominica, the mountain chicken, *Leptodactylus fallax*, has received some level of legal protection for over half a century, in at least part of its range. Perhaps one of the most important laws was the Mongoose Ordinance of 1902, which made provisions for very stiff penalties (100 pounds Sterling) for anyone convicted for introducing the mongoose (*Herpestes auropunctatus*) - a dreaded predator - onto the island. (Mountain chickens have since been extirpated from any islands where they previously existed and where mongooses were introduced.)

Specific legal protection of the mountain chicken in Dominica has been in place since 1939, when the Crapaud Ordinance was enacted in the Legislature. This was the first piece of legislation to govern hunting restrictions and controlled export of the mountain chicken (crapaud). The legislation provided for the "protection and preservation of the Crapaud", made provisions of the setting of a Close Season for the taking of the species, and regulated the export of the species.

The 1939 Ordinance was repealed in 1976, and was replaced by the Forestry and Wildlife Act (12 of 1976), which is umbrella legislation governing the protection and management of several forms and groups of wild fauna on the island – including the mountain chicken. The 1976 Act legislated the mountain chicken hunting season a being for a six-month period (September – February inclusive) each year. Between 1999 and 2002, however, the open season was reduced to three months per year (October – December inclusive) because of fears that a six-month open season was no longer sustainable. In 2004, following the population decline caused by chytridiomycosis (see below), hunting was made illegal throughout the year. Revision to the 1976 Forestry and Wildlife Act is currently under discussion to afford specific protection to the mountain chicken as an amendment to the 1976 Act.

In general, the response of the Dominican people to an effective ban of their national

dish has been favourable. There is widespread public support for the conservation of the mountain chicken with estimated 80-85% support and adherence to the ban. The public have been dissuaded from the unpalatable idea of potentially eating sick animal affected by the disease. Widespread publicity of the isolation of *Shigella* sp., a bacterium that can cause severe illness in humans, from one of the first mountain chickens that died in 2002 (and before chytridiomycosis was diagnosed), also had a positive effect on the hunting ban as it led to the belief that people might get sick from eating frog meat.

Also, the degree of public concern about chytridiomycosis arises from its threat to a charismatic and iconic species for the nation. In islands where the amphibian species are smaller, with no particular social or economic significance, the challenge to raise public concern based on protection of biodiversity alone may be greater.

It is currently legal to hunt the mountain chicken in Montserrat.

## 4. THREATS TO THE MOUNTAIN CHICKEN (*Leptodactylus fallax*)

Over the last 11 years, the remaining populations of mountain chicken in the Lesser Antilles have been reduced dramatically, due firstly to the spate of eruptions of the Langs Soufriere Volcano on Montserrat since 1995, followed by the outbreak of chytridiomycosis among the Dominican population from around 2002.

Prior to the outbreak of chytridiomycosis, the Dominican population was under pressure from hunting and possibly also habitat loss due to housing developments which, in Dominica, are focused in low altitude villages along the west coast of the island (*i.e.* typical mountain chicken habitat). However, chytridiomycosis has had a rapid and catastrophic impact on the Dominican mountain chicken and, in 2003, it was estimated that the species occupied an area of only approximately 25 $km^2$, which is but a fraction of the species' pre-chytridiomycosis range. It is believed too that between 2002 and 2004 the Dominican population declined by some 70% due to the disease, with one new "cell" of the chytrid disease being discovered in November 2005. The population on Montserrat occupies possibly less than 17 $km^2$

Currently, the species is categorised as **critically endangered**, on account of its current limited range species, combined with the reduction in populations due to (a) the volcanic eruptions on Montserrat, (b) the chytrid fungus disease in Dominica, as well as (c) the relatively heavy hunting of the species that occurred on Dominica prior to the institution of the ban on hunting the species from 2004.

Since 1998, the Government of Montserrat, in collaboration with the Durrell Wildlife Conservation Trust, has been conducting a programme to monitor the health status of mountain chickens in the Centre Hills of Montserrat.

Mark-recapture studies at three intensively studied sites have been undertaken to estimate the absolute abundance of the species, to validate the monitoring programme and to test distance sampling as a potential method of estimating density. Individual identification of frogs was done by photo-identification (photographing both flanks of each frog) and by use of subcutaneous pit-tag transponders that can be read with a

handheld reader.

Using an index of body condition it was observed that frogs were in better condition during the dry season, irrespective of gender, and female frogs from the eastern and less disturbed Centre Hills region exhibited better condition when compared to the western Centre Hills region. This effect was not detected in males.

Skin swabs of mountain chickens and the cane toad *Bufo marinus*, and toe clips from Johnstone's whistling frogs *Eleutherodactylus johnstonei* were tested for the presence of the fungus *Batrachochytrium dendrobatidis*, the causative organism of cutaneous chytridiomycosis. Additionally, mountain chicken blood serum samples were tested for evidence of exposure to ranavirus. (Ranavirus infections are a major cause of amphibian mortality in Europe and North America.) No evidence of infection or disease was detected in any of the three amphibian species tested on Montserrat.

## 5. CHYTRIDIOMYCOSIS AND ITS EMERGENCE IN THE LESSER ANTILLES

Amphibians are undergoing unprecedented declines around the world, including in protected areas and in pristine habitats. Although originally ascribed to natural population cycles, pollution, excessive UV-B irradiation and other causes, over the past 10 years it has become clear that a novel infectious disease, termed chytridiomycosis, caused by the newly-discovered fungus, *Batrachochytrium dendrobatidis*, is the primary driver of these declines.

The exact mode through which chytrid fungus kills frogs is unknown, although two hypotheses exist. The amphibian skin, particularly the vascular drink patch region over the pelvis, is involved with many body functions, including water uptake and osmoregulation. Since chytrid fungus is found in the skin, it is possible that it acts by interfering with the skin's vital functions. Alternatively, it is possible that the fungus may produce a toxin. Research is underway to try and determine the exact mechanism of the disease. For example, some amphibian species have anti-microbial peptides in their skin that help protect against bacteria and fungi. It will be interesting to compare the anti-microbial peptides in species that die with chytrid infection, with those that seem to be resistant to the disease, to identify any peptides that may help protect against the chytrid fungus.

Chytrid fungus can survive between 10-25 $^{o}$C, however its optimum temperature range is 18 – 20 $^{o}$C. Interestingly, exposure to elevated ambient temperature (>28 $^{o}$C) has been used to treat dendrobatid frogs suffering from chytridiomycosis, but this does not always result in a cure: when the ambient temperature returns to normal, the disease can reappear. Although captive animals can be successfully treated using anti-fungal drugs, such as itraconazole, it is not practicable to treat animals in the wild. However, disinfectants can be used to kill chytrid on fomites (*e.g.* equipment and footwear).

Some research has been done to investigate how long chytrid fungus zoospores can survive in the environment (*e.g.* in soil), but more work is required to address this

question which will be crucial to addressing options for disease control (*e.g.* risk posed by moist soil on agricultural crops through trade).

In February 2003, unusually large numbers of dead mountain chicken frogs were found in Dominica and these were found to have died of chytridiomycosis: the first time the disease had been found in the Lesser Antilles. Between August 2002 and March 2004, the island's population of mountain chicken frogs appeared to have declined by at least 80% due to this disease. The mortalities have continued since then and mountain chickens continue to be found sick or dead in Dominica due to chytridiomycosis, although the numbers found is now low and sporadic as the population has been reduced in size. There is a fear that the disease might drive the mountain chicken to extinction on Dominica.

The effects of the disease, if any, on the other amphibians of Dominica are not yet known. Montane species appear to be particularly susceptible to the disease, so there is deep concern about the possible effects it might have on the endemic *E. amplinympha* in Dominica, which is restricted to the high altitude cloud forest. From our knowledge of chytridiomycosis in other parts of the world, it is likely that, in the absence of a strategic and collaborative effort to control this disease, it will spread to other nations in the Caribbean, where it will threaten the biodiversity of other countries.

The mountain chicken is the national dish of Dominica and often is sought by visiting tourists. Although there is some evidence from a previous study conducted by Fauna and Floral International and the Dominican Ministry of Agriculture and Environment that hunting pressures were exerting a negative influence on the mountain chicken population, the speed of the recent decline, coupled with the timing of the observed mortality incidents as a result of disease, indicate that chytridiomycosis is the most important cause of the current precipitous decline.

In April 2005, a three year project – funded by the UK Government's Darwin Initiative for the Survival of Species - was initiated to address the problem of chytridiomycosis and amphibian conservation in Dominica and the Lesser Antilles. The main aims of this project are to develop captive breeding and rapid diagnostic and surveillance technology and to produce a Management Plan to minimise the risk of spread of the chytridiomycosis, and to mitigate its impact should it do so, across the Lesser Antilles region of the Caribbean.

There was concern that many representatives from islands other than Dominica had not heard of the amphibian chytrid fungus and the threat that it poses to amphibian populations. This underlines the need for urgent communication across the Caribbean region about this major threat to the region's biodiversity. Chytridiomycosis in not known to be present on any other island in the Lesser Antilles, but it does occur on Puerto Rico in the Greater Antilles (see below).

### 5.1. Weather and climate

Drought years were experienced in Dominica around the time of the first mortalities caused by chytridiomycosis. Drought conditions are known to increase the severity of

chytridiomycosis in some other amphibian species. It is possible that the drought conditions contributed to the emergence and impact of the disease on Dominica.

### 5.2. Time of disease emergence

Monitoring of mountain chicken populations in Dominica was performed as part of a previous Darwin Initiative project: on Sustainable Wildlife Utilisation in Dominica, led by Fauna and Flora International and the Ministry of Agriculture and Environment. This monitoring detected no decline in mountain chicken populations until late 2002 and so it is thought that the disease was detected relatively quickly after its first emergence as a cause of amphibian mortality on the island. Anecdotal reports of lethargic frogs falling easy prey to hunters, however, occurred for several months (possibly up to a year) preceding the index case (the first definitive mortality incident diagnosed as being caused by chytridiomycosis), so it is possible that the problem began earlier than first thought.

## 6. CHYTRIDIOMYCOSIS IN THE GREATER ANTILLES

The islands and amphibian biodiversity of the Greater Antilles are comprised of: Cuba (56 species, 53 of which are endemic); Jamaica (22 species); Hispaniola (65 species); Puerto Rico. Until recently there were 19 species of amphibian on Puerto Rico, of which 17 were Eleutherodactylids.

Research surveys in the 1980s, however, found that previously recorded *Eleutherodactlyus* species were apparently missing. This was at an early stage when the extent of amphibian global population declines was first being realised. The Puerto Rico studies documented declines in 17 species (8 have reduced in mountainous regions) and three extinctions. Chytridiomycosis has now been documented in Puerto Rico and the disease is thought to have played a role in these amphibian population declines.

While three species have disappeared in Puerto Rico since 1976, populations of other species have been extirpated only from certain areas, and others have recuperated or do not show impact at all. Thus, we questioned what type of mechanisms may be acting to reflect such specific taxonomic and population effects in a small geographical scale. We have documented the occurrence of *Batrachochytrium dendrobatidis* (*Bd*) among declining amphibians in the mountains of eastern Puerto Rico since 1976. To assess the spread of this fungus to other areas we sampled lowland and highland frogs in localities island-wide. We found *Bd* in various species of *Eleutherodactylus* and on *Leptodactylus albilabris*, only in the highlands. Incidence of chytrids with respect to seasonality, ontogeny and ecology of E. *coqui* were investigated showing interesting patterns with respect to the first two variables. Data suggests that a cyclic dry/cool–wet/warm climate linked mechanism is driving a synergistic interaction between chytrid and frogs that allows this pathogen to persist without exterminating its host. While this interaction may maintain ecologically hardy species like *E. coqui*, it can represent a threat for more vulnerable species. Individuals that escape or recuperate from high chytrid infections, carry the fungus at low incidences during the warm/wet season when conditions are less optimal for *Bd*

growth. These frogs serve as reservoirs for the prevalence and spread of the disease. Ontogenetic diagnosis of chytrids on *E. coqui* revealed infections at all stages from eggs to adults, with significantly higher incidence among juveniles. This suggests that parental care in direct developing terrestrial species, can serve as a mechanism to spread *Bd* spores from infected parents to their offspring. Additional studies are underway to investigate associations between fine-scale microclimate data and the response of *Eleutherodactylus* frogs to chytrid infection.

Puerto Rico is the only Caribbean island other than Dominica in which amphibian chytridiomycosis has been found. The "coqui" is the national frog of Puerto Rico and is used in souvenirs for the tourist trade. This has helped raise profile for the threat of chytridiomycosis to amphibian conservation on the island. Also, in Puerto Rico, amphibians are extremely important as predators of nocturnal insects, being the only group with this ecological niche on the island. There are three introduced species of amphibian on Puerto Rico: *Rana catesbiana*, *Bufo marinus* and *Rana grylio*, but it is not known if these were implicated in the introduction of chytridiomycosis. There is a need to investigate further the effect of introduced species on native fauna and concomitant risk of disease introduction.

## 7. MOLECULAR DIAGNOSIS OF CHYTRIDIOMYCOSIS IN DOMINICA

As infection with the pathogen, *Batrachochytridium dendrobatiditis* (chytrid fungus) is a major threat to the survival and conservation of amphibian species in the Caribbean, it is imperative to develop rapid diagnostic capabilities for the detection of this disease in the region.

Rapid detection of chytrid infection is performed by a laboratory technique known as the polymerase chain reaction (PCR), and this can be performed on skin samples taken *post mortem* or on skin swabs collected from live animals.

PCR is a technique for amplifying short regions of DNA *in vitro*. In PCR reactions, the target DNA is copied by a thermostable DNA polymerase enzyme, in the presence of nucleotides and very short sequences of the target DNA or oligonucleotide primers that hybridise specifically to the target sequences. Through multiple cycles of heating and cooling in a thermocycler to produce rounds of target DNA denaturation, primer hybridisation, and primer extension, the target DNA is amplified exponentially. This technique has the potential to generate billions of copies of target DNA from a single copy. Two methods are commonly used for the detection of Chytrid; nested PCR and real-time (RT-) PCR.

In nested PCR, two pairs of primers are used for a single target DNA. The first pair are used in a standard PCR reaction, the second pair then binds to this first PCR product in another reaction to produce a second PCR product that is shorter but more concentrated than the original reaction. In RT-PCR, the amount of amplified DNA is monitored by the use of fluorescent labeled probe. Both methods have their benefits and disadvantages.

The molecular diagnostics laboratory based at the Botanical Gardens in Roseau is now fully equipped to perform the rapid diagnosis of chytrid using nested PCR. This

laboratory is the only one in the Caribbean with this ability and it is hoped that the laboratory, through collaborations with other Caribbean Islands, will serve as a beacon for the conservation and protection of amphibian species throughout the region.

## 8. *EX SITU* MOUNTAIN CHICKEN CONSERVATION RESEARCH

The mountain chicken *Leptodactylus fallax* has been little-studied in the wild. In 1999, animals from Montserrat were taken into captivity by the Durrell Wildlife Conservation Trust's Jersey Zoo headquarters in the UK Channel Islands captivity, in collaboration with the Montserrat Government, to conduct a conservation research project on the husbandry and reproduction of this species. The ultimate aim was to develop a conservation programme for the Montserrat population.

The captive enclosures were large and intentionally simple but provided all key elements of the frog's natural environment including an artificial breeding burrow, and most importantly a climate (photoperiod, temperature and rainfall) carefully controlled to mimic that of Montserrat.

A varied diet of locusts (two species), crickets (two species) and cockroaches was offered almost *ad libitum* and always fortified with a calcium-rich mineral and vitamin supplement. In addition, pre-killed neonatal mice were offered from tongs, mainly to reproductive females, on an infrequent basis.

Frogs were maintained in groups of between two and twelve individuals depending upon the time of year and experimental reproductive manipulations. The amount of food available is increased before the breeding season, to improve their reserves and to encourage the frogs to breed. During the breeding season, the digital spur on the adult male turns from white to black in colour.

Ratios of two males to one female proved to be the most successful at stimulating male:male combat, consequent ownership of breeding burrows and advertisement calling. The "winning" male is then transferred to an enclosure with an adult female. If successful mating does not occur within seven days, the adult female is replaced with another individual.

The first foam nest was produced in May 2000 and several subsequent successes indicated the months of May to August to be the peak period of breeding activity, though nests have been recorded between March and September. In Jersey, the nests are not always made in burrows and some nests have been made with no cover at all.

Courtship and nest production takes up to twelve hours and clutch size has ranged from 25-43 very tiny (~2mm) eggs. Tadpoles hatched after 6-10days, grew rapidly to over 130mm in total length and remained in the nest until metamorphosis at about 6-8 weeks of age.

There can be considerable variation in the size amongst tadpoles in the nest. The timing of tadpoles leaving the nest in captivity has varied by a period of up to 10-14 days. Currently, there is insufficient data available to determine whether there is a

selective advantage for tadpoles that have a proportionately longer tail.

Observation of the female frog and larva in the nesting burrow demonstrated that, contrary to the literature, female mountain chickens returned to their burrows 10-13 times over the period of larval development to deposit infertile nutritive eggs for the tadpoles to feed on. Furthermore, the number of eggs deposited increased with each subsequent visit as the tadpoles grow and the total number of eggs provided over the course of development was estimated to be 10,000-25,000 – a similar number to that laid by a similar-sized American bullfrog *Rana catesbiana.* These trophic eggs were the exclusive food source for the developing larvae, and *L. fallax* therefore appears to be displaying a new form of amphibian endotrophy; all larval developmental energy being derived from the parents.

Currently, there is not enough information available to estimate the clutch mortality rate in captive mountain chickens, however, no dead tadpoles have been found in nests in captivity to date. Selective pressures may have resulted in high clutch survival to avoid dead tadpoles decomposing and spoiling the nest. Research on the chemical composition of the foam nest is ongoing to determine if there are any agents that guard against nest fouling present.

It is possible for the adult female to go without food for the duration of nesting. However, in Jersey Zoo, the adult females took every opportunity to feed when food was made available at the nest. This suggests that, whilst the priority may be for nest guarding, the female will feed when prey is available. In captivity, it takes between 56 and 95 days from the first egg being laid until the final froglet metamorphoses.

Although there have been anecdotal reports in Montserrat of adult females being seen in association with young froglets, this behaviour has not been seen in Dominica. However, only one nest in the wild has been monitored in Dominica and here froglets whose tail had already resorbed were observed to jump back into the foam nest, apparently for protection, when disturbed. In captivity, once they leave the nest, the froglets are separated into groups of similar size to reduce any risk of cannibalism and for ease of management. The froglets are fed on half grown crickets with appropriate vitamin and mineral supplementation.

In captivity, the age of sexual maturity (*i.e.* first breeding) has been around two years. Whilst this age may differ in the wild, it is likely to be after the first year to reach maturity.

The *ex situ* research and breeding of mountain chickens has been of great significance. Not only did it show that these giant frogs could be bred in captivity as part of an integrated conservation strategy should it be required, but close observation and investigative research documented a unique reproductive strategy with an unprecedented level of maternal care. It will be interesting to obtain more observations of mountain chicken nests in the wild and to compare these (*e.g.* nesting period, time to emergence of young from nest) with the findings from captivity.

Information of this kind is invaluable not only to the scientific community but to conservation managers charged with implementing legislation and other threat-mitigation measures in the wild. Knowing that larval mountain chickens are entirely

dependent upon their mothers for nutrition, and therefore survival, strongly suggests that allowing adult female frogs to be collected for human consumption during the peak breeding season will have disastrous effects upon recruitment. Furthermore, data on parental care and investment, clutch size and developmental duration indicate that commercial farming of this species is highly unlikely to be commercially viable.

Successful conservation of mountain chickens in the Eastern Caribbean will depend chiefly upon the sustained protection of adequate suitable habitat, monitoring and mitigation of chytridiomycosis, continued absence of introduced mammalian predators, stopping or controlling commercial harvesting and possibly, translocation and/or re-introduction of frogs to former parts of their range.

## 9. MINIMISING THE RISK OF CHYTRID SPREAD TO OTHER CARIBBEAN ISLANDS

### 9.1. Routes of introduction

The workshop recognised two main routes for the potential introduction of *B. dendrobatidis*:

1) the movement of infected amphibians, and

2) the movement of contaminated water or soil.

#### 9.1.1. Movement of amphibians

It was recognised that amphibians could be imported deliberately or accidentally.

- *Accidental movement of infected amphibians within agricultural produce:* This is a very important threat for Caribbean Islands. Studies have estimated 50,000 frogs are accidentally translocated within Australia annually and the majority of these are thought to be in banana bunches. There are many reports of frogs having been found within boxes of imported produce (especially bananas). When they are found, these frogs often escape, or are released, within the importing country.

- *Deliberate import of amphibians:* Although the deliberate import of amphibians or amphibian products was considered as being likely to occur less frequently than the accidental import of amphibians, no information is available as to how many amphibians are deliberately imported into different islands. The workshop recognised that amphibian imports might occur for the pet trade, the food trade, or for scientific research and education. For many islands, there appear to be few restrictions on visitors importing live amphibians or amphibian products for food.

#### 9.1.2. Movement of contaminated water or soil

- *Agricultural produce transported in boxes containing damp soil*: Not only could this soil contain viable zoospores of *B. dendrobatidis*, but also frogs may be more likely to be translocated in banana boxes that contain soil.

- *Dirty footwear, clothes or equipment:* If the lifecycle stages of *B. dendrobatidis* can survive on footwear, clothing or equipment, the risk of entry via this route is high. No cruise liners visit Montserrat directly but virtually all stop at Antigua and offer day excursions to Montserrat. Ten different islands are visited immediately before Antigua by the various cruise ships, at least one of which (Dominica) has had a confirmed cases of chytridiomycosis.

## 9.2. Risk of accidental introduction of chytrid through agricultural trade

The workshop identified the agricultural trade as contributing to two of the highest risk routes of potential *B. dendrobatidis* introduction, *i.e.* the introduction of chytrid through:

1. The accidental import of live amphibians frogs hiding in shipments of agricultural produce ("stow-away" amphibians), and

2. Soil contamination of agricultural produce.

### 9.2.1. Stow-away amphibians

Tree frogs are commonly found in exported agricultural produce, especially in banana bunches, and many species of tree frog can act as carriers of the amphibian chytrid fungus.

The workshop discussed a variety of methods to prevent frogs accessing produce and to eliminate frogs from produce prior to export. It was suggested that the practice of covering developing banana bunches with plastic bags as a protection from insects might help to reduce the numbers of frogs hiding within the bunches of fruit. There is no information available, however to compare covered and uncovered bunches. Also, it was suggested that many frogs access banana bunches after these have been harvested.

The boxing of crops tends to occur on the farm of origin (*e.g.* citrus and banana). In general, bananas are harvested, boxed and taken to the container for export on the same day. It was suggested that if this were an enforced rule, the likelihood of frogs hiding in the crop during storage would be reduced.

The use of low temperatures as a technique to kill frogs hiding within agricultural crops was suggested. However, chilling would be ineffective for killing frogs and freezing would be inhumane and cause unacceptable damage to crops.

Following work conducted in Australia (where the accidental transport of frogs in produce has been recognised as a major problem), immersion in a water bath has been found to be an effective measure for eliminating frogs from produce. The use of saline water, which is toxic or aversive to amphibians, is most likely to drive hidden

amphibians out of the produce and into the water, from where they can be collected and humanely killed or, if at the site of origin, released.

The relative merits of an immersion procedure on the farm prior to transport, at a holding facility prior to export, or at the import dock after transport were discussed. The responsibility and cost of the procedure would fall to different people dependent on where the step was enforced in the custody chain. Preference was shown for immersion at the final port of import, since there would be a risk of frogs accessing the crop after any washing process in the country of origin prior to export (*e.g.* during storage). Also, controls would be in the best interest of the country of import to prevent accidental introduction of alien species (*e.g.* disease, crop pests). Immersion at the point of import was thought to be most viable for small islands (*e.g.* Montserrat) where the majority of produce arrives in small volumes through a limited number of ports, although this technique should also be investigated for larger islands.

An assessment of how the risk of accidental frog introduction varies between crop types was suggested, as was the conducting of a quantitative risk assessment be conducted to evaluate the risk of accidental frog introductions and to disseminate the results to policy makers.

It was suggested that the Windward Isles Banana Development Corporation (WIBDECO) might have a log of accidentally introduced frogs with their shipments. Making contact with their contact in St Lucia was recommended as part of the information gathering exercise.

9.2.2. Soil contamination of agricultural produce

Chytrid fungus is killed by drying and is unlikely to survive in microscopic amounts of soil that might remain (*e.g.* on fruit skins). The fungus is most likely to survive in moist soil. Dasheen and coconut were proposed as crops most likely to have soil contamination remaining at the point of export.

Some people consider that a small amount of soil left around agricultural crops helps them to remain “fresh”, therefore public and farmer education is required to minimise the amount of soil contamination on crops.

A zero tolerance policy to remove soil from crops in some islands in the region is in place, although variable adherence is experienced. This policy was adopted for parasite control to prevent introduction of pest nematodes. Since this policy exists, facilities for cleaning of agricultural crops prior to export are already in place in most islands. Currently, the responsibility for this process falls to the farmer in the country of origin.

The workshop suggested that produce should be washed prior to export and that responsibility for this should be transferred from the farmer to the phyto-sanitary officials.

Concern was expressed, however, about the practicality of placing responsibility for the efficacy and enforcement of any washing process on phyto-sanitary staff. The workshop noted that although protocols are in place for on-farm fungicide treatment

of certain crops, enforcement of these protocols remains problematic in some areas. Adherence to the rules and enforcement of the phyto-sanitary certificate can be difficult and concern was raised that this would be a similar situation with crop washing.

### 9.3. Risk of accidental introduction of chytrid through deliberate import of amphibian species

#### 9.3.1. Pet trade

The workshop considered that no islands in the Lesser Antilles have a significant pet trade (either through imports or exports), however, the pet trade in Puerto Rico is large (primarily involving *Littoria* sp. imported from Australia). Consequently, it was decided that this potential threat was not a priority to address in the region, but that consideration should be given to ensuring any trade in pet amphibians is chytrid-free. The re-export of exotic amphibians from Puerto Rico (or elsewhere) to other Caribbean Islands should also be regarded as a possible threat.

#### 9.3.2. Meat trade

The workshop acknowledged that there was a lack of information about the trade in frogs and frog products for human consumption in the region. The workshop considered that it was likely that such imports did occur in the Caribbean. For example, following the ban on hunting mountain chicken in Dominica and before a national ban on amphibian imports, an importation of frog meat from Taiwan to Dominica is known to have taken place. The majority of frog meat for human consumption in other areas of the world, for example France, originates from Asian and South American countries. The workshop agreed that information on which islands in the region import amphibian products for food consumption, and from where these products are imported should be obtained, if possible.

#### 9.3.3. Scientific research and education

It is currently unclear if any amphibian trade occurs in the region for these purposes. The workshop identified the need to determine whether any medical, research or high school facilities in the region import amphibian species (*e.g. Xenopus* sp., North American bullfrog *R. catesbiana*) for their work.

#### 9.3.4. Reducing the risk from imported amphibians and amphibian products

In Dominica, recent legislation has banned the import, but not the export, of frogs or frog products. However, it is illegal to catch frogs, and no permits to hunt or collect frogs of any species will be given, therefore there probably is no requirement to strengthen the legislation with regard to exports.

The workshop recommended that other Island States in the region consider following Dominica's lead and enact legislation to control the import of amphibians and amphibian products.

Currently, there is a list of animal diseases which must be checked for before animal movements are sanctioned across the region. The workshop suggested that consideration be given to chytridiomycosis being added to this list; this would help to control any unregulated amphibian movements. The molecular laboratory in Roseau could then act as the Regional Reference Laboratory for screening any samples for chytrid prior to documenting animals as "chytrid-free" prior to movement, and following a quarantine period.

International guidelines to minimise disease threats due to the movement of amphibians for conservation reasons are published by the World Organisation for Animal Health (OIE), but these would need to be incorporated into local legislation and enforced to be effective.

Chytrid infection has been reported in frogs farmed for the food trade and the import of frog products in a refrigerated shipment could pose a disease risk since chytrid can survive at 4$^{o}$C. Chytrid fungus is killed by the freezing process, so frozen products should not pose a chytrid disease threat, although viruses affecting amphibians can survive at these temperatures.

### 9.4. Risk of accidental introduction of chytrid through footwear and equipment

The workshop considered that, until and unless there is proof that contaminated footwear, clothes and equipment cannot carry viable zoospores, it would be wise to adopt the precautionary principle. Therefore, methods to minimise the possibility of disease importation via this route should be introduced.

There is a potential risk that chytrid fungus might be spread between and within islands in mud on dirty footwear, on dirty clothing or on dirty equipment. Tourists travelling around the Caribbean visiting several islands over a short period, for example, could pose a particular threat in this respect. However, the potential risk also applies to the movement of local nationals. Tourists in the Caribbean arrive via cruise ships or air travel. At least 13 cruise ship companies currently operate in the Caribbean.

The risk that visitors pose in terms of introduction of chytrid is likely to vary within and between islands, depending on the demography and number of tourists, the types of area that they visit and the likelihood that they will adhere to any rules imposed.

The use of disinfectant footbaths at ingress and egress from ports and airports was discussed, however:

- there was concern that the use of a footbath might scare tourists who, despite information, might be fearful that chytrid poses a threat to human health: *e.g.* there was a notable reduction in the number of U.S. visitors to the U.K. during, and following, a Foot and Mouth Disease outbreak in 2001.

- there was concern that tourists would be worried about damage to their footwear that might be caused by exposure to disinfectant.

- there was concern that, unless a footbath is adequately maintained, the solution will become dirty and no longer be effective.

- the example of Galapagos was quoted where quarantine rules included the use of a disinfectant footbath for on arrival at the airport. However there were problems with the maintenance of an effective disinfectant solution in the footbaths and this measure is no longer in use in Galapagos.

An alternative suggestion of a mat soaked with disinfectant being laid on the ground at the point of arrival for people to walk on was discussed. The workshop decided, however, that, as with footbaths, the maintenance of effective disinfection properties would be problematic.

Practically, the use of a footbath, or disinfection mat, for all visitors could be an option for smaller islands, but the workshop considered that this would not be feasible for the larger islands.

Whilst footwear and equipment would ideally be disinfected, the workshop decided that it would be more practical to simply aim for incoming persons to have clean (*i.e.* removal of visible mud or other visible contamination) footwear, clothing and equipment. This recommendation would require minimal resources to apply and enforce and it would be more likely to obtain a high level of visitor (and local) compliance. The workshop agreed that this would be the most realistic option.

### 9.5. Political support

Although there is a great deal of international political support for amphibian species protection, in the Caribbean region, other than in Dominica, this support is not yet apparent. The workshop recognised that, if biosecurity restrictions are to be introduced to travel and trade, there needs to be political support throughout the Caribbean region.

The workshop agreed that the current lack of political action is almost certainly due to a lack of awareness and information at the political level. This was exemplified by the fact that many of the specialist wildlife and forestry officials invited to the workshop were completely unaware of chytridiomycosis and the threat it poses to amphibians. The workshop noted that, as in Dominica, it will be easier to gain concern from the public and government in countries with an emblematic or endemic amphibian species, or where chytrid has been diagnosed, than in other islands.

In order to encourage governmental and public support for controls to mitigate the spread of chytridiomycosis, the workshop indicated that any recommended actions should include the potential to address economic concerns (*e.g.* market bananas with "chytrid-free" stickers, therefore enhancing their environmental credentials). The power of tourist concern to influence government decision-making was also emphasised.

Ministers of the Environment from each nation in the OECS meet on a quarterly

basis. This provides a forum for the international control of chytridiomycosis to be raised and discussed.

Another possible forum is Caricom (Caribbean Common Market), an organisation which covers the entire region from Haiti to Guyana. The workshop suggested that the issue should be raised with the Director of Caricom.

The workshop agreed that no particular island should be singled out as a "culprit" in terms of which islands have recorded the presence of chytrid. This is because, apart from Montserrat in 2005, there has been no, or insufficient, testing on any other Caribbean island to identify lack of infection. Also, islands should be encouraged to (and not discouraged from) investigating their amphibian chytrid infection status.

### 9.6. Public education

The workshop recognised that there is a need for a stratified and co-ordinated public education approach across the Caribbean region.

As this was a Caribbean-wide problem, the workshop agreed that it is important to develop a unified communication strategy across the region covering a range of media. This could involve the Caribbean Media Association. If public concern can be generated for the issue, this will stimulate government interest and place the issue on the political agenda. Heightened public awareness will also make it easier for the commercial travel operators to implement biosecurity measures.

There was much discussion on whether it should be the responsibility of government (quarantine/customs) or the travel industry (*e.g.* cruise ship companies) to communicate the biosecurity message and to provide funding for this work. It was considered that both would be required, but that the cruise ship operators probably would fund these measures within the cruise ship industry. A precedent set for this has been the collaboration of the OECS countries with Interpol and the United States on the control of parrot smuggling across the region.

The workshop identified a need for effective communication of the threat across all levels, from government to local farmers. The workshop noted that there had been a highly successful campaign regarding the threat of the pink mealybug and that a chytridiomycosis campaign could learn from this. The pink mealybug control program set a precedent for a public education campaign across the region. It was suggested that control of chytrid may be more problematic than for this campaign, since chytrid fungus is not visible with the naked eye. However, frogs and soil are visible.

Successful examples of pan-Caribbean biosecurity measures which included public education programmes, include control programmes for the *Amblyoma* sp. tick and the pink mealybug. The advertising for the latter alien species introduction was so successful that it was brought to the attention of the general public, despite being an issue targeted at farmers. The success of the pink mealybug campaign was partly due to the use of a memorable musical "jingle" and the workshop considered that such a jingle would be helpful to increase the use of chytrid biosecurity measures.

It was suggested that Claus Eckerman, Head of FAO Barbados would be a useful contact for the public education component of a biosecurity management plan. Claus Eckerman is responsible for the Trinidad and Eastern Caribbean region and it was agreed that he (or his successor) would be invited to participate in the Final Management Plan workshop.

The workshop noted that a great deal of work has been undertaken on biosecurity measures associated with travel and trade by Australia. The workshop also noted that colleagues in Australia might be approached to learn how they have approached public education on chytridiomycosis and other similar issues.

The option of an educational leaflet for tourists to explain the importance of cleaning footwear and why this may help preserve biodiversity was discussed. The relative benefits of leaflet versus short video formats for communicating information by the cruise ship companies also were discussed. Cruise ships regularly play information videos and have screens available in public areas of the vessel. In addition, very little effort is required to watch a video as opposed to reading a leaflet which requires the tourist to pick up the material. Ideally a personality well known to the majority of people on cruise ships should be sought to star in the video. Videos were preferred as the most direct approach.

The workshop recommended that public education be provided both in local languages and in languages commonly spoken by tourists.

The workshop suggested that the simplest and most effective way to communicate a message that would assist with control of chytrid spread would be to generalise and avoid focus on a single "disease" condition at all. The principles of wildlife protection, island species endemism, risks of introduction of alien species and diseases and the need to protect unique island biodiversity could be communicated along the lines of:

**HELP US KEEP OUR BIODIVERSITY HEALTHY**

- The Caribbean Islands contains unique, but fragile, ecosystems which need to be protected.
- This includes protection from exotic species and introduced diseases, both of which can be easily spread by travel and trade.

Please help us minimize the risk.

- **Clean your shoes and equipment of any remaining mud or debris before entering each island.**
- **Do not bring any live animals or plants in to, or take any out of, any Island.**

## 9.7. Implementation

There was much discussion of whether the government or transportation company (*e.g.* cruise ship company) should take responsibility for the implementation of any regulations (*e.g.* foot bath, clean footwear)? In Galapagos, the use of biosecurity measures (residual insecticides in airplanes) is stipulated by the Ecuadorian government. Commercial companies must abide by these rules in order to gain permission for entry to the Galapagos.

It was suggested that similar methods for the implementation of biosecurity measures in the Caribbean should be considered by the Caribbean Island States. If all islands were to unite and make a biosecurity system mandatory for arriving ships and aircraft, the commercial operators would be likely to comply. However, if an individual island were to make this request alone it might simply be boycotted by, for example, the cruise ship operators.

Increasingly, cruise ship and airline operators are striving to develop a positive environmental image. The workshop suggested that these operators could use the implementation of chytridiomycosis mitigation actions as a marketing ploy to help highlight their environmental credentials.

The idea of amending the customs declaration form for islands across the Caribbean region was discussed. An additional question could be included that would help minimise the risk of chytrid introduction through dirty footwear (*e.g.* Have you been on a hike or visited the forest during your visit? Is the footwear that you are carrying with you clean?). However, the workshop agreed that poor compliance with answering such questions honestly could be expected. Visitors might perceive that, by completing customs declaration forms with an answer that could raise an issue, they might experience some problem that they would, therefore, try to avoid.

An alternative and favoured suggestion was to use a simple and straight forward public education message. A poster with a friendly and non-intimidating feel requesting visitors to check and clean their footwear (both worn and in luggage) could be displayed. A simple statement could be included on the customs declaration form stating that "All visitors must ensure that their footwear is clean". The workshop agreed that, if this was done, some observation of disembarkation by enforcement officers should be in place and that facilities for cleaning footwear must be made available at the ports of entry.

## 9.8. Enforcement

Even if commercial travel operators adopted the implementation of biosecurity measures, government customs officials would be required to enforce these measures. The workshop suggested that this would be a simpler matter at airports and ferry ports than at ports of entry for cruise ships, but it was recognised that all would be required.

Several islands do not have a customs process for arrival of tourists on the island *e.g.*

St Lucia, Antigua, and Barbados. On other islands, customs officials go on board the cruise ship and obtain a list of passengers, etc., but do not observe the tourists as they disembark.

Also, some islands in the Lesser Antilles have a "free port" system (*e.g.* San Maarten). This means that there are no customs and reduced control over import and export of goods. The workshop identified a need to determine which other islands in the region operate under a free port system and whether import restrictions could be politically or logistically implemented at such ports.

In some countries (*e.g.* the U.S.), members of the public with dirty shoes at airports are given the option of cleaning their shoes or having them confiscated. The workshop agreed that this would be a useful option to help enforce biosecurity regulations, should these be adopted by Caribbean States.

It will also be important to ensure that quarantine and customs staff are properly and sufficiently trained in the importance, and the implementation, of the biosecurity measures in place. Currently, customs officers are given training for a six-month period, which includes a short component on CITES legislation but which does not include disease control. Antigua has a vet at its customs post although this was not thought to be the case in the other islands. The workshop agreed that improved training on disease control and biosecurity measures will be essential for customs officers.

The workshop recommended that export and quarantine staff be specifically educated about chytridiomycosis and the appropriate control measures required to prevent its spread. The workshop also suggested that these professionals could be particularly important in terms of public education.

## 10. LIMITING THE IMPACT OF CHYTRIDIOMYCOSIS IF IT DOES REACH OTHER CARIBBEAN ISLANDS

### 10.1. Early-warning system for disease detection

If chytridiomycosis reaches new islands, its impact could be reduced by rapid detection of such an incursion. This would allow a potentially-feasible eradication plan or mitigation plan to be implemented before the disease became established.

The workshop recommended that early-warning disease detection measures be urgently established by each nation within the region.

Such measures could include, for example, developing reporting networks to submit any dead amphibians found for disease investigation (specifically for the detection of chytridiomycosis, but also to investigate other causes of death).

Additionally, systematic surveillance of amphibians close to ports of entry and major towns (the most likely areas of disease incursion) should be considered.

Reporting networks and public vigilance for making reports can follow from public awareness campaigns, and from field work to evaluate species abundance and distribution. The workshop noted that a model system existed in Dominica where a reporting network has been created with the public through an educational campaign, which included radio and television broadcasts, leaflets and school visits.

The Veterinary Services Division (VSD) Molecular Diagnostic Laboratory in Dominica could provide a within-region diagnostic capability for chytridiomycosis. Contact should be made with staff at the VSD in Dominica on an individual basis for advice on sample handling and submission of cases of disease investigation. Skin swab samples can be preserved in alcohol or frozen. Skin swab samples will degrade rapidly under warm, moist conditions.

### 10.2. Surveillance for Amphibian Chytridiomycosis

The workshop recognised the urgent need for information on the chytrid status of countries across the region. In addition to identifying countries that are currently free of infection, this will also highlight countries where infection exists and which might be undergoing the cryptic loss of their amphibian biodiversity.

The workshop highlighted that the implementation of surveillance programmes for amphibian chytridiomycosis across the region is a priority.

The Molecular Diagnostic laboratory in Dominica can now act as a regional resource for the testing of samples. Work at this laboratory for testing samples in Dominica is supported by the UK government's Darwin Initiative until the end of March 2008. Exact details of screening costs after this funding period, and for other nations, need to be determined. It is likely, however, that a small number of samples over a specific period could be screened at the laboratory free-of-charge, and that further screening on a non-profit basis would be considered for countries within the region.

Central OECS funding, the Carib Environmental Health Institute, the PanAmerican Health Institute and the Caribbean Environmental Health Initiative (CEHI), were suggested as additional potential sources of funding for the laboratory and its work across the region.

The workshop recognised the need for cascade training by Dominican Forestry and Wildlife Division (FWD) staff in amphibian disease screening techniques to Forestry staff from other islands in the region. This type of technology transfer is highlighted within the Darwin Initiative, but the project budget only covers the costs of training Dominican staff. Additional money would need to be raised to cover costs of training additional forestry officers. These costs were not thought to be substantial above local travel fares. F.AO. was suggested as a potential source of funding to cover these additional expenses.

It was suggested that forestry staff could make arrangements to visit Dominica, and participate in training as part of the bimonthly transect surveys performed by staff as part of their routine surveillance.

FWD in Dominica receive an out of hours stipend for transect monitoring surveillance currently provided by the Darwin Initiative. Due to variation in pay and overtime, arrangements to cover forestry staff involvement would rest with each nation.

### 10.3. Public awareness campaign

The importance of a co-ordinated regional pubic awareness campaign was raised in all of the workshop sessions. Different aspects of such a campaign are covered in separate sections of the draft management plan.

### 10.4. Political support

In 2005, the Amphibian Conservation Summit, held in Washington D.C., U.S.A., concluded that there was a need for further monitoring and chytrid surveillance across regions. The Amphibian Conservation Action Plan produced by this summit (http://www.globalamphibians.org/acap_5fsummit_5fdeclaration.pdf) has been adopted and given high priority by the World Conservation Union (IUCN). The formulation of a draft management plan for chytridiomycosis in the Lesser Antilles will help to address this.

The workshop recommended the circulation of the Draft Management Plan from this meeting to the Permanent Secretary of Agriculture for each of the islands in the region.

The workshop recognised the need to find funding to support staff training and forestry staff participation in monitoring and disease surveillance. A strategy to raise funds collectively as a region, or separately on an individual nation basis was discussed. The Global Environment Facility of the World Bank was suggested as a possibility of funding for a regional application.

The possibility of increasing revenue from tourists visiting islands across the region was discussed. In Dominica, visitors are currently charged a set fee of 2 USD to enter park sites. In Antigua, a similar system operates at a charge of 5 USD. The possibility of increasing revenue from natural resources by charging tourists more to visit, which could then be channelled into environmental issues, was raised.

### 10.5. Improved legal protection for amphibian species

The workshop recognised that legal protection for amphibian species in the Caribbean was generally very poor or non-existent.

Caribbean island governments that are signatories to the Convention on Biological Diversity, however, have policy obligations to protect their native amphibians.

In Dominica, there is currently a legislative review in process to discuss including the mountain chicken on a list of protected species within the Wildlife Act. The workshop expressed hope that other countries in the region would follow this lead in

Dominica and would also act to protect their own native and endemic amphibian fauna.

The direct benefits of inclusion in national wildlife legislation were discussed. Whilst any listing might assist with directing resources to protect these species, it would not necessarily lead to financial resources being made available for this work.

It was suggested that legislation to protect endemic amphibian species across the Lesser Antilles, or Caribbean, would be beneficial. It was clarified that suggested legislation would be likely to cover endemic or native species only, excluding introduced amphibian species, in any country.

The implications of the move toward a Caribbean Single Market (CSM) Economy for the OECS countries were discussed. The possibility that legislation could follow a model similar to that of the European Union, where policy rules for member states are agreed and must be adhered to by participating nations was raised. The proposed CSM, however, will principally govern social and employment issues.

The workshop recommended that amphibian population monitoring be more widely established to assess the status of the region's native and endemic amphibian species and to inform the need for protective legislation.

### 10.6. Establishment of a network of contacts across the Caribbean for amphibian health and conservation

The workshop reviewed existing relevant Caribbean staff networks. Forestry staff from across the Caribbean region meet every two years. These meetings tend to focus on specific themes. If possible, amphibian and health and chytridiomycosis should be included on the agenda of the forthcoming meeting and a presentation could be given on the subject.

Currently, there are no regular meetings across the region which include both forestry and veterinary officials. The workshop agreed that communication between these government departments should be improved, as illustrated through the success of the collaboration in Dominica.

The FAO Agricarib Network is a group that discusses social and economic issues across the region and the workshop suggested that this could be a good forum for bringing together people from different government departments to discuss chytridiomycosis and amphibian conservation in the region.

The workshop agreed that the precedent for communication between forestry, customs, animal health and tourism departments which was set by the response to the pink mealybug threat should be used to attack the amphibian chytridiomycosis threat.

In addition, the workshop participants recommended that an informal network to facilitate contact between people working on amphibian conservation and chytridiomycosis should be established using a directory of names, email addresses and telephone numbers.

**APPENDIX 1. PROGRAMME FOR THE INTERNATIONAL WORKSHOP HELD AT THE HOLY REDEEMER RETREAT HOUSE, EGGLESTON, DOMINICA, 21-24 MARCH 2006**

# Addressing a Threat to Caribbean Amphibians: Capacity Building in Dominica

## International Training Workshop on Prevention of Chytrid Spread and Early Surveillance Measures

Holy Redeemer Retreat House, Eggleston, Dominica

21 to 24 March 2006

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### Final Programme

### Tuesday 21st March 2006

**Workshop Session 1 - Official Opening Session**

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|---|---|
| *Chairperson* | *Permanent Secretary* |
| **09.00 to 09.10** | **Mr Oliver Grell, Director of Agriculture**<br>Welcome & Opening Remarks |
| **09.10 to 09.30** | **Dr Andrew Cunningham, Head of Wildlife Epidemiology, Institute of Zoology**<br>Introduction to the Darwin Initiative Project – *Capacity building in Dominica: Addressing a Disease Threat to Caribbean Amphibians*. |
| **09:30 to 09:40** | **Questions** |
| **09:40 to 09:50** | **Dr J. Collin McIntyre, Minister for Agriculture, Fisheries & Environment**<br>Feature Address |
| **9.50 to 10.10** | **Group Photograph** |
| **10.10 to 10.40** | **Refreshments** |

**Workshop session 2 - Amphibian Species and Status across the Caribbean**

***Chairperson*** ***Mr Arlington James, Forest Officer / Dominica***

**10.40 to 13.00** **10 minute presentation to be given by each invited delegate** to include information on amphibian species, range, status and protection, research or monitoring schemes, where available, for each Caribbean island represented.

**13.00 to 14.00** **Lunch**

**Workshop session 3 - Caribbean amphibian species**

***Chairperson*** ***Mr Eric Hypolite, Director of Forestry, Wildlife & Parks (Ag.) / Dominica***

**14.00 to 14.30** **Dr Frank Clarke, Biodiversity Consultant, Fauna and Flora International**
"Eleuthrodactylid species across the Lesser Antilles"

**14.30 to 14.40** **Questions**

**14.40 to 15.00** **Mr Arlington James, Forest Officer, Wildlife & Parks (Ag.) / Dominica**
"*Leptodactylus fallax* in the Caribbean"

**15.00 to 15.20** **Mr Richard Gibson, Curator of Herpetology, Zoological Society of London & Mr Kevin Buley, Curator of Lower Vertebrates, Chester Zoo**
*"Leptodactylus fallax* – ex-situ research and conservation"

**15.20 to 15.30** **Questions**

**15.30 to 15.50** **Refreshments**

**Workshop session 4** **- Chytridiomycosis**

***Chairperson*** ***Mr Ronald Charles, Assistant Forestry Officer, Wildlife & Parks (Ag.) / Dominica***

| | |
|---|---|
| **15.50 to 16.30** | **Dr Andrew Cunningham**<br>"Chytridiomycosis and Amphibian Declines: A Global Perspective" |
| **16.30 to 16.50** | **Dr Reginald Thomas, Acting Head of Veterinary Services Division**<br>"Chytridiomycosis and Dominica" |
| **16.50 to 17.00** | **Questions** |

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## Wednesday 22nd March 2006

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| **Workshop session 5 Material** | **- Amphibian Monitoring, Chytrid Diagnostics and Educational** |
| ***Chairperson*** | ***Dr Reginald Thomas*** |
| **09.00 to 09.30** | **Mr Eric Hypolite**<br>"Amphibian Transect Monitoring in Dominica". |
| **9.30 to 9.40** | **Questions** |
| **9.40 to 10.00** | **Dr Clyde Hutchinson, Molecular Epidemiologist, Institute of Zoology & Dr Valarie Thomas, Veterinary Services Division**<br>"Molecular Diagnosis of Chytridiomycosis" |
| **10.00 to 10.10** | **Questions** |
| **10.30 to 11.00** | **Refreshments** |
| **11.00 to 11.25** | **Dr Patricia Burrowes, Puerto Rico**<br>"Amphibian Research in Puerto Rico" |
| **11.25 to 11.35** | **Questions** |
| **11.35 to 12.00** | **Dr Gerardo Garcia, Head of Herpetology, Durrell Wildlife Conservation Trust**<br>"Amphibian Conservation in Montserrat" |

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|---|---|
| **12.00 to 12.10** | **Questions** |
| **12.30 to 13.30** | **Lunch** |
| **13.30 to 16.00** | Tour of the molecular diagnostic laboratory and Botanical Gardens, Roseau |
| **16.00** | Group recreational visit to Trafalgar Falls |

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## Thursday 23rd March 2006

**Workshop session 6 - Formulation of Draft Management Plan**

***Chairperson*** ***Dr Andrew Cunningham***

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| **09.00 to 09.30** | **Mr Dan Horton, Veterinary Surgeon**<br>"Risk assessment for chytridiomycosis in the Lesser Antilles" |
| **09.30 to 10.45** | **All day discussion - Formulation of Draft Management Plan** |
| **10.45 to 11.00** | **Refreshments** |
| **11.00 to 13.00** | **All day discussion - Formulation of Draft Management Plan**<br>Continued |
| **13.00 to 14.00** | **Lunch** |
| **14.00 to 15.15** | **All day discussion - Formulation of Draft Management Plan**<br>Continued |
| **15.15 to 15.30** | **Refreshments** |
| **15.30 to 16.30** | **All day discussion - Formulation of Draft Management Plan**<br>Continued |

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## Friday 24th March 2006

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| **AM** | **Hike to the Boiling Lake (Optional)** |

## APPENDIX 2. LIST OF DELEGATES ATTENDING THE WORKSHOP

| Name | Position | Affiliation | Address | Contact details |
|---|---|---|---|---|
| Jacqueline André | Assistant Forest Officer, Environment Education | Forestry, Wildlife and Parks Division | Ministry of Agriculture and Environment, Botanic Gardens, Roseau, Dominica | Tel/ +1-767-448-2401 ext. 3439/3430<br>+1-767-266-3430<br>Fax/ +1-767-448-7999<br>Email/ asstforestofficer@cwdom.dm |
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| Timotheus Jn. Baptiste | Wildlife Officer | Forestry Department | Union, Castries, St Lucia | Tel/ +1-758-450-2078<br>Email/ chiefforest@slumaffe.org<br>gaspardtalk@yahoo.com<br>timmyft2003@yahoo.com |
| Kevin Buley | Curator | North of England Zoological Society | Chester CH2 1LH, U.K. | Tel/ +44-1244-389402<br>Fax/ +44-1244-381352<br>Email/ k.buley@chesterzoo.org |
| Patricia A. Burrowes | Associate Professor of Biology | University of Puerto Rico | Department of Biology, P.O. Box 23360, San Juan, P.R. 00931 | Tel/ +1-787-764-0000 ext. 4878<br>Fax/ +1-787-764-2610<br>Email/ paburrowes@uprrp.edu |
| Ronald Charles | Assistant Forest Officer | Forestry, Wildlife and Parks Division | Ministry of Agriculture and Environment, Botanic Gardens, Roseau, Dominica | Tel/ +1-767-448-2401 ext. 3817<br>+1-767-266-3816<br>+1-767-448-7999<br>Email/ morneyam@yahoo.com |
| Frank Clarke | Biodiversity Consultant | Fauna and Flora International | 218 Glasgow Street, Ardrossan, Ayrshire KA22 8JS, U.K. | Tel/ +44-7905-355775<br>Email/<br>wildlifeconservation@hotmail.com.uk |
| Naomi Commodore | Laboratory Technician | Plant Protection and Quarantine Services | Ministry of Agriculture and Environment, Botanic Gardens, Roseau, Dominica | Tel/ +1-767-266-3801<br>+1-767-255-7705 (cell)<br>Email/ naomi_commodore@yahoo.co.uk |
| Andrew Cunningham | Head of Wildlife Epidemiology | Institute of Zoology | Zoological Society of London, Regent's Park, London NW1 4RY, U.K. | Tel/ +44-20-7449-6674<br>Fax/ +44-20-7483-2237<br>Email/ a.cunningham@ioz.ac.uk |

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|---|---|---|---|---|
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| Aden Forteau | Forester One | Forestry and National Parks Department | Grenada | Tel/ 440-2934<br>Email/ michael_forteau@yahoo.co.uk |
| Gerardo Garcia | Head of Herpetology | Durrell Wildlife Conservation Trust | Les Augres Manor, Trinity, Jersey JE3 5BP, Channel Islands, U.K. | Tel/ +44-1534-860072<br>Fax/ +44-1534-860001<br>Email/ gerardo.garcia@durrell.org |
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