



MOUNTAIN CHICKEN MONITORING MANUAL



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**On behalf of the
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Ministry of Agriculture, Planning and the Environment
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EXECUTIVE SUMMARY

Under the International Union for the Conservation of Nature's criteria, the mountain chicken or crapaud, *Leptodactylus fallax*, should be classed as, at the very least, an Endangered species (EN B1+2b,c).

Indeed, this giant frog is now one of the most threatened species of amphibian in the world. The mountain chicken originally inhabited at least five, and possibly seven, major islands in the Lesser Antilles, but now survives on only two. With the reduced population on Montserrat currently under fire from the Soufriere volcano, the need to safeguard Dominica's mountain chickens has become stronger than ever.

Mountain chickens form Dominica's national dish, however, and continue to be hunted legally (by licensed hunters during an annual open season) and illegally, to satisfy the demand for frog meat from local people and a growing number of tourists. Habitat loss is ongoing, and mountain chickens are almost certainly subjected to predation by a battery of introduced animals, including feral pigs, opossums, dogs and cats. Their area of occupancy appears to have shrunk over the past few centuries: reports from Forestry and Wildlife Division (FWD) staff suggest that mountain chickens now occupy scattered areas totalling only some 25-50km² of the 754km² island.

This new manual has been developed as part of the joint FWD and Fauna & Flora International (FFI) project on Sustainable Wildlife Use in Dominica. It aims to provide the FWD with background information on the species' biology and to describe straightforward methods for monitoring the mountain chicken population's distribution range, abundance, reproduction and health. The findings of this research will be used to help determine how best to manage and conserve the population in the long term.

The recommended monitoring programme largely revolves around repeated surveys of permanent sampling units. The FWD has established eight 250m x 10m belt transects in widely



scattered parts of the species known range. The chosen sites vary in a number of aspects, including elevation, proximity to water, and accessibility for hunters. To help detect changes in Dominica's mountain chicken population, standardised Visual Encounter Surveys and Aural Encounter Surveys will be carried out on each transect every three months.

There is clearly still much to learn about the behaviour and ecology of the mountain chicken. During the first round of Visual Encounter Surveys in August 2002, the highest density of mountain chickens was recorded on the Soufriere Sulphur Springs transect, where the soil and water is highly acidic (pH values <5.0). Even more remarkably, the temperature of the stream through this transect ranged from 35.5 to 70.5°C! Mountain chickens appear to be unusually robust frogs in this respect.

Nonetheless, as the histories of Guadeloupe, Martinique and St Kitts attest, mountain chickens are far from indestructible when exposed to hunting and other anthropogenic pressures. Field studies by a team from FWD and FFI in August 2002 revealed that Dominica's mountain chickens are now in danger of local extinction. The frogs are significantly smaller (mean = 12.6cm SVL, 171g mass; range = 4.5-16.0cm SVL, 6-320g mass) than their counterparts in Montserrat (mean = 16.7cm SVL, 436g mass; range = 10.0-20.0cm SVL, 59-670g mass). This is indicative of exceptionally high mortality on Dominica, and can probably be attributed to hunting by humans and/or predation by invasive species. Relatively few frogs survive to maturity, and their small sizes reduces both their value as a source of food and their reproductive potential.

In view of the species' status as an Endangered species and this aforementioned evidence that Dominica's population is being over-hunted, it is crucial to guard the mountain chickens against further declines. This manual therefore outlines several possible conservation measures that were suggested by participants of the FWD-FFI internal mountain chicken workshop in 2002.

SUMMARY OF SURVEY AND MONITORING PRIORITIES

Activity / Rationale	Method	When
<p>Monitor relative abundance of mountain chickens on transects. <i>Declining abundance on transects may signal a serious decline in whole population, perhaps due to over-hunting. An early warning that stronger controls should be put in place.</i></p>	<p>See section 2.1 of this manual. Survey mountain chickens on each established transect every three months using the Visual Encounter Survey and Aural Encounter Survey form and protocol described in Appendix II. (Change or add to the current list of transects now if necessary, but ensure that the final list of transects is agreed by November 2002). Examine the results of surveying each transect to determine whether frog populations have changed. Draw simple bar charts to elucidate trends.</p>	<p>Ongoing process. Repeat every August, November, February, and May. (May be reduced to every six months or even annually if population appears stable).</p>
<p>Map the current distribution of the mountain chicken in Dominica. <i>To assess the conservation status of species and identify priority areas for protection. Also help build understanding of which habitats the frogs prefer</i></p>	<p>See section 2.2 of this manual. Sightings/ calls plotted on a large-scale map at Forestry office, and entered onto a computer (GIS) database. Sources: - Existing knowledge of FWD personnel. - Targeted and opportunistic field surveys. - Informal interviews with public. - Published literature and museum records. - Visiting scientists.</p>	<p>By end 2002. Distribution range should be reassessed every two years to monitor changes.</p>
<p>Monitor body sizes of mountain chickens. <i>Decreases in the relative numbers of old (large) frogs may indicate reduced survival due to over-hunting. A lack of very small frogs would suggest failure to reproduce, ultimately leading to local extinction.</i></p>	<p>See section 2.3 of this manual. Measure (SVL) of all frogs captured on the transect surveys and anywhere else in Dominica as the opportunity arises. Aim to catch and measure at least 30 frogs every quarter. Plot body size against number of individuals, as shown in Figure 3 (this manual). Look out for changes in population structure from one year to the next, or difference in body sizes in different parts of the island.</p>	<p>Catch and measure frogs during quarterly transect surveys and at any other times. Compile a frequency chart of frog body sizes at least once a year.</p>
<p>Monitor health of mountain chickens. <i>Multiple factors could lead to disease or sudden die-offs, including pollution, lack of prey and even global warming.</i></p>	<p>See section 2.4 of this manual. Examine all frogs captured on the transect surveys and elsewhere in Dominica for signs of weakness, disease or deformities. Measure (SVL) and body mass. Plot SVL against body mass and note if any frogs are seriously below average weight. Investigate all reports of frog die-offs. If a number of ill frogs are found, kill and preserve one or more specimens for diagnosis. Specialist help should be sought from DAPTF.</p>	<p>Catch and measure frogs during quarterly transect surveys, plus whenever frog die-offs are reported.</p>
<p>Monitor hunting pressure. <i>This should be carried out in tandem with the studies listed above to help determine the impact of hunting on frog distribution, abundance and reproduction.</i></p>	<p>Interviews with hunters and surveys of markets and consumers (including hotels and restaurants) to estimate number of frogs hunted annually on Dominica. Beware that illegal hunting is liable to be under-reported. Random, surprise checks on the refrigerator contents in houses and restaurants may provide figures that are more accurate.</p>	<p>Hunting surveys are currently being carried out as part of the FWD-FFI project on Sustainable wildlife Use (2001 to 2004).</p>

Activity / Rationale	Method	When
<p>Map the historic distribution of the mountain chicken in Dominica. <i>To assess impact of hunting and other threats. May indicate possible areas for re-introduction.</i></p>	<p>See section 2.2 of this manual. Informal interviews with older residents on Dominica. Plot records on a large-scale map and compare with current distribution range. Attempt to find out why frogs have disappeared from some areas (over-hunting? predation? pollution? etc).</p>	Ongoing.
<p>Gather further baseline information on the ecology of the mountain chicken. <i>Build up a better understanding of the needs of and threats to this species, to help inform good conservation management.</i></p>	<p>See section 1.2.7 of the manual. Various studies would be useful, e.g.:</p> <ul style="list-style-type: none"> - The location and structure of mountain chicken nests (what makes good nesting habitat?) - Diet analysis (stomach contents of road kills/hunted specimens) - Radiotelemetry to study habitat use and home range size (transmitters can be attached as 'frog back-packs'). - Diet of opossum (to determine if it is a significant predator) - Mountain chicken reproductive behaviour (mate selection, courtship, duration of breeding season, larval development, etc). 	As funding (and willing FWD staff or visiting scientists) become available.



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Some of the background information and data in this manual are derived from ongoing work on the mountain chicken in Montserrat, headed by Gerard Gray and the Division of Forests and Environment. Philamon Murrain has produced extensive background information about the natural history of this species in Montserrat. Kevin Buley, Head of the Herpetology Department at the Durrell Wildlife Conservation Trust, and his colleague Richard Gibson, provided fascinating insights into this species’ reproductive behaviour.

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Acronyms and Abbreviations

AES	Aural Encounter Survey	IUCN	International Union for the Conservation of Nature and Natural Resources (the World Conservation Union)
a.s.l.	above sea level (altitude)		
CCA	Caribbean Conservation Association		
cm	centimetre		
DAPTF	Declining Amphibian Populations Task Force (an IUCN specialist group)	km km ²	kilometre square kilometre (area 1km x 1km)
DWCT	Durrell Wildlife Conservation Trust	l m	litre metre
ECS	Eastern Caribbean dollar	mg	milligram
FFI	Fauna & Flora International	mm	millimetre
FWD	Forestry and Wildlife Division	N	North
GIS	Geographical Information System	SVL	Snout to vent length (a standard measure of body length for amphibians)
GPS	Global Positioning System	US\$	United States dollar
g	gram	VES	Visual Encounter Survey
IRF	Island Resources Foundation	W	West



1. GENERAL INTRODUCTION

1.1 DOMINICA

1.1.1 Topography and Geology

Dominica is a very rugged 754km² island in the Lesser Antilles centred on 15°25'N and 61°22'W. It contains the highest mountains in the Eastern Caribbean, including Morne Diablotin (1,447m a.s.l.) and Morne Au Diable to the north. A chain of mountains extends through the south of the island, including Morne Trois Pitons, Morne Micotrin and Morne Anglais. A relatively low and flat area in the centre, known as Bell's Wet Area, separates the northern and southern peaks.

The wet climate has reputedly given rise to 365 streams and rivers, which include some of the largest waterways in the Eastern Caribbean. Deep ravines have been eroded into the mountain slopes, many of which naturally contain water all year round. This abundance of water is particularly significant to the present work because even though mountain chickens live and even breed on land, they nonetheless prefer valleys with permanent water (Daltry, 1998).

Dominica's soils are largely volcanic in origin. More than 50% are deep, strongly weathered allophonic and kaolinitic clays (see CCA-IRF, 1991). Only 9% of the soils are shallow montmorillonitic clays with a silica pan, but these dominate most of the low-lying leeward areas where mountain chickens currently live (see **Map 1**). Volcanic activity has not yet entirely stopped, as can be seen from the hot Soufriere Sulphur Springs and Boiling Lake. A minor eruption occurred in January 1980.

1.1.2 Climate

Dominica has a humid tropical maritime climate with relatively little seasonal variation. Average annual temperatures at sea level are 26-27°C, with a mean low of 20°C in January and a mean high of 32°C in July. Mean annual temperature falls by approximately 0.6°C per 100m rise in elevation. Median annual rainfall ranges from 1,200mm in rain shadow areas on



the leeward coast to over 7,000mm on the higher, windward facing slopes (more than 10,000mm according to CCA-IRF, 1991). Rainfall patterns are highly variable from year to year, but generally, there is a dry season from February to June and a wet season from July to January. Dominica is at risk annually from hurricanes and tropical storms from July to November. The most destructive hurricane in recent years was Hurricane David in August 1979, with Hurricanes Hugo and Luis causing further damage in 1989 and 1995, respectively.

1.1.3 Ecology

The variable rainfall and complex topography has given rise to a wide range of natural vegetation formations, including fumarole vegetation, swamp forest, scrub woodland, littoral forest, seasonal or semi-evergreen forest, rain forest, and elfin cloud forest. Areas of grassland are likely the result of anthropogenic burning and grazing. Dominant species in each natural formation are given in CCA-IRF (1991), among others. Today, over two thirds of the island is forested, but many of the forests on the coasts and flatter areas were historically cleared for agriculture or timber extraction. Secondary forest, banana plantations and orchards dominate the current range of the mountain chicken.

Over 1,000 flowering plants have been recorded on Dominica, and the forests are the most diverse and pristine in the Eastern Caribbean. 11 species of freshwater shrimp and 20 crabs have been recorded, including the edible freshwater crab *Guinotia dentata*, white crab *Cardisoma guanhumi*, and black crab *Gecarcinus ruricola*.

The vertebrate fauna contain a mixture of native and deliberately or accidentally introduced species. Though various species of fish are present, they are largely unstudied and were not discussed by Zamore (2000). CCA-IRF (1991) mentions only the mountain mullet *Agnostomus monticola*. The herpetofauna has been intensively studied and includes four amphibians, five tortoises and turtles, at least ten lizards and four snakes (see **Box 1** for species names and status). Of these, nine species and subspecies are considered endemic to Dominica. 175 birds have been documented, of which 59 are resident. These include two endemic parrots: the imperial parrot or sisserou *Amazona imperialis*, and red-necked parrot or jaco *A. arausiaca*.

Box 1 Amphibians and Reptiles of Dominica

	<u>Scientific name</u>	<u>Origin</u>
Amphibians		
Anura (tail-less amphibians)		
Dominican whistling frog	<i>Eleutherodactylus amblinympha</i>	Endemic species. Typically at higher elevations.
Johnstone's whistling frog	<i>Eleutherodactylus johnstonei</i>	Introduced. Indigenous to Leeward Islands.
Martinique whistling frog	<i>Eleutherodactylus martinicensis</i>	Probably indigenous to Dominica. Also on Martinique, Guadeloupe, Montserrat, etc.
Mountain chicken ('crapaud')	<i>Leptodactylus fallax</i>	Indigenous to Dominica, Montserrat, Guadeloupe (extinct), Martinique (extinct), St Kitts (extinct), ?St Lucia (extinct) and ?Antigua (extinct)
Reptiles		
Chelonia (tortoises and turtles)		
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Indigenous. Global distribution.
Loggerhead turtle	<i>Caretta caretta</i>	Indigenous. Global distribution.
Green turtle	<i>Chelonia mydas</i>	Indigenous. Global distribution.
Leatherback turtle	<i>Dermochelys coriacea</i>	Indigenous. Global distribution.
Red-footed tortoise	<i>Geochelone carbonaria</i>	Introduced. Indigenous to Central and South America.
Sauria (lizards)		
Dominican ground lizard	<i>Ameiva fuscata</i>	Endemic to Dominica.
Dominican tree lizard	<i>Anolis oculatus</i>	Endemic to Dominica.
Crested tree lizard	<i>Anolis cristatellatus</i>	Introduced. Indigenous to the Virgin Islands - Puerto Rico Bank.
Lesser Antillean iguana	<i>Iguana delicatissima</i>	Indigenous. Also Anguilla, St Martin (extinct), St Barthelemy (extinct on Ile Fourchue), St Eustatius, Antigua (extinct), Barbuda (extinct), St Kitts (extinct), Nevis (extinct), Guadeloupe, Les Desirade, Marie Galante (extinct), Iles de la Petite Terre, Iles des Saintes, and Martinique.
Slipperyback skink	<i>Mabuya bistrata</i>	Probably indigenous to most islands between Anguilla and Grenada. Believed extinct on Martinique, St Lucia, Barbados and the Grenadines.
Skink	<i>Gymnophthalmus pleei</i>	Probably indigenous. Also St Lucia Guadeloupe, and Martinique
House gecko	<i>Hemidactylus mabouia</i>	Introduced to Lesser Antilles from Africa



Box 1 Cont.

	Scientific name	Origin
Dwarf gecko	<i>Sphaerodactylus fantasticus</i>	Subspecies <i>fuga</i> endemic to Dominica.
St Vincent dwarf gecko	<i>Sphaerodactylus vincenti</i>	Subspecies <i>monilifer</i> is endemic to Dominica.
Forest gecko	<i>Thecadactylus rapicaudus</i>	Probably indigenous to most islands between Anguilla and Grenada.
Serpentes (snakes)		
Boa constrictor	<i>Boa constrictor</i>	Subspecies <i>nebulosa</i> is endemic to Dominica.
Dominica racer ('kouwes new')	<i>Alsophis antillensis</i>	Subspecies <i>sibonius</i> is endemic to Dominica.
Dominican liophis ('kouwes jenga')	<i>Liophis juliae</i>	Subspecies <i>juliae</i> is endemic to Dominica.
Dominican blind snake	<i>Typhlops dominicana</i>	Subspecies <i>dominicana</i> is endemic to Dominica.

Taxonomy designation follows Schwartz & Henderson (1991), apart from *Mabouya bistrata*, which follows the more recent Malhotra & Thorpe (1999). Reports of the dwarf gecko *Sphaerodactylus microlepis*, and the snake *Clelia clelia*, on Dominica were probably in error.

Also recorded on the island are 12 species of bats (including the endemic mouse-eared bat *Myotis dominicensis* and three regional endemic species). Introduced mammals include rats (probably both *Rattus rattus* and *R. norvegicus*), domestic mice (*Mus musculus*), agoutis (*Dasyprocta antillensis*) and the opossum or maniocou *Didelphys marsupialis* (introduced in 1835). Dominica also has feral pigs, dogs and cats, together with a large number of free-ranging goats, sheep and cattle.

1.1.4 Protected Areas

The protected areas of Dominica comprise two Forest Preserves and three National Parks. The Morne Trois Pitons National Park, established in 1975, contains 6,872ha of rain forest, lakes and waterfalls in the South-Central part of the island. This area has been recognised as a World Heritage Site since 1998. The much smaller Cabrits National Park was established on the West coast in 1986 to conserve the ruins of Fort Shirley and coastal dry woodlands below 180m a.s.l. The newest national park, Morne Diablotin, was established in 2000 and covers some 3,400ha of high-elevation rain forest.



These protected areas contain few if any mountain chickens. Despite encompassing some 20% of Dominica's forestlands, they are generally above the maximum known elevation for this frog.

Outside of these areas, much of the forested state land at lower elevations has been transferred to private ownership since Independence. Under the Crown Lands Ordinance, however, state land within five chains (approximately 100m) of a stream at its headwaters cannot be sold or developed. This law may have helped to safeguard at least some areas of mountain chicken habitat.

1.1.5 Human Population and Economy

Caribs first settled Dominica in the 14th Century, but the island remained unknown to Europeans until 1493. Largely ignored by its first European claimant, Spain, the island changed hands several times between France and Great Britain, who cultivated coffee, sugar and later, cocoa and limes. Dominica finally gained independence in 1979.

The first census in 1844 recorded over 22,000 people on Dominica. The current population stands at approximately 71,000, one third of whom live in the capital, Roseau. Around 90% of Dominicans live on the coast. These figures include some 3,000 Caribs, most of whom live in the Carib Territory on the windward coast.

Dominica's economy is still predominantly agricultural. Bananas have long been the major crop, although their export value has slumped since 1993, forcing banana farmers to diversify. Other important crops include citrus fruits, coconuts, coffee and cocoa. There is some light manufacturing, however, and the tourism sector has grown rapidly in recent years. Visitors include cruise ship passengers and nature tourists.

Hunting and trade in wildlife accounts for a relatively small portion of the domestic economy. The most frequently hunted animals are agoutis, pigeons, opossums, crabs and mountain chickens. The frogs are particularly sought after, and are regarded as Dominica's national dish. The frog also features on the national coat of arms.

1.2 MOUNTAIN CHICKEN AUTECOLOGY

1.2.1 Description

The mountain chicken, *Leptodactylus fallax*, is one of the world's largest frogs, with adult females attaining a snout-vent length of 21.0cm (Krintler, 1986) and a body mass of 700g plus.

A member of the anuran family Leptodactylidae (which also includes the whistling tree frog genus *Eleutherodactylus*), the mountain chicken has a large head and a robust body form. Its hind limbs are very muscular and are more than half the total length of the frog. Colouration is rather variable, but the dorsum is typically light or dark brown, with broad, darker bands across the legs and a black line extending from the snout to the angle of the mouth. There may be dark bands or blotches on the back. The flanks are paler in hue, and are commonly reddish or salmon pink with small dark dots. The eyes are large, with black round pupils and a golden iris.

Like all frogs, mountain chickens continue growing throughout their lives. Newly metamorphosed juveniles are approximately 4cm SVL and weigh less than 10g, while sub-adult mountain chickens of less than 13cm SVL are immature and probably less than three years of age. Adult males tend to be smaller than females of the same age, although frogs that have not fed well, have been ill or have diverted a lot of energy to reproduction will also tend to be relatively small.

During the breeding season, adult males can be easily recognised by the conspicuous black spur on each 'thumb' and their muscular forearms. The spur is used to clasp the female during amplexus, and may be used in fighting between rival males. Reproductively active mountain chickens produce loud yelping calls every 1-1.3 seconds that can carry for up to a kilometre. Male frogs mainly call after sunset, but sometimes also on rainy or humid, overcast days. Unlike most frogs, female mountain chickens also call, though producing softer vocalizations. Both sexes also produce an alarm cry when captured.

Mountain chickens are believed to have a life span of approximately 12 years, becoming sexually mature at around three years of age. Captive bred mountain chickens have matured as young as 20 months (Kevin Buley, pers. comm.).

1.2.2 Distribution, Origin and Conservation Status

This large frog originally inhabited at least five Eastern Caribbean islands, but was extirpated from Guadeloupe, St Kitts and Martinique since the time of Columbus. Mountain chickens are also thought to have originally inhabited St Lucia and Antigua.

Under the internationally accepted IUCN criteria for defining conservation status (see Hilton-Taylor, 2000; or www.iucn.org/themes/ssc/redlists/RLcats2001booklet.html), the global conservation status of the mountain chicken should be classified as, at the very least, Endangered (EN B1+2bc):¹

B. *Area of occupancy estimated to be less than 500 km².*

Certainly less than 200km² on Montserrat and Dominica combined, and probably less than 70km².

1. *Severely fragmented or known to exist at no more than five locations.*

Now confined to only two locations: the islands of Dominica and Montserrat.

2. *Continued decline, inferred, observed or projected, in the following:*

b) *Area of occupancy.*

The mountain chicken has definitely been extirpated from at least three islands, and its area of occupancy on Montserrat and probably Dominica has decreased in recent years.

c) *Area, extend and/or quality of habitat.*

Due to volcanic activity and construction on Montserrat, and agricultural expansion and construction on Dominica.

¹ The status of the mountain chicken is currently being assessed as part of the Global Amphibian Assessment. The preliminary assessment is Critically Endangered (CR B2ab) (pers. comm., Simon Stuart).

It has been rumoured that mountain chickens are not indigenous to the Lesser Antilles, and that Arawaks or Caribs introduced them from South or Central America, like the agouti *Dasyprocta antillensis*, and red-footed tortoise *Geochelone carbonaria*. After all, it seems difficult to believe that mountain chickens managed to cross the seas from island to island without human help: few frogs can endure a soaking in salty water.

There are strong indications that the mountain chicken is endemic to the Lesser Antilles, however. *Leptodactylus fallax* differs morphologically and behaviourally from its nearest relative in South America, *L. pentadactylus*, and exhibits a number of adaptive traits for life on volcanic islands.² While Indians may well have helped transported mountain chickens between islands, this species was almost certainly well established in the Lesser Antilles long before humans arrived.

On Montserrat, mountain chickens have declined because of hunting and habitat loss, and currently inhabit an area of less than 20km² (see **Map 2**: Daltry & Gray 1999). Colonies in the South Soufriere Hills, Soufriere Hills and Garibaldi Hill have been wiped out by the recent volcanic eruptions.

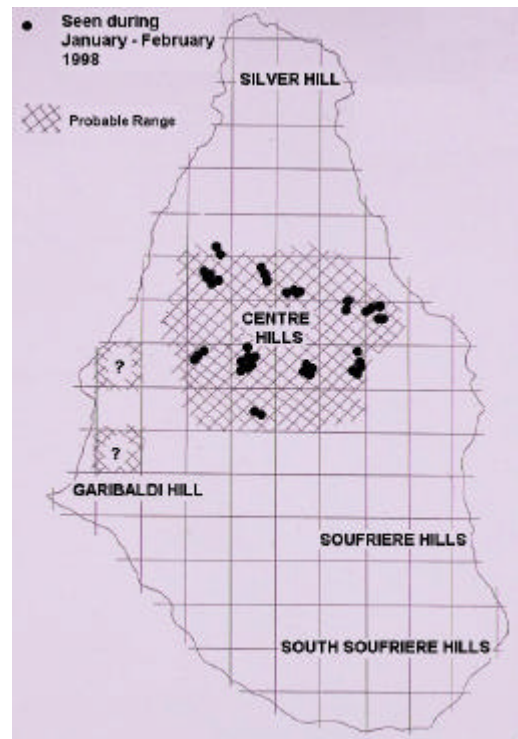
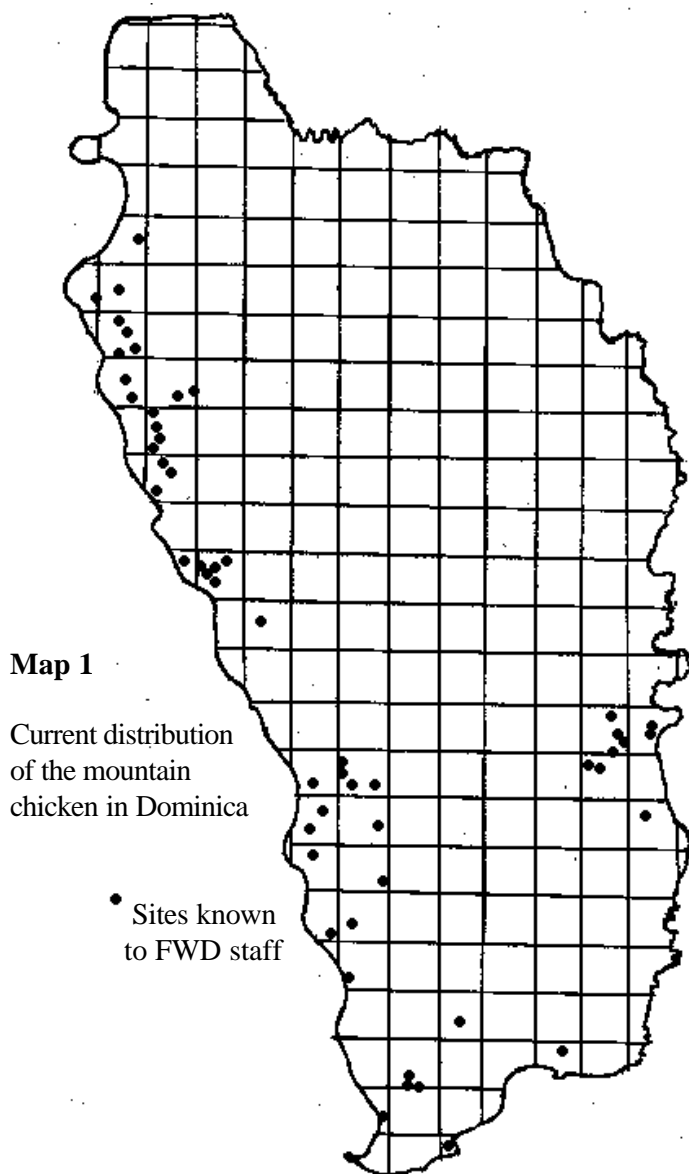
Dominica undoubtedly contains a larger population of mountain chickens than Montserrat, within an area of between 25 and 50km² (**Map 1**). Most are on the western (leeward) side of Dominica and it is often said that the species is naturally confined to the west, avoiding the wetter and presumably more saline windward coast. Some of the existing frog colonies on Eastern coast reportedly were introduced in recent years, including Governor Estate, Rosalie and McIntyre Estate. The mountain chicken *does* occur in identical habitats on the eastern side of Montserrat, however, so it would be surprising if mountain chickens had not historically inhabited eastern Dominica as well. The recent East coast introductions might in fact be *re*-introductions.

² For example, mountain chickens appear to be remarkably tolerant of acidic conditions, even inhabiting hot sulphur springs on Dominica. Their unusual ability to breed on land is ideally suited to living on oceanic islands, where water flow is unreliable. Their catholic diet and naivety when approached are typical of an animal that has evolved in the absence of major competitors or large predators. Frog species from tropical continental areas, on the other hand, tend to have more specialised diets and more advanced avoidance or defence behaviours.



Despite their name, mountain chickens are not montane animals. Their range extends down to nearly sea level in both Dominica and Montserrat. Schwartz and Henderson (1991) give a maximum altitude of only 300m (approx. 980') a.s.l., but the FFI Montserrat Biodiversity Project recorded mountain chickens above 430m (1,400') a.s.l. Several FWD personnel concurred that mountain chickens in Dominica have been documented as high as 400m a.s.l.

It seems highly probable that mountain chickens used to be widespread throughout the forests of Dominica from nearly sea level to 400m a.s.l. or more, but their range has contracted over the centuries due hunting, introduced predators and habitat loss.



On both maps, each square is 1km x 1km in size

1.2.3 Habit and Habitat

Mountain chickens are forest animals, inhabiting dry woodland, riparian forest, seasonal forest and lower rain forest.³ They adapt readily to mature orchards and shaded gardens, but appear to be uncommon in grassland, be it lemon grass, guinea grass or sugar cane fields. Within forests and orchards, these frogs are strongly associated with streams and springs, though it is rare to find them actually immersed in water.

Mountain chickens are terrestrial and principally nocturnal, usually retreating into burrows or rock crevices during the day. Shortly before or after nightfall, mountain chickens commonly move in the open, sitting atop boulders, on footpaths or on quiet roads. This probably gives the frog a larger field of view for detecting prey, and advertises its presence to potential mates. Unfortunately, this habit also makes these frogs easily found at night by hunters and introduced predators.

A study of macrohabitat and microhabitat preferences in 1995 found that mountain chickens were absent from the drier forests of Montserrat and were significantly associated with steep-sided valleys, especially those which contain water throughout the year (J. Daltry, unpublished data). These frogs display a marked preference for damp, shady areas with dense (>70%) tree canopy cover and sparse undergrowth. Frog activity is significantly influenced by ambient temperature and relative humidity, and more are seen on cool, humid nights, especially following a rain shower.

1.2.4 Food and Feeding

According to Blankenship (1990) and Schwartz and Henderson (1991), mountain chickens are strictly carnivorous and consume just about any live animal that can be swallowed whole. Prey animals are typically ambushed at night. Like most sit-and-wait hunters, the frogs sit motionless for long periods. Their colouration affords excellent camouflage in their natural habitat.

Their primary prey are crickets (Brooks, 1982), but other known prey include a wide range of invertebrates (even including scorpions, centipedes and tarantulas) as well as small vertebrates (whistling frogs *Eleutherodactylus* spp., lizards *Anolis* spp., small rodents and even bats). Perhaps the most surprising record was of a 17.5cm SVL mountain chicken on Montserrat that had killed and partly consumed a Lesser Antillean racer snake *Alsophis antillensis*, measuring 65cm total length. Unable to swallow all of this large meal, about 15 cm of the snake's tail still dangled outside of its mouth (Buley, 2001).

Even though mountain chickens eat frogs of other species, there is no evidence that adult mountain chickens are cannibalistic (Brooks, 1982).

Brooks (1982) observed that 54% of 371 mountain chickens collected in Dominica contained fragments of plant material. Blankenship (1990) assumed that such vegetation was accidentally ingested along with intended prey. Montserratian Philamon Murrain, however, has considerable experience of hunting and 'cleaning' mountain chickens and recalls having frequently found whole green leaves of French weed, a low-growing semi-aquatic plant, in the stomach which he believed were deliberately plucked. There are colloquial reports from Dominica of mountain chickens eating a herbaceous plant known as 'crapaud grass'. This seems rather unlikely, but it is worth noting that a similar large frog in India, *Rana hexadactyla*, feeds almost exclusively on plants.

1.2.5 Reproduction

Mountain chickens typically call from forest paths or clearings in the undergrowth. It is not clear whether the calls are intended to attract mates, to ward off rivals, or both. Whatever the reason, mountain chickens more frequently call on cool, humid nights, and especially during the breeding season. Judging from calling activity, staff of the Montserrat Forestry Department and National Trust have determined that the frog breeding season starts towards the end of the dry season (usually in April, when heavy seasonal showers are usually experienced) and continues until August or September. This means that the earliest metamorphs will be emerging at the onset of the rainy season when food is abundant (Buley, 2001).

³ Mountain chickens occur in the moist evergreen forest called 'rain forest' in Montserrat. According to Dominican Forestry staff, however, mountain chickens do not inhabit the wetter, 'true' rain forest in the higher elevations of Dominica.

In Dominica, Davis *et al.* (2000) report that the breeding season extends from mid or late February to September. During the current study, both calling adults and newly metamorphosed young (presumably hatched in June) were found in August. Adult females are thought to breed asynchronously, with each female probably having just one brood per year. Males probably remain reproductively active throughout the extended breeding season, and are probably capable of fathering the young of more than one female.

In Montserrat and perhaps, Dominica, it is unusual to hear mountain chickens calling between October and March. According to Buley (2001) in Montserrat: 'Calling may be heard sporadically (after rain at night) from the end of March onwards. The intensity of calling increases from this point, reaching a peak during June and July. All calling has generally stopped by the beginning of September. Calling is generally heard first high up in the mountains, and it is in the mountains that the last calls of the year can be heard. This is presumably a result of the cooler temperatures experienced at higher elevations and/or the higher rainfall.'

Although most calling takes place after sunset, some males and females gave a brief bout of low intensity calls at dawn, and males occasionally call during the day. Davis *et al.* (2000) found that the calls of a captive female differed from male advertisement calls, and were much quieter. The researchers studied five wild males spaced 20-100m apart, and found that each individual maintained the same calling site night after night during their study period from February to June. 'When one male called loudly at night, others within our hearing range remained quiet. All-night callers took turns on different nights. On some nights, shorter-term callers made a duet, or a trio, with each male's call alternating (antiphonally) with the other(s)' (Davis *et al.*, 2000). This tendency for calling males to influence the calling behaviour of other males means that it would be difficult to estimate population size from calls alone. Furthermore, calling is reduced on dry nights.

When frogs of either sex are in breeding condition, the skin secretes a soapy mucus that 'burns' naked cuts when the frog is handled (pers. obs.).

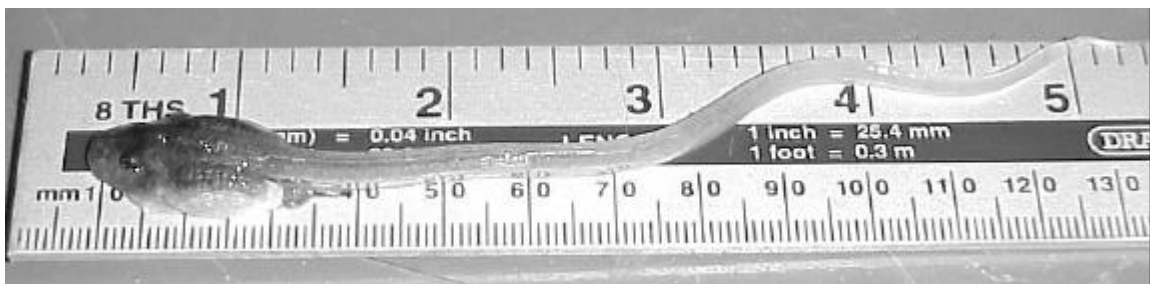
Wrestling bouts and chasing between adult males have been observed in captivity, and are thought to be important in stimulating successful breeding (R. Gibson, pers. comm.).

Although often seen around pools and streams, the mountain chicken differs from most amphibians in that it does not breed in water, but in cavities or burrows on land. These nests are rarely seen in the wild. Davis *et al.* (2000) describe a 50cm-deep nest cavity on Springfield Estate, Dominica, at the bottom of a cement foundation, with a 10x20cm entrance. The temperature within the cavity was a steady 23°C. In Montserrat, nests are similarly reported to be at least 50cm deep, often on the banks of waterways (P. Murrain, pers. comm.). It seems that mountain chickens often use existing cavities or burrows dug by other animals, though they are evidently capable of digging burrows (Lescure & Letalier, 1983).

Mating takes place in the nest cavity. After being clasped in amplexus for several hours, the male and female whip up a nest of thick foam at the end of a cavity or burrow in damp soil. Between 15 and 45 large eggs are laid in the foam.

Mountain chicken tadpoles can reach well over 11cm in total length, with the tail amounting to about 80% of this (Lescure & Letalier, 1983). They metamorphose into miniature froglets after 68 weeks, when they are approximately 3cm SVL. A Dominican nest described by Davis *et al.* (2000) was first observed on 22 April, with 15-20 tadpoles visible by 25 April. Hind legs were present on the larger tadpole by late May, and the first froglets had left the foam nest (but not the nest cavity) by 7 June. By 17 June, no foam or larvae remained.

Remarkably, recent studies in Jersey Zoo have confirmed that the female mountain chicken returns to the nest every few days to replenish the foam and feed the tadpoles with unfertilised eggs. She provides as many as 20,000 unfertilised eggs during the tadpoles' development (Gibson & Buley, 2001).



Captive bred mountain chicken tadpole (courtesy of Kevin Buley, DWCT)

It seems unlikely that maternal care continues after the young froglets have left the burrow. Scriber Daley, a Montserratian forester, however, reported finding '14 baby frogs with a

defending mother' above ground in July 2000 (Buley, 2001).

Blankenship (1990) observed that mountain chickens essentially live singly outside of the breeding season, but are not aggressive to one another at this time.

1.2.6 Predators and Hunting

Humans are major predators of the mountain chicken in Dominica and Montserrat, and hunting probably contributed towards the extirpation of the species from other islands. Frogs are hunted for home consumption and more recently, sold to hotels and restaurants. They are caught by hand at night, using flashlights to pinpoint and dazzle each frog.

In Montserrat, the market value of one adult mountain chicken (or two subadults) is between EC\$10 and EC\$12 (about US\$4). In the early 1990s, as many as 50 frogs were caught on the island every day, chiefly for tourist consumption. Since the onset of volcanic activity in the mid 1990s, however, this figure dropped to about 15 per day (P. Murrain, pers. comm.). There is strong circumstantial evidence that some frog populations, especially those close to towns and villages, have been 'hunted out'.

In Dominica, the market price of one adult mountain chicken is EC\$4 or 5, rising to EC\$10 during the Close Season. A recent survey found that up to 4% of households had hunted mountain chickens during the 2001/2002 Open Season: 12 households alone accounted for the capture of 832 mountain chickens. The total harvest nationwide was estimated to be at least 12,300 during those three months (Jno-Lewis, pers. comm.).

In addition to humans, several species of animal may eat mountain chickens, especially the smaller individuals. Although it is typically diurnal, the indigenous Lesser Antillean racer *Alsophis antillensis* often eats whistling frogs (*Eleutherodactylus* spp.) and probably opportunistically preys on any juvenile mountain chickens encountered during the day. Chicken hawks and cattle egrets hunt a wide range of small animals and may feed on mountain chickens, although like the snake, they hunt during the day when most mountain chickens are hidden from view.

Introduced mammals present a more serious threat. The omnivorous and nocturnal opossum or

manicou *Didelphys marsupialis*, from South America, has become widespread on Dominica and is known to prey on frogs. Hunters report that opossums often hunt along the banks of streams and rivers (Zamore, 2000). Eurasian black rats (*Rattus rattus*) and brown rats (*R. norvegicus*) are known to attack even large adults (P. Murrain, pers. comm.). Mountain chickens also fall prey to feral cats *Felis domesticus*, and dogs *Canis familiaris* (Faaborg & Arendt, 1985). Feral pigs *Sus scrofa*, are omnivorous and would undoubtedly eat mountain chickens if given the opportunity (they have the ability to dig up entire mountain chicken nests).

The aforementioned mammals and cattle egret are relative newcomers to the island, and the frogs are unlikely to have had sufficient time to evolve appropriate avoidance or defence behaviours. Indeed, compared with continental frog species, mountain chickens are approachable and can be caught with relative ease.

While on the subject of alien predators, it should be noted that Dominica has so far been spared invasions by the small Asian mongoose *Herpestes javanicus*, which has decimated indigenous animal populations on other islands throughout the Eastern Caribbean. If this rapacious predator were ever to be introduced accidentally or deliberately, it would undoubtedly seal the mountain chicken's fate.⁴

1.2.7 Research

According to Kaiser (1994) 'the most comprehensive work is by Lescure (1979a). Heyer (1979) integrated the species into the *L. pentadactylus* group and provided comparative morphological information. Lamotte and Lescure (1977), Lescure and Letalier (1983), and Houdry and Beaumont (1985) discussed reproduction. Brief accounts were given by Brooks (1968), Lescure (1979b), and Schwartz and Henderson (1991). Brooks (1982) provided information on prey choice and consumption. For an account of the species on Montserrat, see Bovey (1986).'

Blankenship (1990) provided detailed information on the species' natural history in Montserrat.

⁴ With remarkable foresight at a time when mongooses were being deliberately introduced throughout the Caribbean, Dominica issued a law against introducing mongooses in 1902 (Zamore, 2000). There is nonetheless a risk of mongooses being brought to the island either accidentally in cargo or deliberately: an airplane passenger in St Eustatius was recently found to have two mongooses in his hand luggage.



The Montserrat Biodiversity Project studied the distribution, relative abundance and habitat requirements of the mountain chicken in Montserrat in 1995. Further research has been carried out since 1998, as part of the Montserrat Mountain Chicken Monitoring Programme (see below). In recent years, novel research on the reproduction and growth rates of Montserratian mountain chickens in captivity have been conducted by the Durrell Wildlife Conservation Trust (e.g., Gibson & Buley, 2001).

On Dominica, Davis *et al.* (2000) carried out a pioneering study of mountain chicken calling behaviour and the development of mountain chicken tadpoles in a wild nest on the Springfield Estate. In March 2002, an interview-based survey was carried out on wildlife hunting in Dominica as part of the Sustainable Wildlife Use project. This pilot study includes novel information on the collection and trade of mountain chickens, and will be published by the Forestry and Wildlife Division and Fauna & Flora International.

During the mountain chicken workshop on 31 July and 1 August, participants from the Forestry and Wildlife Division identified the following questions that need to be answered, in descending order of importance. All of these would provide useful baseline information for conservation management planning:

1. *What is the status (distribution, abundance) of the mountain chicken?*
2. *What are the habitat requirements of the mountain chicken?*
3. *What is the off-take of mountain chickens by hunters, and what impact does this have on the population?*
4. *Which other threats affect the mountain chicken?*
5. *What do mountain chickens eat?*
6. *What is the breeding behaviour of the mountain chicken?*
7. *Are mountain chickens able to re-colonise abandoned banana plantations and other fields?*

The participants also recommended that the frogs' population status and hunting pressure be monitored, both to assess the impact of hunting and to provide an early warning if the mountain chicken population starts to crash.

1.2.8 Threats and Conservation Measures

Strong arguments can be put forward for conserving the mountain chicken in Dominica and Montserrat, including:

- i *Ecological importance.* Mountain chickens are among the largest native insectivores on Dominica and Montserrat, and undoubtedly have a significant impact on invertebrate populations. They provide a useful service as pest control agents in farms, orchards and gardens within their distribution range.
- ii *Economic importance.* Frog meat is sold to local people and tourists, providing a small but significant income to hunters and restaurateurs.
- iii *Cultural importance.* The mountain chicken is strongly identified with the Commonwealth of Dominica. It is regarded as the national dish, and features on the national coat of arms. The calls of the mountain chicken are, by and large, enjoyed by countless Dominican families living near forested areas, even in the suburbs of Roseau. It is probable that almost every child and adult on Dominica knows what the mountain chicken looks and sounds like, and the animal is not generally feared or disliked.

Dominica has long recognised the need to conserve the mountain chicken. The 1939 Crapaud Ordinance made 'provisions for the protection and preservation of this species of edible frog, as well as making provision for the setting of a Close Season during which the hunting or taking of this amphibian was not allowed' (Zamore, 2000). The closed hunting season extends from 1 March to 31 August. Hunting of mountain chickens was banned in the late 1990's, although a three-month open season was declared at the end of 2001. According to CCA-IRF (1991), the maximum penalty for violations is EC\$400 and/or three months imprisonment (*cf.* EC\$5,000 and three years imprisonment for illegal hunting of parrots). Forestry personnel at the 2002 mountain chicken workshop reported that the penalty had increased to EC\$620 and three months imprisonment.

Dominica now represents the mountain chicken's best hope of survival in the wild. There is a real danger that the entire population in Montserrat could collapse in the face of ongoing



volcanic activity, aggravated by the shifting focus of urban development from the South to the Central Hills, where almost all of the remaining mountain chickens live. According to the Forestry and Wildlife Division's mountain chicken workshop in 2002, however, Dominica's mountain chickens are under threat from a number of sides:

- i *Over-hunting by humans.* Their large size, loud calls and tendency to sit in the open make mountain chickens an easy target for hunters. The limits of sustainable off-take in Montserrat and Dominica are not yet known. Because mountain chickens have relatively small brood sizes, however, they have a relatively limited capacity to recover from heavy losses. Harvesting breeding females is especially damaging, because the tadpoles depend on the mother for food and moisture (see 1.2.5: Reproduction).
- ii *Introduced predators.* Predatory mammals such as feral cats, dogs, pigs and opossums present a relatively new threat to Dominica's mountain chickens (see 1.2.6: Predators and Hunting).
- iii *Habitat loss and degradation.* Dominica's mountain chickens appear to be largely confined to coastal areas, where there is greatest demand for land for construction, industry and farming. Bush fires are often ignited for little reason by landowners. CCA-IRF (1991) reported escalating clearance of forests for bananas and other crops. The declining market price of bananas means that some of these fields have been abandoned, however, and are being reclaimed by forest. Fortunately, mountain chickens appear able to adapt to old fields and orchards (see 1.2.3: Habit and Habitat).
- iv *Pollution.* Most of Dominica's mountain chickens occupy areas in and around farmland and may be exposed to agrochemicals, such as the highly toxic and persistent herbicide Gramaxone (Paraquat). Deaths of birds, opossums and freshwater animals have been linked to the use of Furadan and other agrochemicals on banana plantations (CCA-IRF, 1991). Fishermen use toxic, plant-derived chemicals to paralyse freshwater fish (R. Winston, pers. comm.). CCA-IRF (1991) also report problems of raw sewage and solid waste being released into freshwater systems.



- v. *Declining Amphibian Populations Phenomenon.* Since the late 1980's, herpetologists have become acutely aware of mysterious collapses in frog populations around the world. Some species have become extinct, even in relatively undisturbed and well-protected areas. Possibly a combination of factors are to blame, such as increase ultra-violet radiation, global warming and fungal disease, but this is still a poorly understood phenomenon. The possibility of Dominica's mountain chicken succumbing to this phenomenon cannot be ruled out.⁵ For more information, see the website of the Declining Amphibian Populations Task Force (www.open.ac.uk/daptf/index.html).
- vi. *Natural disasters.* Deforestation and road construction have been blamed for landslides and floods in Dominica (CCA-IRF, 1991), especially in the coastal zone where mountain chickens live. Mountain chickens cannot be protected from eruptions (Dominica contains several active and potentially dangerous volcanoes) or the seemingly increasing incidence of hurricanes, though their ability to cope will be reduced if the population is already under pressure from over-hunting and other threats.

The Montserrat Mountain Chicken Monitoring Programme was started in 1998 to monitor changes in distribution, abundance, reproductive success and health of the wild population (Daltry & Gray 1999). Eighteen transects were established and all but one continue to be surveyed using visual and aural methods every three or six months (Buley, 2001).

Also in response to the threat to Montserrat's mountain chicken population, six adult male and three adult female mountain chickens were taken to Jersey Zoo in July 1999 as part of a captive breeding feasibility study. The colony had already increased above 100 by August 2002. This experiment has shed light on this species' extraordinary reproductive habits (see section 1.2.5: Reproduction), as well as providing a reassuring safety net against the species' extinction in the wild.

⁵ According to local reports, there have been unexplained mountain chicken "die offs" in several parts of Dominica, including Lahaut on the West coast and the St Kitts river area to the East.



2. SURVEY AND MONITORING TECHNIQUES

2.1 ABUNDANCE

2.1.1 Introduction

In studies of animal abundance, zoologists distinguish between *absolute abundance* (the actual number of individuals in the population) and *relative abundance* (a measure of abundance that is correlated with absolute abundance: for example, the number of individuals seen, heard or trapped in a given area during a certain period of time):

2.1.1.1 *Absolute abundance*

It is not possible to find and count every mountain chicken in Dominica. It *is* possible to estimate of frog numbers in selected areas, however, and extrapolate these figures to estimate the absolute abundance of mountain chickens across the island.

Appendix V describes a mark-recapture method for calculating the absolute abundance of mountain chickens in selected areas. This method could be more usefully applied *after* baseline studies of distribution (section 2.2) and relative abundance (section 2.1.1.2 below) have been completed.

2.1.1.2 *Relative abundance*

To evaluate the impact of hunting or other pressures on Dominica's mountain chickens, a monitoring plan based on measuring relative abundance is almost as instructive as one based on absolute abundance, and certainly much easier and more cost effective to carry out.

Relative abundance studies can identify which areas contain more frogs than others, and find out whether the population is increasing, decreasing or remaining the same over time. A method for assessing relative abundance will be described here.

2.1.2 Materials and Methods

2.1.2.1 Establishing belt transects

Changes in the size of Dominica's whole mountain chicken population can be assessed by monitoring changes in the relative abundance of frogs within standard 'sampling units' in areas of prime habitat. The recommended sampling unit is a belt transect of standard length and breadth. During the mountain chicken workshop, participants agreed on a length of 250m and width of 10m. This could be extended if desired.

Eight 250m x 10m belt transects were marked out in August 2002. These transects were selected to cover a broad range of the species distribution range (**Map 1**), including areas subjected to heavy hunting pressure.

Southern Range	1.	Soufriere Springs
	2.	Macoucherie
	3.	Lahout
Northern Range	1.	Coulibistre
	2.	Dublanç
	3.	Milton Valley
Eastern Range	1.	St Kitts River
	2.	Rosalie

All of these areas were known by the local range staff to contain mountain chickens. To help explain why some of these areas support more frogs than others, the biotic and abiotic characteristics of each transect was recorded in August 2002 using the datasheet and instructions in **Appendix I**.⁶

⁶ Some range staff asked whether they could search for better areas to establish transects. This is fine, but the list of mountain chicken transects should be finalised by November 2002 for the next round of VES's and AES's. If transects are moved thereafter, it could become impossible to detect real changes in frog abundance.

Each transect is intended to be systematically subjected to a *Visual Encounter Survey* (VES) and an *Aural Encounter Survey* (AES), as described below. Neither a VES nor an AES provide reliable information on precisely how many frogs live on each transect (absolute abundance) because some of the frogs may be entirely hidden from view or silent, but these survey methods can help show the *relative abundance* of frogs on different transects - and within the same transect over time. VES's and AES's should be used together because the findings of one method can be used to verify the findings of the other.

Judging from the preliminary visit by FFI and FWD in August 2002, one of the most densely populated areas is the Soufriere Sulphur Springs ecotourism site. This is in spite of the fact that the Soufriere Sulphur Springs transect is heavily disturbed by recreationalists during the day and contained the most acidic soils (pH 4.8, even after heavy rain) and water ($pH < 5.0$) of the eight transects. Exposure to low pH levels (where industrial pollution has caused acid rain, for example) has been blamed for population crashes of frogs around the world and for an increased incidence of deformities. Very low pH levels can be directly lethal, while exposure to sub-lethal levels can lead to a depressed immune system, thereby increasing the frog's susceptibility to disease (but see Carey, 1997).

Even more astonishing is that the Soufriere Springs stream is hot, ranging from $35.5^{\circ}C$ at the transect start to $70.5^{\circ}C$ at the end of the transect (upstream). Streams in or near most of the other transects were around $24-26^{\circ}C$.

2.1.2.2 Visual Encounter Survey (VES)

Each transect should be regularly resurveyed by a team comprised of at least two, and preferably three, people to detect any changes in the abundance of mountain chickens within and between transect sites. Ideally, transects should be surveyed by the same group on each occasion, because different people naturally vary in their skill in finding frogs.

The VES team must follow precisely the same protocol described in **Appendix II** to ensure comparability of findings among transects as well as within individual transects over time. It is crucial that the survey begins at 19:45 sharp, and that the team records ambient relative humidity and ambient temperature at this time.

Recommended periods for repeating the VES of each transect are at three-monthly intervals (the next round of surveys is due in early November) although more additional surveys can be conducted if an upsurge in hunting or other threats is anticipated.

2.1.2.3 Aural Encounter Survey (AES)

Supplementing VES data with AES data is advisable because many transects follow streams, and mountain chickens are believed to move to higher ground to call during the breeding season. If frogs are no longer seen on a particular transect, the AES will help determine whether they have genuinely disappeared or have merely moved.

Every AES team should follow the protocol described in **Appendix II** to ensure comparability of findings within and between transects. The team should carry at least one copy of the transect survey datasheet.

The AES method requires less effort and personnel than VES, and can be readily conducted in additional areas to the eight demarcated transects. AES's can be conducted by anyone with a reasonable sense of hearing, and even different field personnel surveying the same area at the same time should obtain more or less the same results. Like the VES, the recommended period for repeating the AES is at three-monthly intervals.

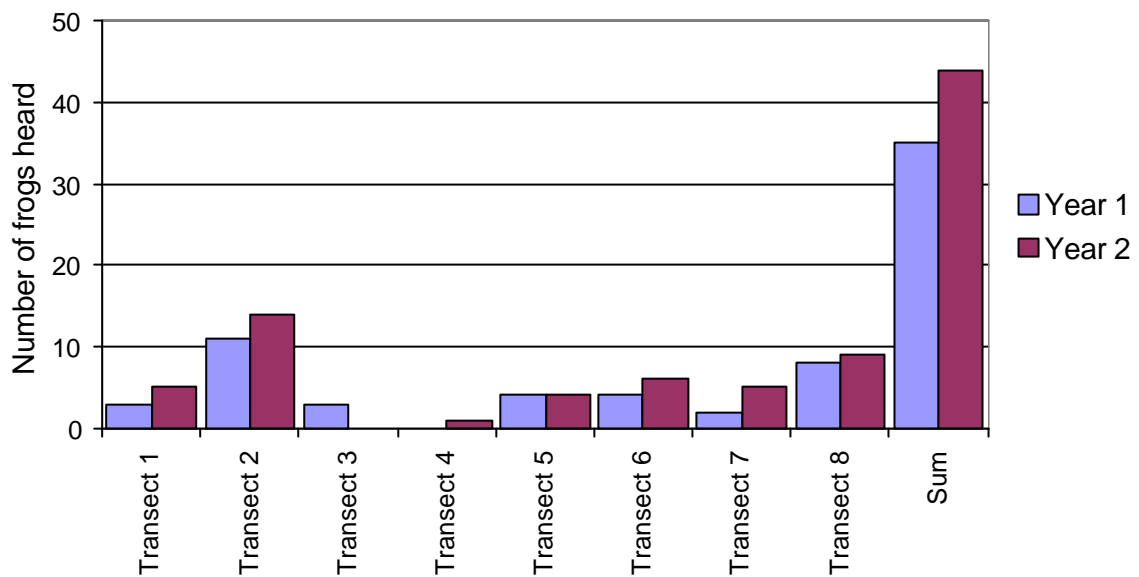
2.1.3 Interpretation of Results

The simplest method for assessing whether frog numbers have changed from one season or year to the next, is to compile a chart, as shown in **Figure 1**. The numbers of frogs seen or heard on each transect are unlikely to be identical from one quarter or year to the next.⁷ Staff should not feel disappointed if they fail to see or hear frogs on their transect - this is not a competition to find the most frogs and 'even no data are data'! The absence of mountain chickens could be important. If repeated surveys in the area still find no frogs, there may have a local extinction, which would signify the need to bring in stronger conservation measures for the surviving populations.

⁷ For more advanced analysis, it may be helpful to use a non-parametric statistical tests, such as McNemar's test (testing for change on permanent transects between two periods), Friedman's test or Wilcoxon signed ranks test (testing for change on permanent transects between three or more periods). Instructions on how to conduct these

Of course, minor random variation in frog numbers can happen by chance or due to changes in weather. The researchers are likely to find fewer frogs when there has been no rain for several days, or when the moon is full. The transects may have to be surveyed several times before the researchers will develop a feel for what conditions encourage frog activity.

Figure 1. Hypothetical results of Aural Encounter Surveys of eight transects in Year 1 and Year 2. On average, frog records had increased by Year 2.



Preliminary surveys of five transects in August 2002 recorded between 0 and 11 frogs heard during AES's, and between 0 and 6 frogs seen during VES's. Mountain chickens are patchily distributed in Dominica, but some of the patches, most notably Macoucherie and Soufriere Sulphur Springs, appear to support quite high densities.

None of the counts, however, come even close to the relatively remote and undisturbed area of Sappit River on Montserrat, where as many as 32 mountain chickens were caught during a VES of a 200m x 10m belt transect (Daltry, 1998). Sappit River perhaps illustrates just how dense mountain chicken populations can be, in good habitat and in the absence of hunting pressure.

tests can be found in most statistical tests books and probably downloaded for free from the Internet. With only eight transects, however, the change would have to be very large in order to be *statistically* significant!



If fewer frogs are seen and heard when the transects are resurveyed, there may be several possible explanations, notably:

Frogs are still present, but less active

Mountain chickens become less active or vocal during dry spells and outside of the breeding season. This is a difficult factor to evaluate accurately, but we already know, for example, that frogs are more likely to be seen and heard when ambient humidity is high. It is therefore crucial to carefully record date and weather conditions at the time of each survey.

Frogs have migrated away from the transect area

Many of the transects follow valleys, and evidence from Montserrat indicates that some frogs move to higher ground during the rainy season. The number of frogs seen during the VES may drop between May and September, but it should be possible to hear them calling during the AES.

The team did not conduct the survey thoroughly.

Personnel who conduct each survey should have previous experience of searching for mountain chicken frogs, be fully aware of the monitoring protocol, and appreciate the importance of accurate and honest recording. If in doubt, a second team should be assigned to repeat the survey. They should avoid conducting surveys during heavy rain, when it may be hard to see or hear the frogs.

Frogs are being hunted out.

Even one experienced hunter can have a severe impact upon a local frog population. Hunting is unlikely to be a problem throughout the whole distribution range, however, and therefore should not affect every transect equally. It is most likely to affect the more accessible transects close to human habitation, such as the Macoucherie and Rosalie transects.

Frogs have disappeared due to other factors.

If frogs are thought to be dying due to pollution, invasive predators or other factors, then additional conservation activities may be needed.

2.2 DISTRIBUTION

2.2.1 Introduction

Based on the currently available information, the mountain chicken has a perilously small distribution range in both Dominica and Montserrat (**Map 1** and **Map 2**).

For the purposes of conservation management, it is important to clarify exactly where the mountain chickens live in Dominica, and where they used to occur. In Montserrat, for example, mountain chickens have disappeared from certain areas close to human habitation, but potentially could be reintroduced to these areas if hunting and domestic dogs are controlled

2.2.2 Materials and Methods

2.2.2.1 *Identifying historical distribution range*

Given the lack of detailed published records from the past, there are only two methods available for assessing the historic distribution range of the mountain chicken in Dominica:

- i Whenever archaeological surveys are conducted, the scientists should be requested to look out for fossil or sub-fossil frog bones. Frog bones are very fragile however, and rarely survive intact.
- ii Older members of the public can be informally questioned about areas where the species occurred fifty or sixty years ago. Interviews could be carried out by FWD personnel or visiting researchers. It may help to appeal for information on the radio.

2.2.2.2 *Identifying current distribution range*

During the mountain chicken workshop on 31 July and 1 August, participants identified five ways of evaluating the species' current distribution range:

- i *Existing knowledge of Forestry personnel.* FWD staff already have first-hand knowledge of many mountain chicken sites.

- ii *Opportunistic field surveys.* FWD staff should be alert to mountain chicken sightings or calls whenever they are in the field, for example while travelling to and from the survey transects.
- iii *Informal interviews.* People in rural areas, especially known hunters, can be informally questioned about where they have seen mountain chickens in recent years. These interviews can be carried out by FWD personnel and/ or trusted visiting researchers, taking care to ensure that the known localities are plotted accurately. Ideally, the interviewee should be asked to go to the field to point these areas out.
- iv *Published literature and museum records.* Some specimens have been collected from Dominica, and their locality records can be checked.
- v *Targeted field surveys.* To confirm information gathered by the above means, and to help fill in the gaps, it will be necessary to visit the area at night to listen and look for mountain chickens. This could be done by FWD personnel and/ or trusted visiting researchers during the breeding season. Many of these areas can be reached by vehicle.
- vi *Visiting researchers.* Dominica receives a large number of biologists to study its fauna and flora. Future researchers should be asked to keep an eye (and ear) out for mountain chickens, and inform the FWD of confirmed localities. Herpetologists who have visited Dominica in the past can be asked to provide details of places where they have seen mountain chickens.⁸

All recorded sightings and calls should be plotted together with their dates, indicating which are confirmed (e.g., recent sighting made by Forestry staff) and those that are unconfirmed (e.g., potentially unreliable interview reports). In practice, FWD staff can put coloured pins or stickers on a large-scale map of Dominica in the head office to denote new localities as they

⁸ The following herpetologists have all spent a significant amount of time in Dominica and may be able to provide additional observations regarding mountain chicken distribution: Shirley Davis (Ronald_Davis@umit.maine.edu), Dr Hinrich Kaiser (hkaiser@lasierra.edu), Prof. Roger Thorpe (bss024@bangor.ac.uk), Dr. Anita Malhotra (a.malhotra@bangor.ac.uk), Mark Day (mark.day@fauna-flora.org) and Jay King (Jay@marz.com).

are found. The locality coordinates can also be stored on computer, however, ideally using a Global Information System. Back up copies of the data should be stored in separate locations in case of fires, computer viruses, etc. It is hoped that by the end of 2002, the known distribution range could be somewhat larger than it appears on **Map 1**.

2.2.2.3 Monitoring future changes in distribution range

Systematic monitoring of the eight transects using VES and AES (see next section on Monitoring Abundance) will help monitor mountain chicken presence and absence in these areas, but they amount to only two hectares in area (albeit in known mountain chicken hotspots). To determine changes in the species distribution range more accurately, an attempt should be made to review the species distribution every two years.

2.3 DEMOGRAPHIC STRUCTURE

2.3.1 Introduction

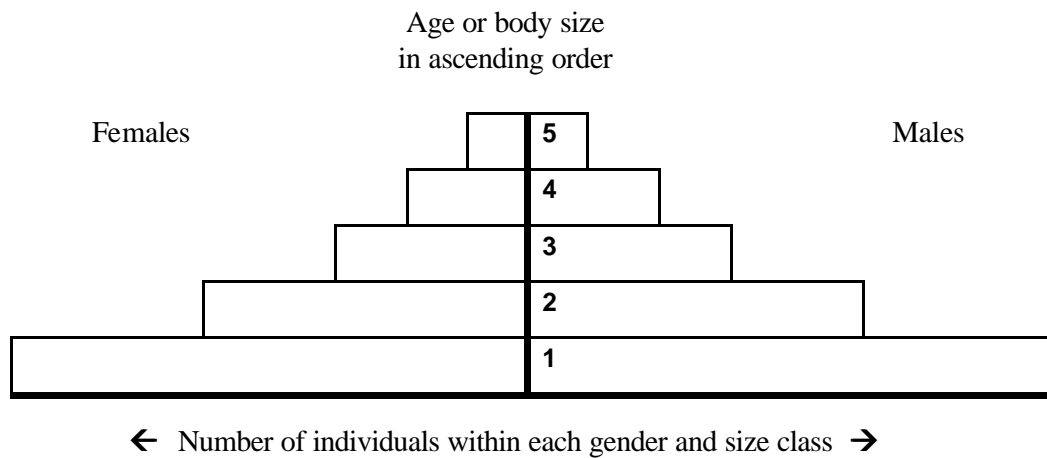
The demographic structure of a population – the frequency of individuals in different age classes and the relative proportion of males and females – is a valuable indicator of how well the frogs are reproducing and surviving.

A normal healthy population should have an almost equal number of males and females, and a good balance of juveniles, subadults and adults.⁹ (It is difficult to estimate the age of a frog, but since they grow all their lives, the largest individuals tend to be the oldest).

Wild frog populations normally contain a preponderance of juvenile animals, and a smaller number of large, old adults. Their population structure takes the form of a pyramid, as follows:

⁹ In this section, juveniles are defined as mountain chickens of less than one year of age, and sub-adults as mountain chickens of more than one year of age, but which are not yet sexually mature.

Figure 2. Example population pyramid for a hypothetical frog population



An absence of individuals in certain age or size classes could indicate serious problems. For example, the apparent paucity of small (young) mountain chickens in Montserrat in 1998 may be due to decreased breeding or recruitment because of the volcanic activity (see **Figure 3**). Judging from these data, this population seems to be ageing, and may be heading for local extinction.

A follow up study on Montserrat in mid 2001 by the Montserrat Forestry staff and Kevin Buley (unpublished data) again found that frogs on this island are still relatively large (long lived). 61 frogs were captured, which had a mean SVL of 16.4cm (range 9.5-19.5cm) and mean body mass of 381g (range 70- 680g).

Preliminary studies by FWD and FFI in Dominica, on the other hand, have indicated a real lack of large adult mountain chickens in this population (**Figure 3, Table 1**). This is not easily blamed on sampling error: Brooks (1982) examined a much larger number of specimens (n = 371) and similarly found Dominica’s mountain chickens to be relatively small (mean SVL = 9.97cm; maximum SVL = 16.9cm).

Table 1.

Summary statistics of Montserratian and Dominican mountain chickens

(Montserrat data from Daltry 1998; Dominica data from preliminary FWD-FFI study in August 2002)

	Snout-Vent Length (cm)		Body mass (g)	
	Montserrat	Dominica	Montserrat	Dominica
Sample size (n)	115	31	115	31
Minimum	10.0	4.5	59	6
Maximum	20.0	16.0	670	320
Mean	16.7	12.6	436.2	170.9
Standard Deviation	1.8	2.6	114.1	79.7

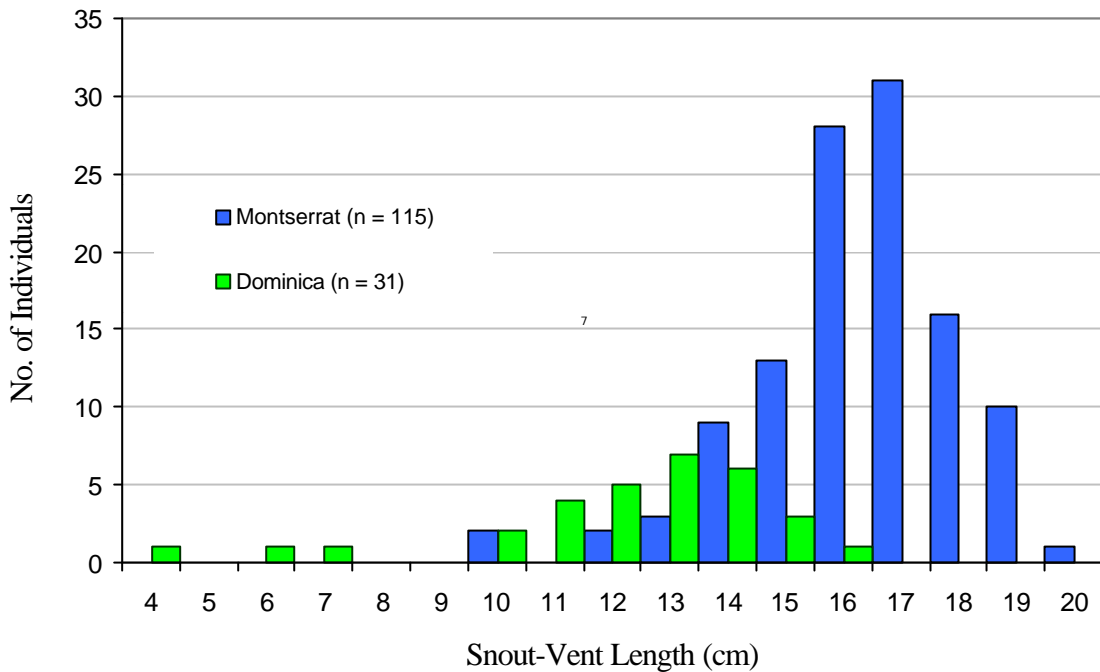
While other causes cannot be ruled out at this stage, the pattern in Dominica is typical of over-hunting by humans. It is encouraging to note that the population is still breeding, as proved by the presence of juvenile and subadult frogs. Ongoing depletion of adults could lead to local extinction, however. Small females cannot produce as many young as large females, and if few frogs even survive long enough to attain maturity, the reproductive output of the population could be cut to critically low levels.

The relatively small size of the mountain chickens also reduces their usefulness as a source of food for people. On average, a hunter would have to catch around 2.5 Dominican mountain chickens to produce the same amount of meat as one Montserratian mountain chicken!

An alternative explanation for the findings above is that Dominican mountain chickens naturally do not grow as large as the Montserratian mountain chickens, perhaps because of differing genetic or environmental constraints. The Dominican race clearly has the capacity to grow very large, however, because the world’s largest known mountain chicken (21.0cm SVL) was recorded on Dominica (Krintler, 1986).



Figure 3. Body sizes of mountain chickens in Dominica and Montserrat



2.3.2 Materials and Methods

Forestry personnel should try to capture, measure and sex all frogs seen both on and near transects, irrespective of their size (see **Appendix II**). The FWD should attempt to catch and measure at least 30 frogs every quarter.

Snout-Vent Length (SVL) is measured in centimetres from the tip of the snout to the cloaca or vent (amphibians have one opening for the urogenital tract and alimentary canal), as shown in **Figure 4**. The frogs can be weighed using a spring balance attached to a string noose around their hips.

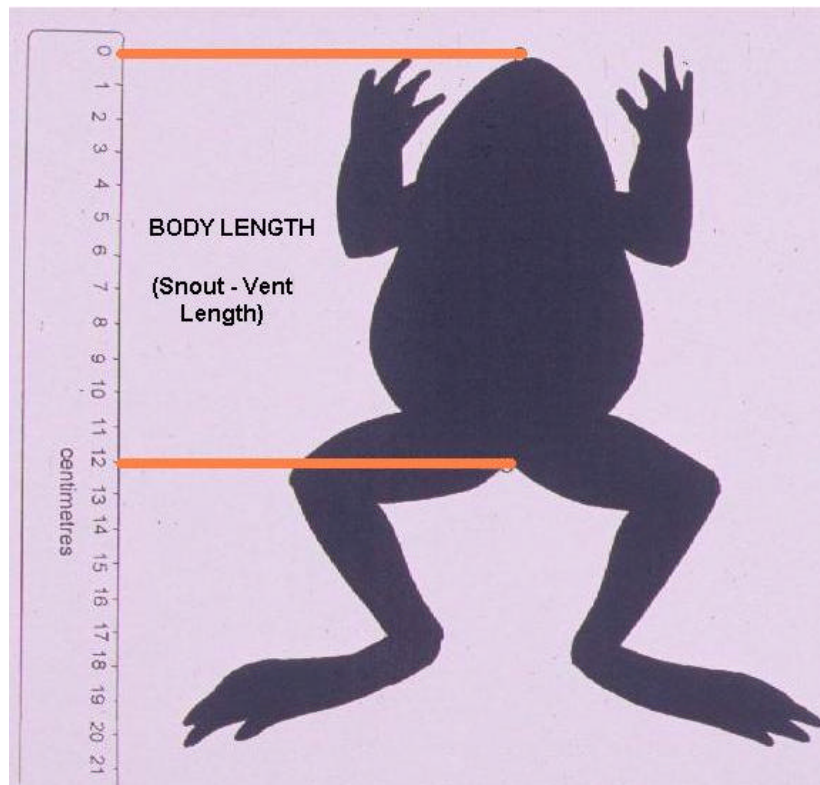


Figure 4. How to measure frog body length

During the breeding season from about February to September, mature males have a black spike on the thumb that is absent from mature females. The sex of immature individuals and adults outside of the breeding season is difficult to determine. For frogs of uncertain gender, write ‘?’.

2.3.3 Interpretation of Results

To analyse the findings, it is helpful to plot the numbers of individuals in different size classes/ age groups as shown in **Figure 3** While compiling these data, it is important to consider whether there are differences in the structure of mountain chicken populations in different parts of Dominica.

Also, check whether the number of adult males and females are roughly equal. All things being equal, stricter controls on hunting should help mountain chickens to breed more successfully (leading to an increased number of juveniles) and live longer (leading to an increase in the number and size of large adult frogs on the transects and elsewhere).

If few large/ old frogs are recorded when the transects are resurveyed, however, there may be several possible explanations, notably:

Large adult frogs are still present, but harder to spot or catch

It is unlikely that old frogs will be harder to see, but they may well prove harder to catch and measure. In areas where hunting pressure is high, any frog that manages to live a long time will be extremely wary of humans!

Large adult frogs live outside of the transect area

Perhaps the areas selected as transect areas do not provide particularly good habitat for nesting or for adult frogs to live? Forestry staff should watch out for large old frogs, even in areas outside of the transects.

Large adult frogs are being overlooked in favour of young ones

This is unlikely. There is a natural temptation among most field personnel to aim to catch the largest individuals seen, even at the cost of allowing small ones to escape!

Adult frogs have been hunted.

This is the most probable explanation. Hunters prefer to capture the largest frogs, and where hunting pressure is high, few frogs will live to reach a large size. This is most likely to affect the more accessible transects, such as Macoucherie.

High mortality due to other causes

For example, predation by introduced mammals or pollution may lead to an increased rate of mortality, and fewer frogs living to a ripe old age. All reasonable possible causes should be investigated.

2.4 HEALTH

2.4.1 Introduction

Agricultural pesticides and other chemicals were identified as potential threats to mountain chickens in Dominica (see 1.2.8: Threats and Conservation Measures). Amphibians tend to be more sensitive to environmental pollution than mammals and birds, and the discovery of dead or sick frogs or tadpoles can be an indication that the natural ecosystem is headed for trouble.

During the preliminary study in August 2002, the team did not find any dead or obviously ill or deformed frogs, even in areas close to fields where pesticides are used. Localised mountain chicken die-offs have been reported in Dominica, however, and these might be due to some form of pollution.

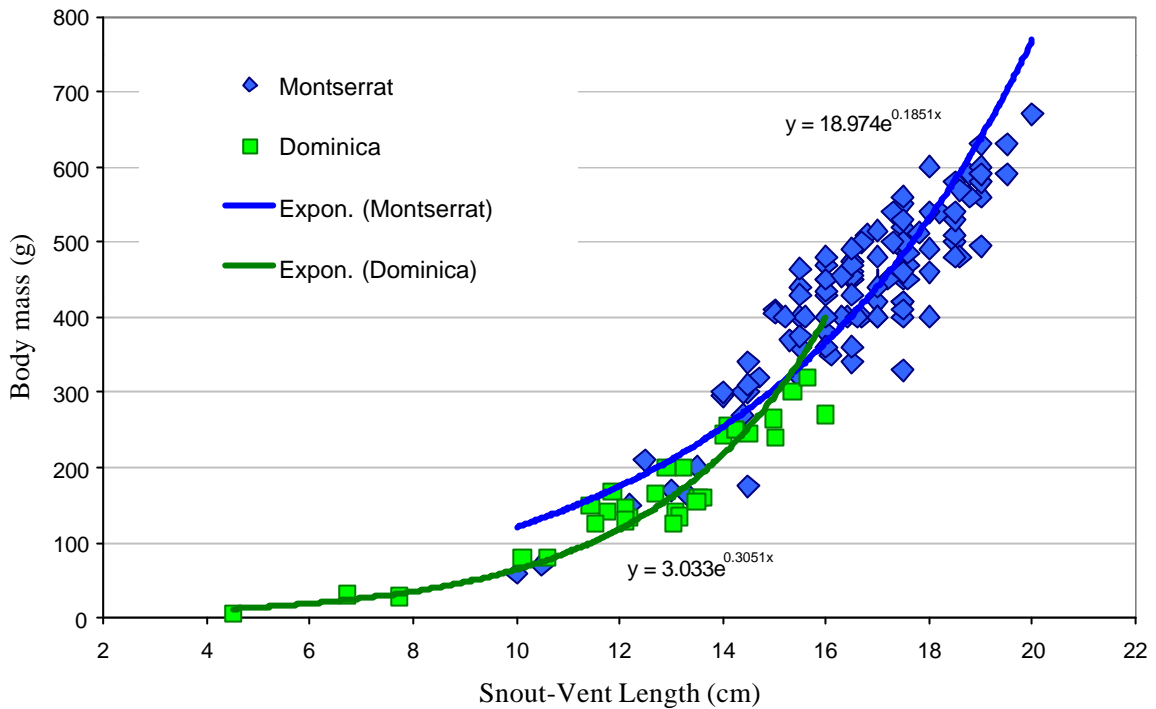
2.4.2 Materials and Methods

Forestry staff can continue to monitor the general health of mountain chickens on the eight transects, and to check out any future reports of mountain chicken die offs in Dominica.

Diseases may be manifest in different ways, but all frogs showing signs of *rashes/skin lesions, cloudy eyes or flaking skin* should be noted. Particular attention should be paid to the skin on the feet and belly. Certain forms of pollution can cause deleterious *deformities*; so young frogs in particular should be carefully examined for signs of abnormalities such as oddly asymmetrical bodies, missing toes, etc.

The *alertness* and *agility* of the frog should also be considered. A healthy mountain chicken should kick strongly when restrained and be capable of prodigious leaps when released. It should also be plump and muscular, with a high body weight relative to body length (if in doubt, compare the frog to **Figure 5**. Individuals that fall far below the green curve are underweight and probably sick). Every frog captured by Forestry personnel on or near the transects should therefore be weighed using a 300g or 1,000g spring balance attached to a string around the frog's hips. To reduce stress of capture, however, frogs should not be handled for more than three minutes.

Figure 5. Relationship between body length and weight in the mountain chicken



It is not possible to provide a comprehensive review of frog pathology here. Frogs with suspicious signs of diseased or deformities must be examined by an expert. Although the survey personnel should normally refrain from killing frogs found within transect areas, badly affected individuals should be humanely killed, preserved and sent to a laboratory. Preservation methods and the contact details of a specialist are given at the end of this guide. Corpses of mountain chickens found in the field should also be collected to determine cause of death.

2.4.3 Interpretation of Results

Various diseases can naturally strike any amphibian population at any time, so there is a chance that some mountain chickens could become ill even in the absence of man-made pollution. One-off cases of underweight or deformed mountain chickens are nothing to worry about.

If the poor health or death is recorded among a number of frogs or localities, however, it may be worth inviting an amphibian pathologist to investigate the problem more closely. Scientists

with the IUCN Declining Amphibian Populations Task Force have special interest and expertise in solving unexplained amphibian population diseases and declines. Contact the International Co-ordinator, John Wilkinson (E-mail: daptf@open.ac.uk) for more information.

3. CONCLUDING REMARKS AND RECOMMENDATIONS

There is now sufficient data to support inclusion of the mountain chicken as an Endangered species on the IUCN Red Data list. It should thus be a priority animal – nationally, regionally and globally – for wise conservation management. Though this remarkable frog has somehow survived alongside humans and feral mammals on Dominica for several centuries, the cracks are starting to show. The mountain chickens on Dominica are neither as large (long-lived) or widespread as they should be. Unexplained die-offs have been reported in several areas. The frogs continue to be hunted, fall prey to invasive mammals, and have no sanctuary in any existing reserves or national parks.

Given that Dominica's mountain chickens are not faring as well as hoped, what can or should be taken to safeguard them? Participants in the 2002 mountain chicken workshop suggested the following conservation measures, most of which are intended to help give mountain chickens greater protection against over-hunting in the wild:

- i Controls on hunting
 - *Use of open and close seasons for hunting.* This has been the main management intervention up to now. Participants agreed that the close season should cover the entire breeding season for the mountain chicken. This appears to extend from April to September, which more or less matches the current close season. However, the hunting season approach does not prevent extra heavy hunting during the open season to compensate for reduced off-take at other times. It is also prone to cheating (e.g., people with frogs in their freezer could claim they were hunted during the open season).

- *A bag limit for licensed hunters.* Leaving aside the problem of how to set a sustainable quota, the consensus of participants at the workshop was that this would be difficult to enforce.
- *A minimum size limit, allowing licensed hunters to take only frogs above a certain weight or length.* This is a common approach in wildlife management, and could prevent immature or young adult frogs being taken, to ensure there are enough breeders in the population to sustain the population. The consensus of participants at the workshop was this would be difficult to enforce.
- *A total ban on hunting and trading mountain chickens.* Though likely to be unpopular, this would be the most straightforward and enforceable approach to take, and ultimately the most ideal for the mountain chicken population. Anyone found in possession of a mountain chicken would be liable to a fine and/or imprisonment.

ii Habitat protection

- *Establish mountain chicken sanctuary(ies).* Areas identified as mountain chicken ‘hotspots’ could be maintained as special sanctuaries, where no hunting or habitat destruction is permitted. The ecotourism site of Soufriere Sulphur Springs, for example, may be a good candidate because there appears to be a dense population of mountain chickens here, and the area is under special management already. On private land, the owners have the power to forbid their employees and tenants from hunting mountain chickens on the estate.
- *(Re-)Introduce mountain chickens to existing protected areas.* This may be the easiest way to ensure that at least some mountain chickens are in a forest reserve or national park, though it would be unwise to release the frogs into areas where they historically did not occur. (The mountain chickens might be unable to survive in the long term, or have a negative impact on resident wildlife). Unfortunately, most of Dominica’s existing protected areas are above the maximum known elevation for this species. There needs to be some research,

perhaps by interviewing elderly residents, to find out whether mountain chickens ever lived in these areas (see section 2.2.2.1).

iii Education and awareness

The following themes should entail use of a wide range of media and materials, supported with one-to-one meetings with target audiences, such as hunters, tour operators and hotel managers. A few mountain chickens could be kept on view to the public and visitors, perhaps in the Botanic Gardens:

- *Raise awareness of the law pertaining to the hunting and trade of mountain chickens.* It is crucial to ensure that the public is aware of the laws pertaining to mountain chickens and the penalties.
- *Dissuade hotels and restaurants from buying or cooking mountain chickens.* As the leading customers of this ‘product’, the refusal of hotels and restaurants to buy frogs would significantly reduce the incentive to hunt them in the first place.
- *Discourage visitors from ordering frogs’ legs.* Tourists and the tourism industry should be strongly discouraged from supporting mountain chicken exploitation. Currently, many brochures and guidebooks urge visitors to try ‘Dominica’s national dish’, but removing such propaganda and advertising the mountain chicken’s endangered status would help deter most tourists from ordering frogs.
- *Promote national pride in the mountain chicken.* Dominicans rightly can feel proud of having the larger of only two surviving populations of this unusual animal. With a little positive ‘marketing’, this frog could become a national icon or symbol, much like the endangered sisserou parrot.
- *Raise awareness of the ecological, economic and cultural importance of conserving mountain chickens.* To help enlist public approval and support for conserving this species, it is necessary to spread the news that this species is endangered, and that it fulfils a number of important functions (see under 1.2.8: Threats and Conservation Measures). Dominica would be the poorer, culturally and ecologically, without it.

- *Discourage deliberate use of fire.* Bush fires were identified as a possible threat to mountain chickens. While landowners are at liberty to start fires on their own land, they may be unaware of the danger this poses to frogs and other wildlife.

iv Farming or ranching

- *Breed and raise mountain chickens in captivity to supply the food trade.* This was suggested as a possible mechanism to provide income for struggling farmers *and* reduce the pressure on wild mountain chickens. Farming or ranching (raising wild-born young) might seem to be a dream solution, but could prove unviable economically.¹⁰ Mountain chickens have been successfully bred and raised to maturity in captivity, but require ample space and a colossal input of live food, such as crickets (K. Buley, pers. comm.).

v Ecotourism

- *Generate alternative income from mountain chickens through guided frog-watching tours.* Nature tourists are especially drawn to Dominica, and it would probably be feasible and profitable to conduct evening tours for visitors and the public to see and learn about mountain chickens. Seeing these attractive, giant frogs in their natural habitat would be a novel experience, and would probably dissuade the tourists from wanting to eat them.

vi Research

Baseline research is the first step towards designing an effective management strategy for the mountain chicken in Dominica, as in Montserrat.

- *Implement a countrywide mountain chicken monitoring programme.* (As described in this manual). By surveying and monitoring changes in the abundance, distribution, population structure and health of Dominica's mountain chickens, the FWD will gain a much clearer understanding of the frog's status, needs and threats to its survival. The monitoring programme will also act as an early warning system in the event of a catastrophic crash in the mountain chicken population.

¹⁰ The advice of Kevin Buley, former Head of the Herpetological Department, Durrell Wildlife Conservation Trust, can be sought. He is now Curator of Lower Vertebrates & Invertebrates at Chester Zoo, Upton-by-Chester, Chester. CH2 1LH, UK. Email: k.buley@chesterzoo.co.uk Mr Buley has unrivalled expertise in mountain chicken husbandry.



- *Monitor the off-take of mountain chickens by hunters.* This should be carried out in tandem with the studies listed above to help determine the impact of hunting on frog distribution, abundance and reproduction. Interviews with hunters and surveys of markets and consumers (including hotels and restaurants) can be used to estimate number of frogs hunted annually on Dominica, although illegal hunting is liable to be under-reported. (Random, surprise checks on the refrigerator contents in houses and restaurants may provide figures that are more accurate!). Hunting surveys are currently being carried out as part of the FWD-FFI project on Sustainable Wildlife Use (2001 to 2004).
- *Other studies of the needs of and threats to Dominica's mountain chickens.* The participants identified a number of important questions to be answered, such as what mountain chickens eat and whether they can re-colonise abandoned banana fields. Though some answers will emerge during the course of the monitoring programme (above), interested FWD staff and visiting researchers could be encouraged to conduct special studies of various aspects of mountain chicken biology.

It is hoped that the above can be used as the basis for further discussion within FWD and with other stakeholders to develop a more effective conservation management strategy for Dominica's mountain chickens. Probably a combination of measures will be required.

4. USEFUL REFERENCES

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APPENDIX I

Datasheet for describing transects

TRANSECT NO. & NAME

No 3: Milton Valley

GPS Co-ordinates

Start 20P: 0667030/ 1716830
End 20P: 0667109/ 1716634

Forest type (tick one or more)

Scrub Forest	Dry Forest	Second. Forest	Season. Forest	Rain Forest
		✓		

Range

Northern

Route to transect

Via lower Syndicate road. Where road is paved with concrete, turn first right into small feeder road

Land use (tick one or more)

Livestock	Crops	Houses	Old fields	Ruins
			✓	

Date

9 Aug 2002

Height of trees (m)

15

Dominant tree species

1	2	3	4	5
La-Gli	Coco poule	Pois Doux	Lavier	Hett

Canopy cover (%)

Start	End
85	50

Understory height (m)

2

Dominant understory species

1	2	3	4	5
Pois Doux	Coconuts	Heliconia	Roadside weeds	

Elevation (m)

Start	End
c. 400	c. 390

Slope angle (°)

Start	End
10	20

Slope aspect (°)

Start	End
110 (ESE)	150 (SSE)

Proximity to water (m)

Start	End
c. 700	c. 400

Soil type (tick one or more)

	Clay	Loam	Sandy	Stony	Rocky	Moisture	pH	N	P	K
Start	✓					3.4	6.0	0	1	0
End		✓				2.9	5.9	0	1	0

Properties of water (tick one or more)

	Permanent (tick)	Seasonal (tick)	pH	Nitrates	Nitrites	Temperature (°C)	Evidence of pollution (explain)
Start	✓		7.5	2.5 mg/l	0 mg/l	22.9	Possibly agricultural run off
End	✓		7.5	2.5 mg/l	0 mg/l	22.9	Possibly agricultural run off



Hunting pressure on mountain chickens in this area

(Tick one, and explain choice under Explanation)

Nil	Light	Medium	Heavy	Don't know	Explanation
	✓				Relatively remote area. However, signs of agouti hunting seen on transect (bananas being used as bait)

Other Wildlife Species in this area

Reptiles: tree lizards *Anolis oculatus*; *Gymnophthalmus pleei*;

Amphibians: tree frogs

Birds: hummingbird (Antillean crested?), black whiskered vireo, mangrove cuckoo, plumbeous warbler, Lesser Antillean bullfinch, bananaquit

Mammals: probably agouti, maniocou (opossum fur seen in dog faeces on transect), domestic dog.

Additional information



Transect Instruction Notes:

EQUIPMENT NEEDED: This form, measuring tape (in metres), flagging tape, spray paint and/or tree tags to mark the transect, Global Positioning System (set to record UTM), altimeter if available, clinometer, compass, soil moisture meter, thermometer (for water temperature), soil pH meter, pens or pencils, plastic case to keep this form dry, containers for soil and water samples, permanent marker pen to label these containers. Also useful: topographic map, binoculars for birds.

Use a different sheet for each transect. Transect description sheets can be added to or revised at any time, as more information is gathered or changes detected.

Each belt transect is 250m in length and 10m wide. It should be marked at the start and end using flagging tape, tree tags and/or spray paint.

Use a GPS to record LOCATION. The UTM grid co-ordinates should be used.

Under FOREST TYPE and LAND USE, tick one box or more. If the forest type and/ or land use do not fall into the suggested categories, describe them in the box marked 'Additional Comments'.

In ROUTE TO TRANSECT, give enough information to enable a fellow Forestry staff member to find the transect.

HEIGHT OF TREES is the average height of the tree canopy in and around the transect. Ignore unusually tall, emergent trees. Estimate the height by eye, but to be more accurate, you should check the height using a clinometer.

UNDERSTORY HEIGHT is the average height of the undergrowth in this area of the transect. This is likely to include bracken, grasses or tree saplings. Ignore trees and large woody shrubs. Estimate by eye and check using a tape measure. The undergrowth is unlikely to be more than 3m in height.

DOMINANT TREE SPECIES and DOMINANT UNDERSTORY SPECIES are the most common species of plants growing along or near the transect. Give the local, Creole name if you are unsure of the English or scientific name.

CANOPY COVER is estimated by eye as a percentage. 0% means zero canopy cover (fully open sky), while a dense canopy might reach 90%. Take care not to exaggerate. A 100% canopy cover is almost unknown in nature.

ELEVATION should be recorded using an altimeter or read from a topographic map. A GPS can be used, but will provide only an approximate reading.

SLOPE ANGLE and SLOPE ASPECT describe the prevailing slope within the 10-m wide transect. Ignore slopes outside of the belt transect. Record **slope angle** using a clinometer (To do this, two people stand facing one on the slope, at least five metres apart. The first looks through a clinometer, and records the degree slope corresponding to the eye level of the second person. The degree slope is the left-hand scale on the Suunto clinometer). Record **slope aspect** (the direction in which the slope is facing) in degrees using a compass. Use the 'Additional Comments' box to describe other major slopes or land forms in the study area.

PROXIMITY TO WATER is measured as the shortest distance to a stream or river from the mid-line of the transect, and is measured at the start and the end of the transect. Use a tape measure if possible. If the transect is more than 100m from water, estimate the distance by eye.

SOIL TYPE is classified according to particle size. Clay soils contain more than 40% very fine particles, and form a compact ball if rolled between the fingers. Sandy soils are granular and porous, with more than 80% sand-sized particles. They feel rough to the touch. Loam soils are in between, containing a mix of fine and large particles.

Tick the relevant box if **BOULDERS** are present at the start and/or the end of the transect.

SOIL MOISTURE is recorded by inserting the Tenax™ Mini Moisture Tester vertically down to a depth of 15cm. This provides a reading of between 0 (dry) and 5 (saturated).

To record **SOIL pH**, scrape away the top 5 cm of soil and break up and crumble the soil underneath to a depth of 12cm. Remove any stones, litter or plant material. Thoroughly wet the soil with rainwater to the consistency of mud. Insert the probe of the Tenax™ Mini pH Tester in the wet soil to a depth of 10cm. Wait for one minute and record the reading (between 3 and 10). Any reading below 7 is acid, readings above 7 are alkaline.

To record **SOIL NUTRIENTS (nitrogen - N, phosphorus - P, and potassium - K)**, scrape away the top 5 cm of soil and collect a cupful. Write the name and number of the transect on the sample container. The soil is tested indoors following the instructions of the Rapitest™ Soil Test Kit

To record **WATER pH, NITRATES AND NITRITES**, collect a cupful of water from the nearest stream. Write the name and number of the transect on the sample container. The water is tested indoors following the instructions of the Tenax™ Pond Test Kit

WATER TEMPERATURE is recorded in the field using a thermometer.

EVIDENCE OF POLLUTION might include signs of garbage in the waterways or reports of local farmers using pesticides.

HUNTING PRESSURE is inferred from local reports, the accessibility of the transect and evidence in the field (e.g., signs of frequent human use). 'Light' would be only one visit per year by hunters. 'Medium' would be a visit every two or three months or several visits during the Open Season. 'Heavy' would be a visit every month, including illegal hunting during the Close Season.

OTHER WILDLIFE SPECIES in this area. List any birds, mammals, reptiles, frogs or invertebrates seen in the transect area. This list may be extended at any time. Pay particular attention to possible frog predators and prey.

Use **ADDITIONAL INFORMATION** for any extra comments you think are relevant. For example, include any information to explain why you think this transect should support more or fewer mountain chickens than other areas.

APPENDIX II

Datasheet for surveying mountain chickens on transects

Transect no. & name

Transect no. & name	Weather (tick)				Human disturbance (tick one or more)							
	Clear	Cloudy	Overcast	Rain	Wind	Litter	Footprint	Transect markers	Burning/Fire	Report	Heard	Met
No. 1: Soufriere Sulphur Spring	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Range

Southern

Observers (list all names)

Phillip Matthew, Matthew Maximea,
Stephen Durand, Jenny Daltry

Phase of moon (tick one)

New	One quarter	Half	Three-quarters	Full
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Feral dogs

Report	Heard	Seen
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Feral cats

Report	Heard	Seen
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Livestock

Report	Heard	Seen
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Date

2 August 2002

	Start time	Stop time	Ambient relative humidity (%) at start	Ambient temp (°C) at start	Soil moisture at start	TOTAL FROGS seen (VES) or heard (AES)
Visual Encounter Survey	19.48	20.35	66	29	2.7	6
Aural Encounter Survey	20.45	21.15	71	27.4	0.5	6

Frogs caught:

	SVL (cm)	Weight (grams)	Sex (M/ F/ ?)	Health (OK/ poor)	In water	On land	Calling	Nesting	Eating	Other
1	13.17	135	M	✓		✓				
2	15.35	300	F	✓		✓				
3	10.60	80	?	✓		✓				
4	12.19	134	F?	✓		✓				
5	13.53	160	M	✓		✓				
6	7.73	28	?	✓		✓				
7	16.00	270	F	✓		✓				
8	12.13	147	F	✓		✓				



9	12.69	165	M	✓		✓				
10	4.51	6	?	✓		✓				
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

General Comments

Use this space for additional information, e.g., frogs seen or heard on the way to or from the transect

Frogs 7 - 10 were caught on and near the transect after the VES (during the AES). Two were beside to the hot stream (35-40 degrees centigrade).

Juvenile No. 10 hatched this year? Evidence of breeding in this area.



Transect Instruction Notes:

EQUIPMENT NEEDED: This form, thermohygrometer, soil moisture meter, flashlights, spare batteries; pens or pencils, ruler and/or callipers, spring balance to weigh frogs, string, watch, plastic case to keep this form dry.

Use a different sheet each time you survey a transect. The Transect number and name should be clearly written on the data sheet (e.g., No. 1: Soufriere Sulphur Springs).

Time on the transect should be about 2 hours. The VISUAL ENCOUNTER SURVEY is carried out as the team walks from the start to the end of the transect (1 to 1.5 hours). The AURAL ENCOUNTER SURVEY is carried out on the return walk back to the start (approx. 20 minutes).

Three people should walk each transect. One to fill out the form correctly, while the other two seek and handle the frogs.

List all OBSERVERS taking part in the survey. Include the names of Forestry personnel and any other persons taking part.

Record any evidence of HUMAN DISTURBANCE since the last survey by ticking one or more boxes: **Litter** = any debris, such as cigarette butts and plastic bags, **Footprint** = footprints or tracks, **Transect Markers** = transect markers disturbed, **Burning** = signs of fires on or near the transect, **Report** = reports of hunting e.g. from local farmers, **Heard** = heard people/ hunting dogs when in this area, **Met** = met hunters in this area.

Record PHASE OF MOON as the percentage of moon visible from Earth. A new moon is less than one quarter full. If you cannot see the moon (e.g., if the sky is cloudy), check its phase using a calendar. Frog activity may increase or decrease, depending on the phase of the moon.

Begin the survey at 19:45 (quarter to eight o'clock). Starting on time is essential. If you are not ready to start on time, go home and come back to survey this transect another day!

The VISUAL ENCOUNTER SURVEY is conducted first. The team assembles at 19.45 SHARP at the START of the transect and walks slowly up the transect to the end, counting every mountain chicken seen. The team should search within the band 5 metres either side of the transect midline. Do not count any mountain chickens seen outside of this band. Depending on the number of frogs seen, the team should reach the end of the transect in about one hour. Enter the number of frogs seen in the TOTAL FROGS box. Use the hand tally if this helps.

At the start of the Visual Encounter Survey (19.45), record ambient relative humidity and temperature using the handheld thermohygrometer, held at about chest-height. These values are essential, because frog activity will vary depending on climate. Also record soil moisture at the start of the transect using the Tenax Mini Moisture Tester.

DO NOT RUSH !!! Some frogs may be sitting in the open and easy to see, but others will be well hidden in the vegetation.

If you do not see any frogs on the transect during the Visual Encounter Survey, put a '0' in the box under TOTAL FROGS SEEN.

Do not forget to record the time that you STOP the Visual Encounter Survey (i.e., the time you reach the end of the transect).

The Aural Encounter Survey is conducted second, after the VES is finished. The team assembles at the END of the transect at approximately 20.45 and walks slowly AND QUIETLY along the transect back to the start, counting every mountain chicken heard within 100m distance from the transect midline. The team should reach the end of the transect in about 20-30 minutes. Enter the number of frogs heard in the TOTAL FROGS box. Use the hand tally if this helps. If different members of the team come up with different figures, take the average.

At the start of the Aural Encounter Survey (approximately 20:45), record ambient relative humidity and temperature using the hand-held thermohygrometer, held at about chest-height. These values are essential, because frog calling activity will vary depending on climate. Also record soil moisture at the start of the transect using the Tenax Mini Moisture Tester.

Do not forget to record the time that you STOP the Aural Encounter Survey (i.e., the time you reach the start of the transect).

FROGS CAUGHT: Attempt to catch all frogs seen on the transect, both during the VES and the AES. For each frog, measure **Snout Vent Length (SVL)** using a ruler or callipers from the tip of its snout to its vent (the hole in its bottom). **Weigh** the frog using a spring balance attached to a string noose around the frog's hips. During the breeding season from about February to September, mature **males** have a black spike on the thumb that is absent from mature **females**. The sex of immature individuals and adults outside of the breeding season should be recorded as ? Examine the frog for **signs of injury or ill health**. Is it plump? Does it kick strongly when handled? If health is considered poor, explain how under the column marked 'Other'. Do not handle each frog for more than five minutes, and release it in the exact spot where it was caught. Take care not to record the same individual twice.

Bonus frogs': In addition to frogs captured on the transect during the VES, the team is encouraged to catch and measure any additional frogs seen on the night of the survey. Space is provided for up to 45 frogs, and you can use a fresh survey form for more. Recording their sex, lengths and weights will provide valuable information on the state of the population, but please take care not to include these individuals under the TOTAL FROGS SEEN.

Use GENERAL COMMENTS box for additional observations, e.g. other frogs or other animals seen on way back from monitoring, or signs of fire or cutting disturbance in the vicinity. Include any explanation as to why you think you saw or heard many (or few) frogs tonight.

APPENDIX III

Soil and water tests conducted

The following tests were carried out to provide baseline data on the properties of water and soil on the monitoring transects. Most of the tests were conducted using domestic garden test kits that are widely available in the UK. Ideally, a specialist ecology test kit should be applied to corroborate the results found here and to investigate other parameters, such as the presence of toxic heavy metals.

Soil

	Rationale	Method	General observations
pH	Frogs cannot survive extreme pH levels and may become ill and/or stop breeding at sub-optimal levels. pH is measured on a scale from 0 to 14, with pH 7.0 being neutral. Values below 7.0 are acid; values above 7.0 are alkaline.	Scrape away the top 5 cm of soil and break up and crumble the soil underneath to a depth of 12cm. Remove any stones, litter or plant material. Thoroughly wet the soil with rainwater to the consistency of mud. Insert the probe of the Tenax™ Mini pH Tester in the wet soil to a depth of 10cm. Wait for one minute and record the reading (between 3 and 10).	Soils on the transect ranged from slightly acidic (c. pH 6.0) to very acidic (c. pH 5.0), as would be expected on soil of volcanic origin. The most acidic soil was on Soufriere Sulphur Springs (pH 4.8).
Moisture	Frogs are highly prone to desiccation. Most species are associated with damp habitats.	Insert the Tenax™ Mini Moisture Tester vertically into the soil to a depth of 15cm. This provides a reading of between 0 (dry) and 5 (saturated).	During the rainy season, most transect soils were rather damp. It would be worth retesting the soils at the height of the dry season.
Nitrogen	One of three major plant foods that are essential for plant growth.	A soil sample was taken from 5cm below the surface, dissolved in neutral tap water (1 part soil to 5-parts water), and left to stand for one hour. A 'nitrogen capsule' (Rapitest™ Soil Test Kit) was added to approximately 30ml of the solution and agitated. The colour of the resulting solution was compared against a colour chart provided by the manufacturer. Levels were measured on a scale from 0 (depleted) to 4 (surplus).	All transect soils studied were nitrogen deficient.
Phosphorus	One of three major plant foods that are essential for plant growth.	As above, but using the Rapitest™ Soil Test Kit 'phosphorus capsule'. Levels were measured on a scale from 0 (depleted) to 4 (surplus).	All transect soils studied were phosphorus deficient.
Potash	One of three major plant foods that are essential for plant growth.	As above, but using the Rapitest™ Soil Test Kit 'potash capsule'. Levels were measured on a scale from 0 (depleted) to 4 (surplus).	All transect soils studied were potash deficient.

Water

	Rationale	Method	General observations
Temperature	As poikilothermic ('cold blooded') animals, frogs are often highly selective about the temperature of their environment.	Measured in degrees centigrade (°C) using a high-precision Vaisala™ thermo hygrometer.	Stream water temperatures ranged from a cool 22.4°C (Coulibistre) to a warm 28°C (Rosalie), to a scalding 70.5°C (Soufriere Sulphur Springs).
pH	Frogs cannot survive extreme pH levels and may become ill or stop breeding at sub-optimal levels. pH is measured on a scale from 0 to 14, with pH 7.0 being neutral. Values below 7.0 are acid; values above 7.0 are alkaline.	A 'pH capsule' (Tenax™ Pond Test Kit) was added to approximately 30ml of water and agitated. The colour of the resulting solution was compared against a colour chart provided by the manufacturer.	Water was slightly alkaline (pH 7.5) on all transects apart from Soufriere Sulphur Springs, which was very acidic (<5.0).
Nitrate	Nitrates are necessary to promote plant growth, but can be harmful to aquatic animals at high levels (>50mg/l). It can be lethal to fish at levels exceeding 200mg/l	As above, but using the Tenax™ Pond Test Kit 'nitrate capsule'. Levels were measured in milligrams per litre (mg/l)	Water samples from all transects contained around 2.5mg/l nitrates.
Nitrite	Nitrites are produced by the decomposition of organic matter and are much more toxic than nitrates. Levels above 0.5mg/l are harmful to aquatic animals, and levels exceeding 5mg/l are lethal to most fish.	As above, but using the Tenax™ Pond Test Kit 'nitrite capsule'. Levels were measured in milligrams per litre (mg/l)	Water samples from the transects contained no measurable nitrites, apart from Soufriere Sulphur Springs (c. 5mg/l). The latter is probably of natural (volcanic) origin.

APPENDIX IV

Preserving and packing mountain chickens for pathological study

If a sick or severely injured frog is found, it should be killed as quickly and humanely as possible. Some herpetologists favour killing frogs by pithing (slicing through the upper brain with a sharp knife). Another method is to smear a small amount of a gel containing benzocaine on the frog's head (benzocaine-containing gels are sold in most pharmacies as toothache medication): this causes death within a few minutes. Frogs can alternatively be drowned in warm water (43-47°C) or weak alcohol (15-25%): diluted white rum would suffice.

To preserve a frog for pathological study, it should be placed in 70% ethyl alcohol (overproof white rum is suitable - *not* methyl, rubbing or isopropyl alcohol). To ensure that the alcohol permeates throughout the body, the frog should be pierced in several places with a clean sharp knife before being fully immersed. Tadpoles and eggs can similarly be preserved in 70% ethyl alcohol. The storage container should of course be watertight and preferably plastic rather than glass.

If the specimen cannot be preserved immediately, it *can* be temporarily stored in a freezer. This should be avoided if possible, however, because freezing can cause the skin (which may be of interest to the pathologist) to slough away.

The preserved frog should be clearly labelled with a quality paper or plastic tag, firmly tied with cotton thread around its hips or to one leg. The tag should record when and where the frog was collected using pencil.

Before being sent off-island (either by airmail or hand-carriage), a preserved frog should be taken out of the storage container and wrapped in cheesecloth or paper towels soaked in 70% ethyl alcohol, and placed in a plastic bag. The bag should be securely tied and placed into a second bag before being sealed in a plastic container ready for posting. Tadpoles and eggs should not be wrapped up, but shipped in vials or similar containers with some 70% ethyl alcohol.

An address label should be placed on the inside as well as the outside of each package. The package should also be labelled: 'FRAGILE: preserved biological specimen'.

Preserved mountain chickens can be sent to:

Dr Andrew A. Cunningham
Veterinary Science Group,
Institute of Zoology,
Regent's Park,
London, NW1 4RY
United Kingdom

e-mail: a.cunningham@ioz.ac.uk



APPENDIX V

Estimating mountain chicken population size using mark-recapture

The following methods could be used to estimate mountain chicken population size within a defined area (such as a valley). The resulting estimate could then be used to produce a population estimate for the whole island.

Frogs can be marked in various ways, e.g., toe-clipping, non-toxic paint and Passive Integrated Transponder tags (see Heyer *et al.*, 1994). It is important to use a method that will last the duration of the study and does not affect the animal's chance of survival or makes it more likely to recaptured.

a) Two sample method

A number of individuals are caught, marked and returned to the capture site (e.g., within a quadrat or valley). Shortly after this, a second series of captures is made in the same area. The number of re-captured (marked) animals is compared with the number of new (unmarked) individuals, to assess the efficiency of the capture method and thereby estimate the total number of individuals in the area (**N**) using the following equation:

$$\hat{N} = \frac{(n^1 + 1)(n^2 + 1)}{m^2 + 1} - 1 \quad \text{(Chapman, 1951: a bias-adjusted modification of the Lincoln – Petersen Estimator)}$$

Where n^1 is the number of individuals caught in the first series, n^2 is the number of individuals caught in the second series (marked and unmarked), and m^2 is the number of marked animals caught in the second series. This method assumes that:

- The population is closed between marking and recapture.
- All animals have equal probability of being caught in the first sample.
- The marking of an animal does not affect its probability of being caught.
- Animals do not lose their marks between capture and the second series of captures.

Example:

On the first visit to a valley, **30** mountain chickens are caught. Every one is marked using a PIT tag. The 30 marked frogs are then released and allowed to mix with the other wild frogs.

A few days later, the valley is revisited and **35** mountain chickens are caught, including **10** marked ones and **25** new, unmarked frogs.

The total population (absolute abundance) of mountain chickens in this area is estimated as:

$$\begin{aligned} \hat{N} &= \frac{(30 + 1)(35 + 1)}{10 + 1} - 1 \\ &= 100 \end{aligned}$$

b) Multiple sample method

The Weighted Mean Method of Estimating Population Size (Begon, 1979) differs little from the more familiar Petersen estimate above and makes all the same assumptions. It accumulates data over several days and is generally appropriate for studies in which there are relatively few captures made during each sample.

On each day, n_i individuals are caught, of which m_i are already marked. Unmarked animals are then marked, and r_i marked animals released. (There are, therefore $(r_i - m_i)$ additional marked individuals released each day). The number of marked animals increases with time. The number of marks at large on day i ($= M_i$) is, therefore, the number of mark animals released on day 1 (r_1) plus the number of additional marked animals released on all days between day 1 and day i ; that is, $(r_2 - m_2) + (r_3 - m_3) \dots + (r_{i-1} - m_{i-1})$. Population size (N) can then be estimated using a standard Petersen estimate:-

$$N_i = \frac{M_i n_i}{m_i}$$

We have assumed, however, that the population is closed and that all N_i 's are themselves estimates of the total population size, N . Yet some N_i 's are likely to be more accurate than others, and it is of course sensible to give most weight to the most accurate estimates. This can be done by arguing that the accuracy of an N_i depends on how much information it was derived from. In other words, an N_i obtained from a sample containing very few marked individuals is likely to be much influenced by chance effects on the actual size of m_i . Samples in which m_i is large, on the other hand, will be much less influenced by chance effects and will, on average, produce more accurate N_i 's. We can, therefore, use the m_i 's as our weights:

Estimate of population size

$$N = \frac{M_i n_i}{(\sum m_i) + 1}$$

Standard error of the population estimate over 3 days:

$$SE_N = N \sqrt{\frac{1}{\sum m_i + 1} + \frac{2}{(\sum m_i + 1)^2} + \frac{3}{(\sum m_i + 1)^3} \dots \text{etc}}$$

