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Saving the mountain chicken

Long-Term Recovery Strategy for the Critically Endangered mountain chicken 2014-2034



Adams, S L, Morton, M N, Terry, A, Young, R P, Dawson, J, Martin, L, Sulton, M, Hudson, M, Cunningham, A, Garcia, G, Goetz, M, Lopez, J, Tapley, B, Burton, M and Gray, G.



Front cover photograph

Male mountain chicken. Matthew Morton / Durrell (2012)

Back cover photograph

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Saving the mountain chicken

A Long-Term Recovery Strategy for the Critically Endangered mountain chicken 2014-2034

Mountain Chicken Recovery Programme



Forewords

There are many mysteries about life and survival on Montserrat for animals, plants and amphibians. In every case survival has been a common thread in the challenges to life on our small Caribbean island, the home to a now passive volcano at our Soufriere Hills, formerly home to an abundance in biodiversity. North Montserrat however, remains the home to many unique species including the Montserrat Oriole (our national bird), the galliwasp lizard, the endemic Montserrat orchid and the mountain chicken frog. Once a popular delicacy amongst islanders and visitors alike, the mountain chicken, which can only be found in Montserrat and Dominica has been pushed to the brink of extinction.

Whilst the population of mountain chickens on Montserrat had been showing declines following the volcanic eruptions of the Soufrière Hills which started in 1995 it was the arrival in 2009 of the deadly amphibian chytrid fungus that has pushed the species to the brink of extinction.

Thankfully due to the swift action of the government and our overseas partners a number of individual frogs were rescued and brought into bio-secure captive breeding programmes in European zoos. This has provided a safety net population that may one day re-populate Montserrat with its Mountain Chicken and bring its distinctive airy night-call back to the island. With our partners, we have formed a coalition: the Mountain Chicken Recovery Programme, actively working in Montserrat, Dominica and in Europe to save our mountain chicken.

Much and varied research and work needs continue however before our rescue mission is achieved. The chytrid fungus remains on Montserrat and currently there is no known cure. Our Long Term Recovery Strategy sets out a 20 year framework of activities to help address the chytrid crisis for the mountain chicken on both Montserrat and Dominica. This strategy will guide the Mountain Chicken Recovery Programme – one of the World's leading programmes attempting to mitigate the interactions of the chytrid fungus with native amphibians. As such the research and supporting work are likely to have additional beneficial impacts far beyond the salvation of our mountain chicken.

We see the successful conservation of the mountain chicken as being vitally important for Montserrat as this 'frog' is part of our natural heritage. Our hope is that through this Strategy the mountain chickens' distinctive call may once again be heard across the island and be enjoyed by nature lovers from around the world.

As Minister with responsibility for the Environment, I embrace this opportunity to give my full support and that of the Government and People of Montserrat to this project, sponsored by the Darwin Initiative and Balcombe Trust. I applaud all those who have assisted in taking this project forward, not least among them staff of our own Department of Environment, leading the way here in Montserrat.

Hon. Claude E. S. Hogan
Minister of Agriculture, Trade, Lands, Housing
and the Environment
Government of Montserrat

Forewords

The Commonwealth of Dominica is proud of its rich biodiversity heritage and of the way Dominicans have managed this resource for centuries. Our 'Nature Island' boasts the most extensive forests in the Eastern Caribbean and a diverse assemblage of wildlife. Among its animal treasures are the Imperial Amazon known locally as the sisserou and the mountain chicken frog or crapaud as it is known in kwéyòl. The crapaud is part of our cultural heritage too. It was once the unofficial national dish, it forms part of many of Dominica's traditional proverbs and jokes and appears on our national crest.

Since 2002 the crapaud has been dwindling due to the effects of the deadly amphibian chytrid fungus. Within living memory of most Dominicans, it was so abundant that large numbers could be harvested for food, but by 2008 many feared that it may possibly be extinct. Fortunately this proved not to be the case though they are now only found in very low numbers. A similar catastrophic crash in the mountain chicken population has also happened on Montserrat, the only other country in the world with which we share this species.

The mountain chicken's perilous situation has brought together the conservation efforts taking place in both Dominica and Montserrat to produce the unified strategy presented in this document for trying to reverse the trajectory of the species towards extinction. This Long-term Recovery Strategy will promote closer collaboration between our

partners in Montserrat and further afield and encourage the exchange of ideas and methods we are developing to effect the recovery of this iconic species. The Strategy is aligned with the Dominica National Biodiversity Strategy and Action Plan 2014-2020 which sets out a series of actions to minimise the loss of biodiversity in Dominica. The Strategy will help deliver this goal, supported by the crapaud captive breeding centre that has been established in our country.

My Ministry wishes to recognise the efforts of all the partners, stakeholders and funders of the Mountain Chicken Recovery Programme, notably including our own Division of Forestry, Wildlife and National Parks, in bringing this timely Strategy together. I offer the support and encouragement of the people and Government of the Commonwealth of Dominica to delivering the goal of this Strategy over the next 20 years.

Hon. Johnson Drigo
Minister of Agriculture and Fisheries
Government of the Commonwealth of
Dominica

Acronyms and abbreviations

BC	Birds Caribbean (previously the Society for the Conservation and Study of Caribbean Birds)	MNT	Montserrat National Trust
Bd	The pathogenic fungus <i>Batrachochytrium dendrobatidis</i>	MOU	Memorandum of Understanding
BMNH	British Museum of Natural History	MUL	Montserrat Utilities Limited
CCC	Coral Cay Conservation	MWA	Montserrat Water Authority (Note: MWA now fall under the responsibility of MUL)
CEMA	Draft Conservation and Environmental Management Act, Montserrat		
Chester	North of England Zoological Society, Chester Zoo	NEMS	National Environment Management Strategy
COD	Commonwealth of Dominica	NGO	Non-governmental Organisation
DICE	Durrell Institute of Conservation and Ecology, University of Kent	OECS	Organisation of Eastern Caribbean States
DOE	Department of Environment, Montserrat (MALHE)	PIT	Passive Integrated Transponder
Durrell	Durrell Wildlife Conservation Trust	PPU	Physical Planning Unit
EAZA	European Association of Zoos and Aquaria	qPCR	Real-time quantitative polymerase chain reaction
FFI	Fauna and Flora International	RSPB	Royal Society for the Protection of Birds
FWPD	Forestry, Wildlife and Parks Division, Dominica		
GIS	Geographical Information System (software)	RBG-K	Royal Botanical Gardens, Kew
GOM	Government of Montserrat	SCSCB	Society for the Conservation and Study of Caribbean Birds
GPS	Global Positioning System		
IRF	International Resources Foundation	SGD	St George's Declaration of Principles for Environmental Sustainability in the OECS
IUCN	International Union for Conservation of Nature		
MALHE	Ministry of Agriculture, Land, Housing & Environment, Montserrat	ZSL	Zoological Society of London
MCRP	Mountain Chicken Recovery Programme		

Table of Contents

Foreword	iv
Acronyms and abbreviations	v
Principle Contributors	vii
Donor	vii
Acknowledgements	viii
Executive Summary	x
1. Introduction	1
2. Background	3
2.1 Overview of species	3
2.2 Distribution, abundance and population trends	9
2.3 Threats, potential threats and limiting factors	15
2.4 Red List Status	23
2.5 Cultural Values	23
2.6 Conservation Management	24
3. Long Term Recovery Strategy 2014 – 2034	33
3.1 Justification	33
3.2 Vision, goal and objectives	33
3.3 Projects and activity tables	36
4. References	54

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Donor

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Executive Summary

Overview

The mountain chicken is a Critically Endangered frog found only on Montserrat and Dominica and is the largest native amphibian in the Lesser Antilles. Populations on both islands have been devastated by the deadly amphibian chytrid fungus, first on Dominica from 2002 and subsequently from 2009 on Montserrat. The wild population on both islands is currently estimated to be less than 100 individuals.

Chytrid struck Dominica in 2002 and led to a population reduction of over 80% in just 18 months. The population crash was so severe that it was feared the Dominican population was possibly extinct by late 2000's. However, surveys since 2011 have confirmed the population is still surviving and the presence of juveniles indicates successful breeding. A captive breeding centre was established on Dominica through a 2005 Darwin Initiative grant and whilst no successful breeding has yet occurred is successfully maintaining five individuals.

In response to the chytrid outbreak in Montserrat 50 individuals were evacuated and used to establish ex-situ safety net populations in three European institutions. Simultaneous pioneering treatment trials using anti-fungal agents to try and protect wild frogs were undertaken in Montserrat though these were found not to provide long-term protection. In 2010 with funding from the Darwin Initiative a 3-year programme of research, experimental reintroductions and public engagement was undertaken in Montserrat and established the Mountain Chicken Recovery Programme. During this period a total of 173 mountain chickens were released under varying conditions to study differences in survival rates and to determine whether releases can be considered a viable conservation strategy in the future. The culmination of the Darwin funded project was a participatory workshop in July 2013, which developed this Long Term Recovery Strategy for the mountain chicken on both Montserrat and Dominica. The workshop was attended by Dominican, Montserratian and UK experts and other stakeholders. Given the primary threat facing the mountain chicken, the chytrid fungus, and the scale of the diverse research to be done in relation to it the workshop participants agreed that a 20 year action plan was needed to achieve a reasonable goal.

The Strategy summarises the current state of knowledge of the mountain chicken's population status, taxonomy and ecology, and of the threats facing it, and describes the

institutional framework for conservation management in Dominica and Montserrat. It lists the key stakeholders in the Strategy, and the vision, goal, objectives and activities of the Strategy are reported. Each activity has a responsible institution(s), an approximate costing, a time-frame and key risks and opportunities in achieving it.

The Strategies Vision is "to have healthy populations of mountain chickens as a flagship species for the islands' natural and cultural heritage". Its goal is that "there are healthy mountain chicken populations across their former year-2000 ranges on each of Montserrat and Dominica by 2034". The higher priority objectives, to be achieved by 2034 are to:

1. By 2020, the mountain chicken is a flagship species for global amphibian conservation, generating strong motivation among all partners and stakeholders to take the necessary steps to restore the species in the wild.
2. By 2028, research has discovered or developed method (s) to mitigate the impact of Bd on mountain chickens in the wild.
3. Establish growing populations at 5 sites on each island through a combination of in situ and ex situ management.
4. An ex situ breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met.

Lower priority objectives to be achieved by 2034 are:

5. The moratorium on hunting in Dominica and Montserrat is maintained and enforced over the lifetime of this plan.
6. The impact (number of deaths of mountain chickens) of invasive species is estimated where possible and does not strongly limit the recovery of the mountain chicken population.
7. No net loss of mountain chicken habitat due to climate change on Dominica and Montserrat.
8. Loss of suitable mountain chicken habitat because of other causes on Dominica and Montserrat is minimized and does not strongly limit the recovery of the mountain chicken population.

1. Introduction

The mountain chicken frog, *Leptodactylus fallax*, is the largest native amphibian found in the Lesser Antilles, Caribbean. Distinctive not only because of its size but also for the charismatic male calls which once reverberated round the forest at night; this species is highly valued culturally, scientifically and also economically through hunting. Once found on seven islands in the Caribbean, the mountain chicken is now restricted to the islands of Montserrat and Dominica, where numbers have declined through impacts of invasive species, historical habitat destruction, hunting pressure from humans and, more recently, disease.

Since 1995, repeated volcanic explosions have destroyed and degraded large areas of forest in Montserrat threatening the local population of mountain chickens. Combined with the pressure of unsustainable hunting, particularly in Dominica where the mountain chicken was the national dish, the global population was severely reduced.

Devastatingly, the presence of the fungus *Batrachochytrium dendrobatidis* (*Bd*) was confirmed in Dominica in 2002. The fungus caused the outbreak of the fatal fungal disease, chytridiomycosis, within the mountain chicken population which resulted in estimated declines of 80% within 18 months of being detected and led to the species being listed as Critically Endangered (IUCN). The population declined to such low numbers that 2008 surveys failed to detect any surviving mountain chickens in the wild in Dominica raising fears it had gone extinct. Despite efforts to increase island biosecurity on Montserrat

the impacts of chytridiomycosis were observed in the local population in February 2009 by the Department of Environment and a population crash of similar levels to those seen in Dominica followed.

Since the rapid decline in populations, recognition of the ecological role of the mountain chicken and the discovery of its unique breeding strategy has highlighted the importance of the conservation of the species. Efforts have been made on both islands to increase protection of the species to cease hunting activity and conservation of the mountain chicken along with the preservation of local biodiversity is seen as positive step towards encouraging eco-tourism and an appreciation of a rich environmental heritage.

In response to the *Bd* crisis and the desire to conserve the species, the Mountain Chicken Recovery Programme (MCRP) was formed which pulls together expertise, institutional capacity and governmental support in a collaboration to prevent the mountain chicken from going extinct. The MCRP has conducted significant research and developed management techniques to prevent extinction of the mountain chicken but no methods have yet been successfully developed to mitigate the impacts of *Bd* on the species in the wild. As efforts on a global scale have so far failed to develop a cure for chytridiomycosis, it is recognised that intensive long term management of the mountain chicken will be required and that this collaborative strategy is essential to coordinate and guide these efforts.

2. Background



Fig. 1. Mountain chicken on leaf litter (photo: E. Downie)

2.1 Overview of species

2.1.1 Taxonomic background

The mountain chicken, *Leptodactylus fallax*, was first described on Dominica by Müller in 1923 under an alternative name (a synonym), *Leptodactylus dominicensis*, which is no longer used. It is known by a number of common English names, including the Dominican white-lipped frog (Frank and Ramus 1996), giant ditch frog (Hedges, <http://www.caribherp.org/>), giant woodland frog (Groome 1970), but mountain chicken seems by far the most frequently used. In Dominica, it is also known by the kwéyòl name of kwapo (originally written as "crapaud"). It is classified into Leptodactylidae (neotropical frogs), a large, diverse family of over 800 frog species found primarily in the new world tropics (the Americas including the Caribbean). The mountain chicken belongs to the genus *Leptodactylus* (foam-nest frogs and white-lipped frogs), which occur throughout most of South and Central America reaching as far north as southern Texas and are also found in the Greater and Lesser Antilles. The number of species in the genus is not fully known, but it is likely there are more than 70 species.

Genetic analysis has revealed that the mountain chicken and the only other species of *Leptodactylus* known from the Caribbean, *L. albilabris* from Hispaniola, Puerto Rico and the Virgin Islands, diverged from their mainland ancestors sometime between 23 and 34 million years ago (*L. fallax*) and 24 and 58 million years ago (*L. albilabris*). There is no variation (separate races, etc.) described within the species *L. fallax* and genetic work by Hedges (2007) suggested that the Montserratian and Dominican populations are almost identical, the implication being that they arose from a single founder stock or were moved between both islands, presumably by Amerindian settlers. More recent work by Bruford *et al.* (2014 in prep.), however, found moderate, not low, genetic variation within the species and differences between the Montserratian and Dominican populations, with the genes in the former being a subset of those in the latter. Mike Bruford writes:

"while under normal circumstances one might endeavour to manage the two island populations separately, in this case we see no strong genetic discontinuity between the islands that might imply a negative outcome if they were mixed, notwithstanding the possibility of some local adaptation that this study was not designed to detect."



Fig. 2. Spurs on male (arrowed) during breeding season (left) and outside of breeding season (right). (photos: G. Garcia/Durrell)

2.1.2 General biology

The mountain chicken is the largest living *Leptodactylus* species (Kaiser 1994) and one of the largest extant frog species (Fig. 1). With wide mouths and powerful hind legs it can reach a head and body length of over 20 cm and weigh over 1,000 g (Rosa *et al.* 2012), although most adults are more typically between 16 and 17 cm in length. The large body size observed in *L. fallax* could be considered in association with the island effect, which is a known cause of dwarfism or gigantism. The mountain chicken is the only native frog living in Montserrat, where autochthonous predators were absent or scarce. Both these factors may have produced a relaxed selective pressure and the utilization of a wide range of prey, with the effect of allowing the survival of a large frog like the mountain chicken (Guarino *et al.* 2014).

The body colour and pattern of mountain chickens vary, but they are usually a reddish brown on the back, often orange-brown on the flanks and cream coloured on the belly. The hind legs and sides of the face are commonly patterned with dark bars and blotches; the dorsum may be uniform in colour but is usually also broken into darker and lighter brown patches. This patterning is quite striking but effectively camouflages frogs against leaf litter on the forest floor.

Females tend to be larger than males although colouration and patterning are similar. Males alone have a 'spur' below the thumb, used to stimulate the female as she is grasped during mating (Fig. 2). This spur is keratinised and typically black during the mating season but white outside of this season. The presence of the spur is the most reliable way of distinguishing between the sexes.

Along with the tiny whistling frog *Eleutherodactylus*

johnstonei, which is a carrier of the fungus but appears not to be severely affected by the disease chytridiomycosis, the mountain chicken is one of the only two amphibians native to Montserrat (the third is the cane toad, *Rhinella marina*, an introduced species). On the considerably larger island of Dominica, there are two other amphibians, both *Eleutherodactylus* species: the Endangered *E. amplinympha* and the regionally endemic *E. martinicensis* (Fig. 3, Caribherp 2014).

Mountain chickens are primarily nocturnal, spending the days hiding in burrows, rock crevices or relying on their camouflage to hide in the leaf litter. They emerge at dusk to feed and, in the breeding season, to seek mates (Fig. 4). They are particularly active on cool, humid nights. Skeletochronology on wild frogs (dead frogs collected following the *Bd* outbreak of 2009 in Montserrat) provided a maximum estimated age of 7 years in wild frogs (Guarino *et al.* 2014). The longest period for a frog kept in captivity has been 15 years (wild caught in 1998). Sexual maturity reached within two years (a captive female reproduced at 22 months at Durrell's breeding facilities).

2.1.3 Breeding behaviour

Mountain chickens have a unique reproductive strategy for an amphibian with an unprecedentedly high level of maternal care which includes obligatory oophagy in which mothers feeding tadpoles their own unfertilised eggs (Gibson and Buley 2001, 2004). Much of what we know about mating and parental care in mountain chickens is based upon observations of captive animals.

Male mountain chickens are territorial, with individuals seeking to seize and defend territories through combat. Males stand on their hind legs, each contestant supported by the other's body weight and attempt to wrestle the



Fig. 3. Other amphibian species: cane toad, *Rhinella marina* (top left; photo: G. Garcia/Durrell); Johnston's whistling frog, *Eleutherodactylus jonstonei* (top right; photo: M. Morton/Durrell); *E. amplinympha* (bottom left; photo B Tapley/ZSL) and *E. martinicensis* (bottom right; photo B Tapley/ZSL). The cane toad and Johnston's whistling frog are found on Montserrat; *E. amplinympha* and *E. martinicensis* are found on Dominica.



Fig. 4. Male mountain chicken calling females from a boulder in the wild (photo: S.L. Adams/Durrell)



Fig. 5. Mountain chicken pair in amplexus (in captivity; photo: G. Garcia/Durrell)

other to the ground. Skin secretions seem to stimulate aggression in other males (King *et al.* 2005).

Males attract females by calling from burrows (Gibson and Buley 2001). The call is a distinctive “whooping” increasing in tempo to a “trilling” sound (at 100–120 calls/min) that can be made at day or, more commonly, night. Calling is most intense in March and April, coinciding with the onset of increased humidity in Montserrat. Calls appear to attract a female to enter a male’s burrow where mating occurs, with the male using his forelimbs to grasp the female in front of the forelimbs (a position called inguinal amplexus, see Fig. 5).

Males seem to use their hind legs during mating to stimulate females to produce a foam nest into which her eggs are laid; in captivity, 10-80 froglets have been recorded metamorphosing successfully per nest. The nest is produced at the bottom of the male’s burrow (although nests may also be laid under logs, rocks or in small depressions at the base of plants). A ‘skin’ forms on the surface of the foam after approximately 24 hours, providing protection against desiccation, some potential predators and also possible fungal / bacterial infection. The tadpoles develop in the foam nest and, uniquely, feed only on eggs which their mother deposits in the nest every 1-7 days. The female will also deposit more foam in the nest to prevent the eggs and larvae from becoming desiccated.

The female, and commonly the male, guards the nest, and will actively defend it against intruders (Davis *et al.* 2000). Metamorphosis from tadpoles to froglets occurs within 6-8 weeks after egg deposition. Tadpoles reach up to 150 mm in length, including a long tail, and newly metamorphosed froglets are approximately 30 mm long



Fig. 6. Metamorphosing tadpoles (bottom) and fully metamorphosed frog with mother (top; photos: G. Garcia/Durrell)

and weigh 1-3 g (Fig. 6). It takes 2-7 days for all individuals to metamorphose and leave the nest, after which they receive no more parental care. In captivity, females have only been recorded laying one fertile clutch per year.

2.1.4 Diet and ecological role

Like all frogs mountain chickens are carnivorous, with both sexes and all sizes feeding on almost any animal that they can catch and swallow, including a wide range of insects, millipedes, spiders, tarantulas (Fig. 7; Rosa *et al.* 2012), land snails and slugs as well as vertebrates (tree frogs, anoles and snakes have been reported as food items; Brooks



Fig. 7. Mountain chicken eating a tarantula in the wild in Montserrat (photo: S.L. Adams/Durrell)



Fig. 8. Centipede in Dominica (photo: C. Fenton)

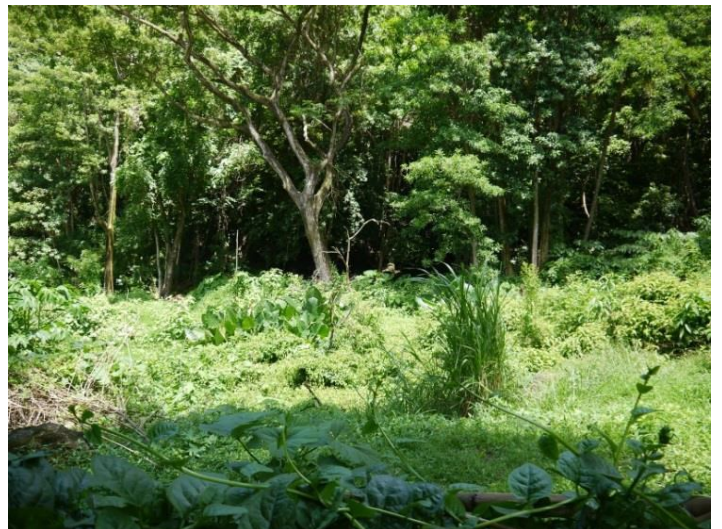


Fig. 9. Typical mountain chicken habitat in Montserrat (left) and Dominica (right): moist ghauts (photos: S.L. Adams/Durrell and M. Hudson/Durrell)

1982; Rosa *et al.* 2012 and also geckos; *G. Garcia pers. comm.*). Cannibalism has never been recorded (except mothers feeding eggs to their tadpoles). The main food item is crickets but millipedes, beetles, and snails are also important in wild populations (Brooks 1982).

Despite being a native apex predator, little is known about the ecological role of the mountain chicken or whether it functions as a keystone species. It is suspected that with such a wide diet and voracious appetite (the mountain chicken has been recorded to eat up to 100 crickets per week in captivity; *M. Goetz pers. comm.*) there is some impact on ecological system function. Following the large decline in mountain chicken numbers, the effects of the reduction in pressure on local invertebrates are being seen in Dominica, with reported cases of an increase in centipedes, millipedes and crickets (Fig. 8, C. Fenton and

M. Sulton pers. comm.). The decline of the mountain chicken population in Montserrat was followed by a reported increase in sightings of the invasive cane toad (*Rhinella marina*) (C. Fenton and L. Martin *pers. comm.*). It is speculated this is due to a reduction in competition for food and is predicted to result in increased negative impacts on native species.

2.1.5 Habitat requirements and resource assessment

In Montserrat, mountain chickens have been recorded at a full range of elevations, from near sea level to as high as the once forested peaks of the Soufrière Hills at 1,000 m above sea level (ASL) (*G. Gray and L. Martin pers. comm.*; Daltry 1999). On Dominica they are believed to be restricted (both before and after the arrival of the *Bd* fungus) to areas below about 330 m ASL (*A. James pers.*



Fig. 10. Mountain chickens during the dry season, sitting together on the edge of a pond (left) and a live mountain chicken sat next to a dead one (right) (photos: S.L. Adams/Durrell)

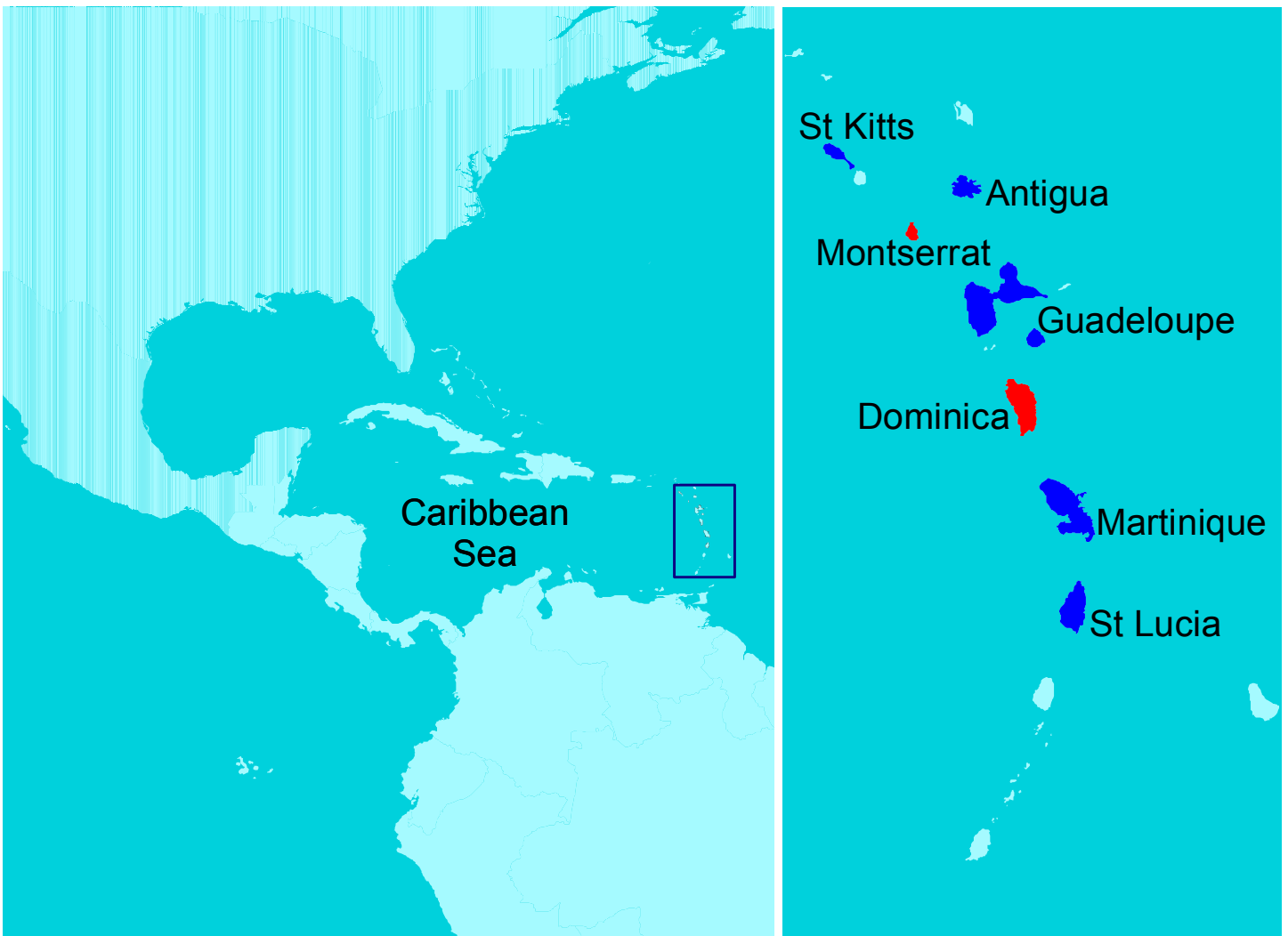


Fig. 11. The current (red) and historic (dark blue) distribution of the mountain chicken

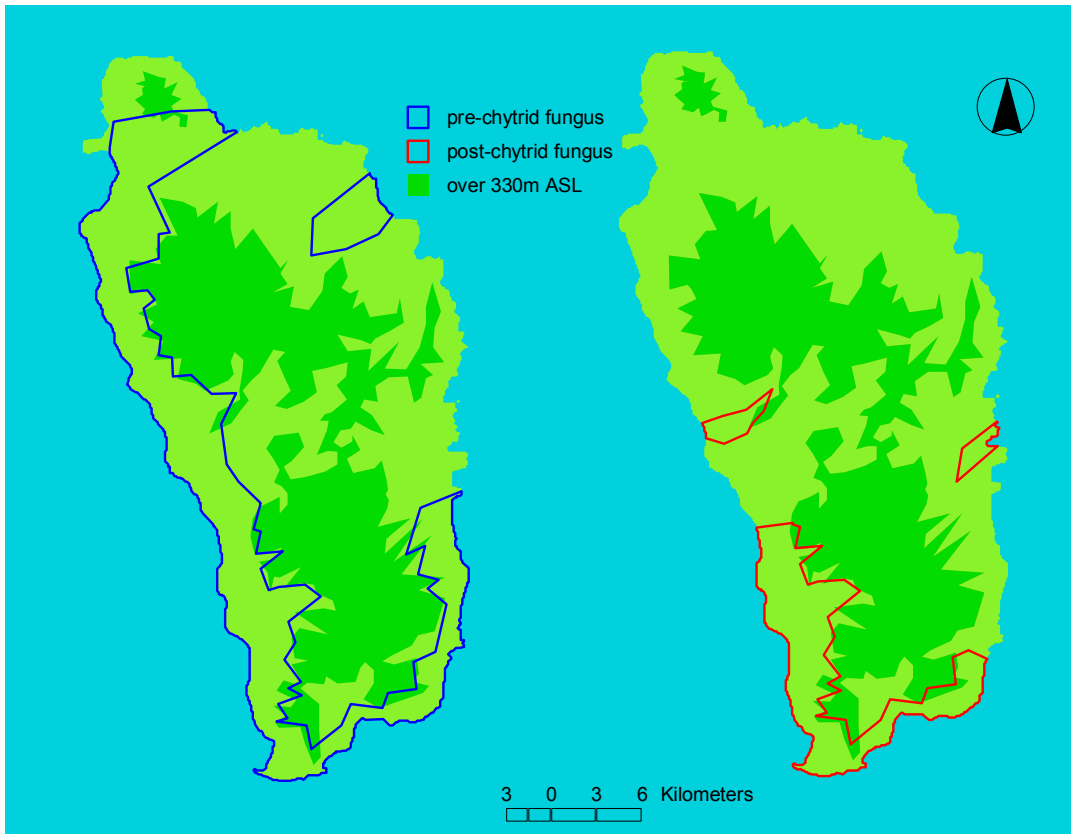


Fig. 12. The approximate known distribution of the mountain chicken in Dominica before and after the arrival of the *Bd* fungus on the island (McIntyre 2003 and A James *pers. comm.*).

comm.; McIntyre 2003, see Fig. 12), occurring down to almost sea level. It is not clear why this difference in altitudinal preference occurs. Mountain chickens in Montserrat tend to be found in forests, in contrast to Dominica where as well as being associated with lower elevation mesic and wet forest below about 330 m ASL, are also found in gardens and plantations (Fig. 9). This difference between the two islands has persisted after the introduction of *Bd*. They do not occur in arid habitats where natural vegetation is dominated by scrub and cactus, presumably because they would easily desiccate.

A study in Montserrat in 1995 (Daltry 1999) provided information on finer scale habitat associations of mountain chickens on Montserrat. Within mesic and wet forests, mountain chickens are associated with areas with permanent water and good canopy cover and appear to avoid areas of thick undergrowth. However, the latter two habitat variables are often correlated as closed canopy retards the growth of understory vegetation. Forest with closed canopy may generate deeper leaf litter and maintain humidity, which likely promotes high invertebrate prey abundance. The optimal habitat for mountain chickens therefore is likely to be undisturbed, mature forest with permanent watercourses. During the dry season, DOE staff has only found mountain chickens close to streams in ghauts, however, the frogs are more widely distributed

during the wet season.

During experimental releases of captive bred mountain chickens conducted between 2011 and 2013, frogs which were tracked showed that during dry periods, mountain chickens accumulated around available water sources such as ponds. In these ponds multiple frogs, (including cane toads which are carriers of *Bd*) were often recorded in close proximity and sitting in the same water. This tendency for mountain chickens to congregate in water during dry periods could increase the risk of transmission of *Bd* from infected to healthy frogs and could amplify the prevalence of *Bd* turning these ponds into 'hot spot' areas of infection (Fig. 10). It is hypothesised that during periods of heavy rainfall and/or elevated levels of water in the ghaut, mountain chickens disperse more widely up the banks of the ghauts and spread out increasing the distance between them and neighbouring mountain chickens and cane toads (M. Hudson *pers. comm.*). If this hypothesis is confirmed following analysis of wet season movement data, it could lead to management strategies based on releasing captive bred frogs in the wet season to reduce the risk of transmission of the *Bd* fungus and therefore increase survival rates, though further investigation would be needed.

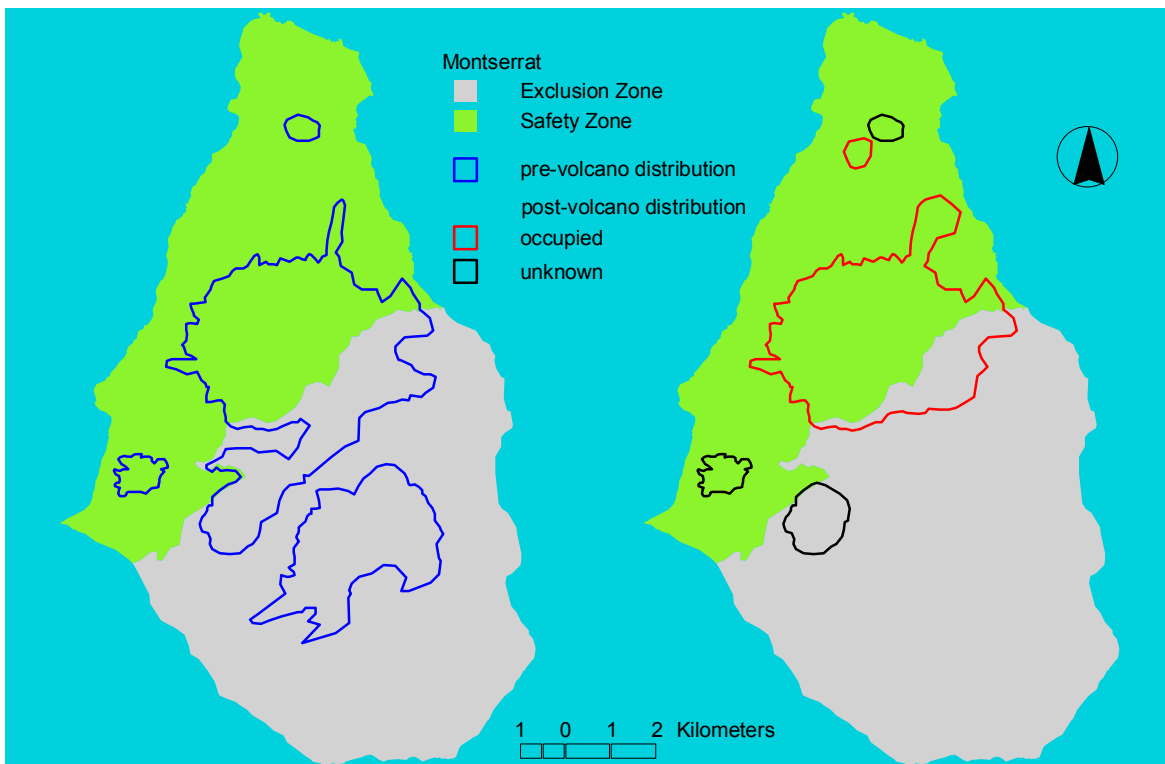


Fig. 13. The approximate known distribution of the mountain chicken in Montserrat before and after the volcanic emergency; based on information from DOE field staff.

2.2 Distribution, abundance and population trends

2.2.1 Historic and current distribution

The mountain chicken is now confined to just Dominica and Montserrat after once also occurring on Guadeloupe, Martinique, Saint Kitts and Nevis, and possibly on St Lucia and Antigua (Fig. 11). It had disappeared from Martinique by the 19th century (writings of the Anonymous of Carpentras 1618-1620; Bouton 1640; du Tertre, 1654, 1667; de Labbat 1722, 1724; de Leblond 1813; Plee 1820 BMNH MS.71.II), and from Guadeloupe (Heyer 1979; Schawrtz and Henderson 1991 and Crombie 1993), St. Kitts (Lescure 1979) and St. Lucia (Lescure 2000) in the early 20th century probably as a result of the combination of deforestation, introduced predators and competitors, habitat disturbance, and hunting for human consumption (Kaiser 1994; Lescure and Letellier 1983; Brueil 2009). Of these seven islands, only Montserrat and Dominica never had the small Indian mongoose (*Herpestes javanicus*) introduced to them, suggesting it was likely the primary driver of mountain chicken extinction on the other islands (Hays and Connant 2007).

In Dominica, the mountain chicken was, until recently,

widely distributed in low elevation natural and semi-natural habitats along the western coast of the island, with a number of small isolated populations introduced to the east coast (see Fig. 12). In the early 2000's, *Bd* arrived in Dominica, causing extremely high mortality in mountain chickens through the disease chytridiomycosis and driving a rapid and severe population decline (McIntyre 2003; Magin 2004). By 2007, the species was restricted to small pockets predominantly on the west coast, representing a decline in area occupied of over 60%, although the percentage decline in mountain chicken numbers is believed to be higher still (M. Morton *pers. comm.*).

Prior to the arrival of *Bd* to Montserrat, the range of the mountain chicken on the island had also contracted, due to the destruction of forest habitat during the volcanic eruptions of the Soufrière Hills volcano which have been occurring since 1995. The species was once found in the Centre Hills, Soufrière Hills, St Georges Hill, Molyneaux and on Garibaldi Hill (Daltry 1998; see Fig. 13). Pyroclastic flows and ash fall have almost certainly destroyed the Soufrière Hills and Garibaldi Hill populations, along with those in the Silver Hills and St Georges due to ash fall (G. Gray *pers. comm.*). It seems probable that by the time *Bd* did arrive in Montserrat the species was almost entirely restricted to around 1500 ha of forest in the Centre Hills.

Since the arrival of *Bd* in Montserrat, in late 2008 or early

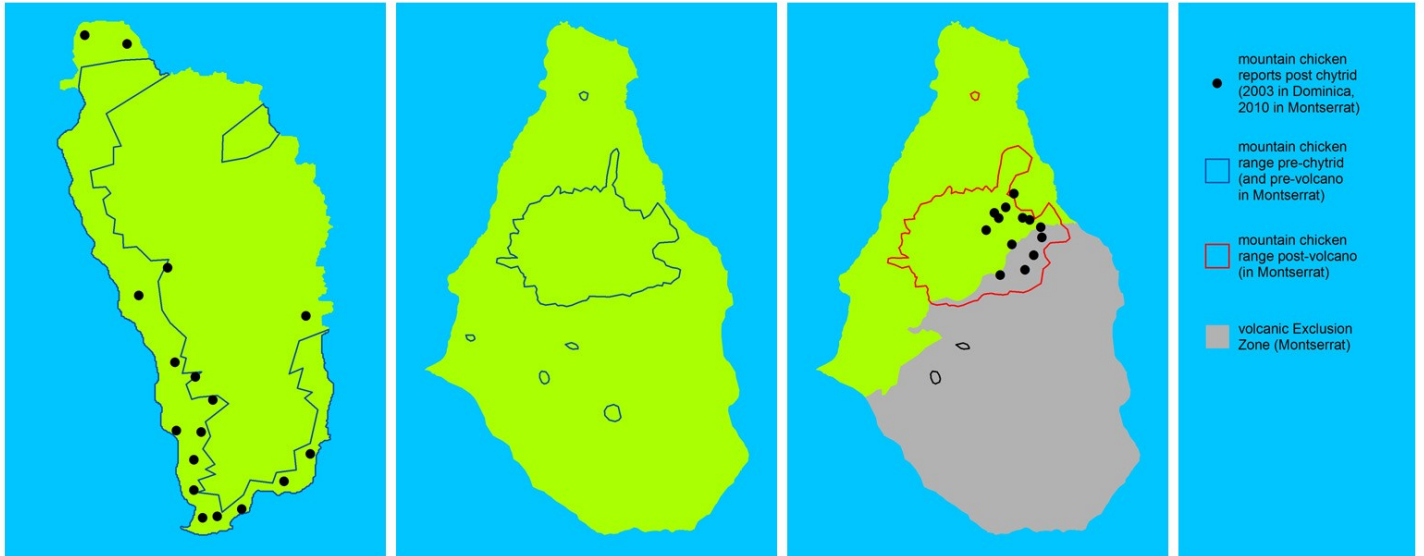


Fig. 14. Reported sightings of mountain chickens on Dominica and Montserrat since the arrival of *Bd*. Left: reported sightings (black dots) collected by McIntyre (2003) from Dominica, with the approximate pre-*Bd* range outlined in blue (A. James *pers. comm.*). Centre: the pre-*Bd* and pre-volcano distribution of mountain chickens on Montserrat. Right: reported sightings (black dots) of mountain chickens on Montserrat one year after the arrival of *Bd*, with the post-volcano range outlined in red.



Fig. 15. Swabbing a surviving mountain chicken to sample for presence of the *Bd* fungus (photo: R. Adams/Durrell)

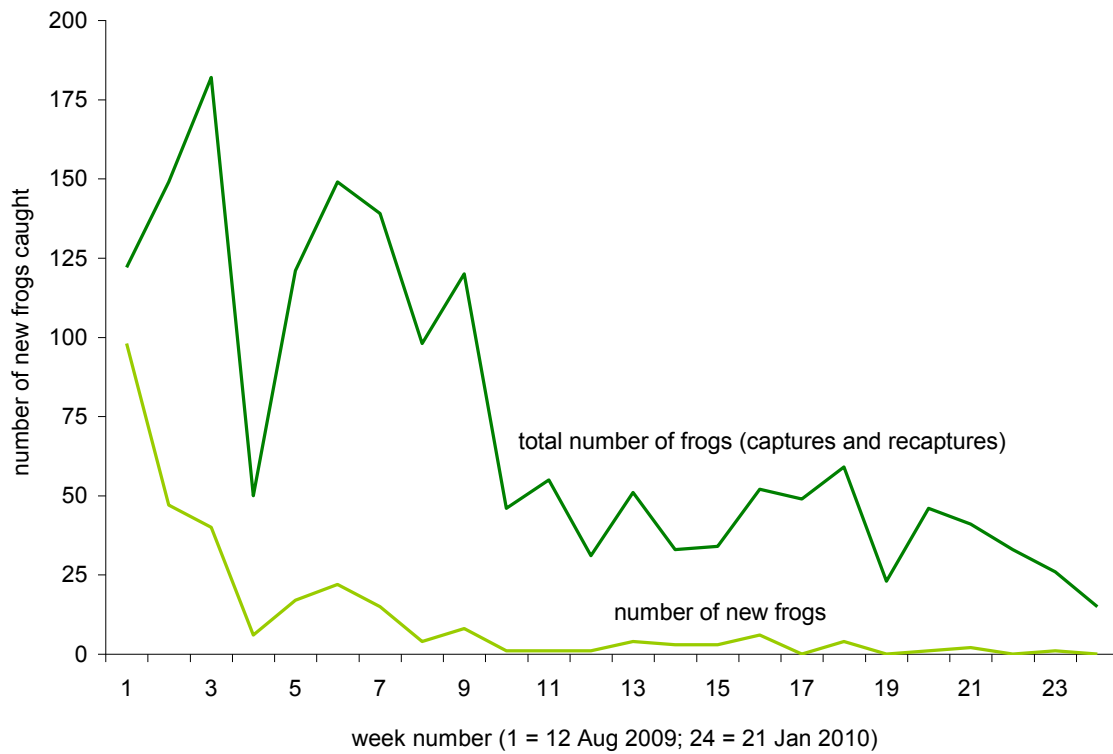


Fig. 16. Decline in mountain chicken numbers at Fairy Walk, Montserrat (one of the last mountain chicken sites *Bd* reached) during a 6-month period of intensive searching, August 2009 – January 2010. (Anomalous low result week 4 was due to missed surveys caused by a tropical storm)

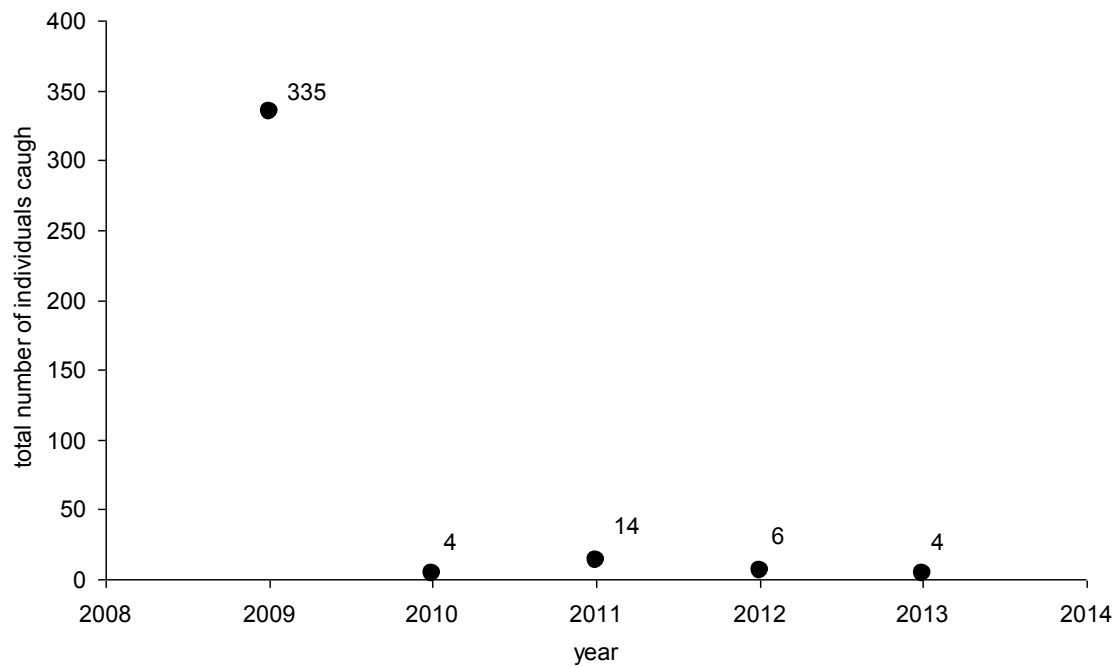


Fig. 17. Numbers of individual frogs caught on the eastern slopes of Montserrat's Centre Hills from 2009 (first detection of *Bd*) to 2013. Note; the data are not comparable with the standardized estimates of relative abundance shown in Fig. 19 and are the results of much more intensive search efforts



Fig. 18. Marking out a transect (left) by day; recording mountain chicken measurements (right) from a night time capture on a transect (photos: G. Garcia/Durrell and C. Fenton)

2009 (Garcia *et al.* 2009), the range of the mountain chicken has contracted much further. Approximately one year after the arrival of *Bd*, scattered individuals were being reported only from the eastern side of the Centre Hills (C. Fenton *pers. comm.*; P. Murrain *pers. comm.*); three years later (2013) even fewer detections (sights and/or calls) were made, despite exhaustive survey efforts between 2010 and 2013 (see Fig. 14). In Dominica reports of further detections were made in 2012 and 2013 and were confirmed during surveys which were conducted in the same years (Fig. 14).

2.2.2 Abundance and population trends in Montserrat

No historical or current estimates of population size exist for the mountain chicken in Montserrat. The ongoing monitoring programme run by the Department of Environment (DOE) is designed to generate indices of abundance as a surrogate of population size and trend rather than produce absolute abundance estimates (Daltry and Gray 1999; Young 2007). However, in 2005, a number of repeat surveys of three monitoring sites were carried out to estimate the size of these local populations using an analytical technique known as mark-recapture. At that time (prior to the arrival of *Bd*), in the highest density site, Fairy Walk, 252 ± 75.7 (s.e.) frogs were estimated to occur along a 200 m stretch of ghaut. In Sweetwater Ghaut and Cat Ghaut, 39 ± 6.2 (s.e.) and 7.5 ± 3.0 (s.e.) frogs respectively were estimated along 200 m stretches. It is not possible to extrapolate these estimates to

the wider population, but they did show that mountain chicken density within the Centre Hills varied widely between sites. The reason for such variation is unclear, but likely factors were habitat quality and the effects of hunting and possibly of invasive vertebrates.

Since the first detection of *Bd* on Montserrat in 2009, the local population has experienced catastrophic decline (Fig. 16). With the exception of three individuals found at Killikrankie in 2011, no mountain chickens have been detected at any of the annual population monitoring transects outside of those on the eastern slopes of the Centre Hills. Intensive searches in ghaunts here have found only very low numbers of mountain chickens after 2009 (Figs. 16 and 17).

By counting frogs along 15-20 transects situated along a number of ghaunts in the Centre Hills, the monitoring programme in Montserrat enables an analysis of trends in the mountain chicken population between 1999 and 2005 (Young 2007).

The dry season monitoring data between 1999 and 2005 suggests little overall change in mountain chicken numbers during this period despite considerable fluctuation in the encounter rate index (see Fig. 19). Post-*Bd* in 2009, however, the population crashed very rapidly (Fig. 19). The drop in frog numbers in the years preceding this (2006-2007) can be explained by two possible factors (S. Mendes *pers. comm.*):

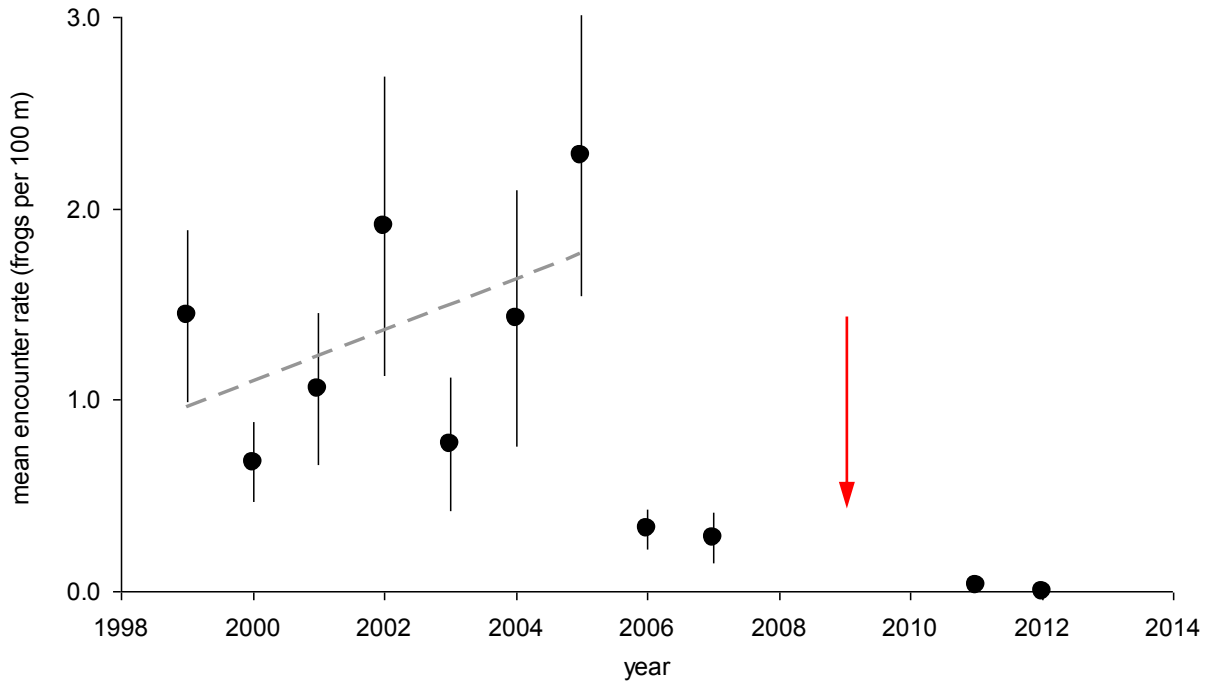


Fig. 19. Changes over time (1999-2013) in the relative abundance of mountain chickens in Montserrat. Red arrow shows first detection of *Bd*.

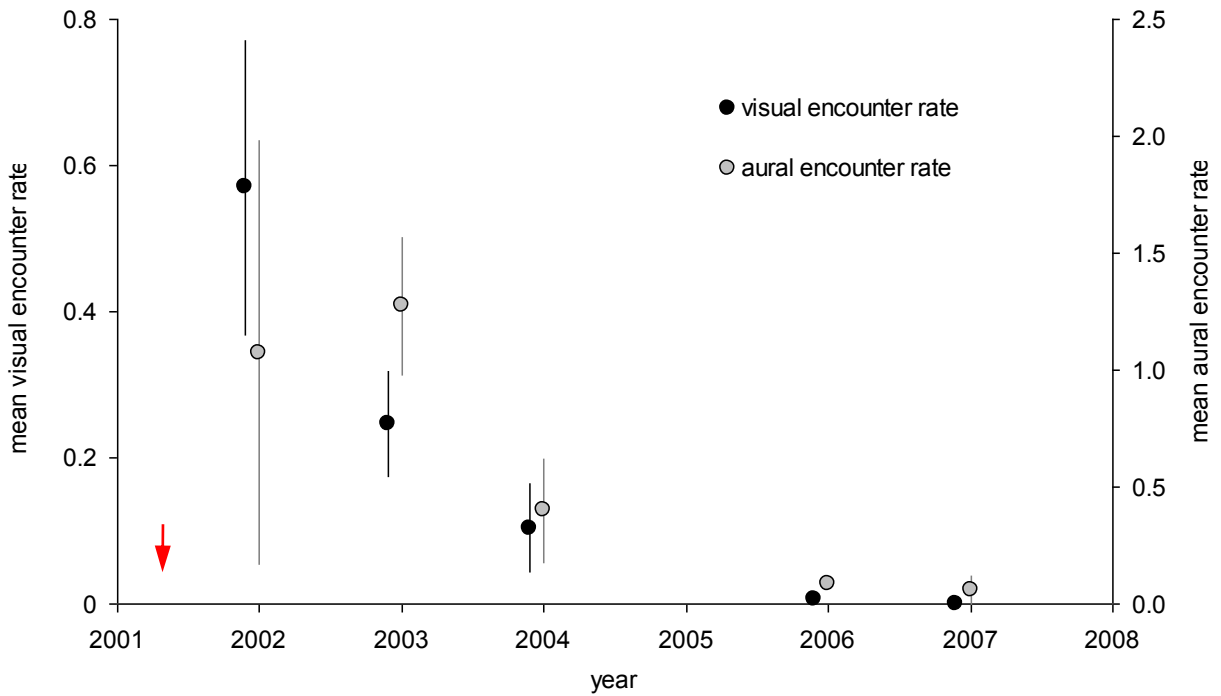


Fig. 20. Changes over time (2002-2007) in the relative abundance of mountain chickens in Dominica. Red arrow shows first detection of *Bd*. Mean aural encounter rates (number of frogs heard per 100 m of transect) and mean visual encounter rates (frogs seen per 100 m of transect) of mountain chickens

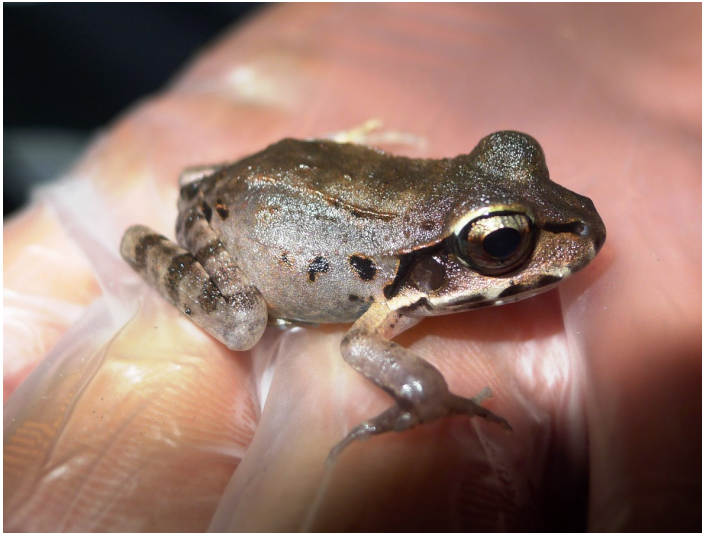


Fig. 21. Juvenile mountain chicken found in Dominica during surveys in 2012, ten years after the presence of *Bd* was first reported (photo: Jenny Spencer)

1. Though there was continuous data collection, there was no input or analysis of the data during that time period. Forest staff accounts do not confirm the drastic drops as highlighted in the data.
2. A series of eruptions and heightened volcanic activity limited access to some of the transect sites, resulting in incomplete data sets and therefore less frogs than in previous years.

2.2.3 Abundance and population trends in Dominica

In Dominica, monitoring of relative abundance started in 2002. It was during these initial surveys that the presence of *Bd* was first confirmed from specimens collected from one of the transects (McIntyre 2003).

By 2007, detections were very low and annual surveys were suspended over concerns of spreading *Bd*. Following the implementation of biosecurity measures for field workers, searches were made to follow-up reports of mountain chicken detections at sites not known to be occupied by mountain chickens since 2007 and small clusters and scattered individuals were found (Fig. 20). By 2008 it was reported that no mountain chickens were being seen or heard at survey transects but that the occasional one could be heard calling (outside of surveys) during the breeding season, suggesting the population on Dominica was not extinct (Cunningham *et al.* 2008). Regular survey efforts were not conducted in Dominica from 2008 to 2012.

In 2011, successful preliminary searches, using strengthened field biosecurity protocols, located additional small clusters and scattered individuals of



Fig. 22. Chytridiomycosis casualties: dead mountain chickens in Montserrat's Centre Hills 2009 (photo G. Garcia/Durrell)

mountain chickens including recently metamorphosed individuals and juveniles. Further fieldwork was conducted in July 2012 when 16 transects were surveyed over ten nights of fieldwork which included nine of the old transects. A total of 22 mountain chickens were recorded, and 13 were caught and swabbed for presence of *Bd* (Spencer 2012). Two juveniles were also caught which was the first signs of breeding seen in Dominica in nine years (Fig. 21). These results could suggest nascent recovery of the mountain chicken population in Dominica, or at least some level of coexistence with the *Bd* (M. Hudson *pers. comm.*).

2.3 Threats, potential threats and limiting factors

2.3.1 Chytridiomycosis caused by the *Bd* fungus

Amphibians are in crisis around the world (Gascon *et al.* 2007). Since the 1970's, amphibian populations have undergone precipitous declines, sometimes leading to the complete extinction of amphibian species. Most worryingly, many of these declines and extinctions have occurred in protected areas. The extent of these declines and extinctions is without precedent in any class of animals over the last few millennia, and it has been the focus of much scientific research. At least 43 % of all known amphibian species are declining and nearly one-third (32 %), i.e. about 2,000 species, are now threatened with extinction. Over 120 species may have gone extinct since 1980 (Daszak *et al.* 2003).

Whilst habitat loss and degradation continues to be a serious problem for amphibians, the emergence of the

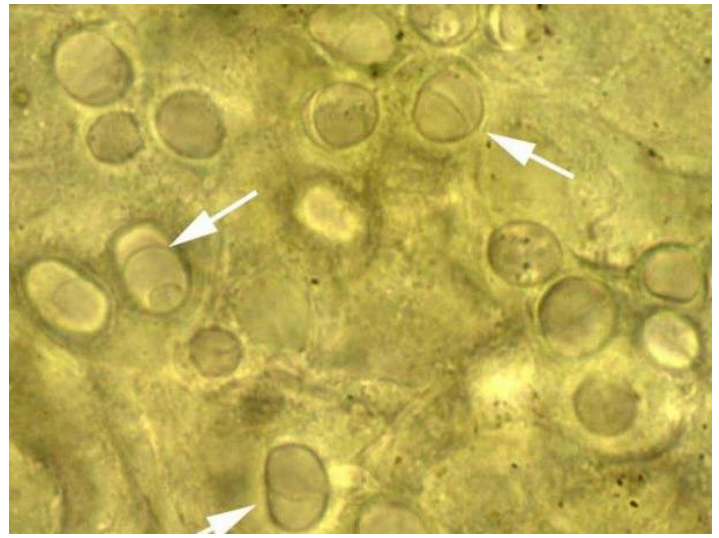
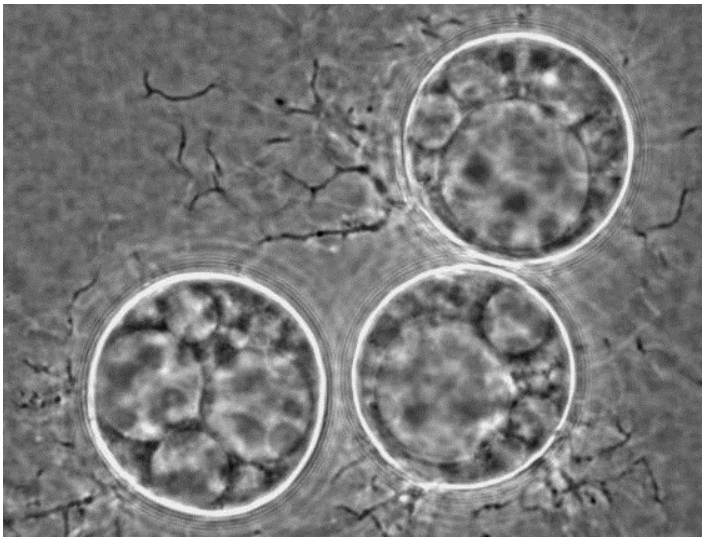


Fig. 23. *Bd* fungus (*Batrachochytrium dendrobatidis*): spores (left) and infected skin cells of the green frog, *Rana clamitans* (right, 100X magnification). (Photos: J.E. Longcore, University of Maine)



Fig. 24. Healthy mountain chicken (left); mountain chicken displaying clinical signs of chytridiomycosis (right) (photos: S.L. Adams/Durrell)

amphibian disease, chytridiomycosis has had a great impact on amphibian species over a short period of time (Berger *et al.* 1998). Chytridiomycosis is caused by *Bd* an aquatic chytrid fungus which is not host specific and is known to infect all extant classes of amphibia (Gower *et al.* 2013). Amphibian chytridiomycosis was first discovered in 1998, when it was found to be the main cause of amphibian declines in the rain forests of Australia and Central America (Berger *et al.* 1998). Since then, this disease has been associated with amphibian declines and extinctions in many countries. Indeed, it has been found to be an emerging threat to > 300 species (of frog, toad, newt and salamander) representing at least 14 amphibian families across six continents (see Daszak *et al.* 2007 for a review).

In Dominica, *Bd* first emerged in 2002 when large numbers of reports of dead and dying mountain chicken frogs were received by the Forestry and Wildlife Division (McIntyre 2003). The disease quickly spread across the island and the mountain chicken population declined by approximately 80 % within two years of the first confirmed cases (Cunningham *et al.* 2008). The mountain chicken population in Dominica is now relatively small and there is ongoing fieldwork to determine the state of the population. A captive breeding programme was developed with an international aspect in order to help safeguard the future of the Dominican mountain chicken though is now largely redundant having just a single male left (B. Tapley *pers. comm.*). As this emerged a 2003 survey was conducted in Montserrat to investigate the presence



Fig. 25. Habitat loss through volcanic activity (photo G. Garcia/Durrell)



Fig. 26. Fairy Walk ghaut (left), a stronghold for mountain chickens, and an equipment box (right) covered in ash after 2010 dome collapse (photo: S.L. Adams/Durrell)

of chytridiomycosis and ranavirus in the islands amphibian fauna, which returned negative results (Garcia *et al.* 2007).

Despite the actions outlined in the 2007 mountain chicken Species Action Plan which identified the need for strict island wide biosecurity protocols and a chytrid screening programme, the first reports of the arrival of the *Bd* fungus to Montserrat were made by the Montserrat DOE to Durrell Wildlife Conservation Trust (Durrell) in February 2009. Forest rangers and a local hunter observed unusual behaviour when frogs were sighted during the day and were congregating in large numbers around water sources in Cedar ghaut. They also reported dead and sick looking frogs and described clinical signs of chytridiomycosis (Fig. 22). In March 2009 the presence of the *Bd* fungus was confirmed at multiple sites in Montserrat with losses

expected (Garcia *et al.* 2009), and subsequently confirmed, to be similar to those seen in Dominica in 2002.

The fungus has been also found in swabs from eleutherodactylid frogs in both Dominica and Montserrat and since they have been found to be apparently-healthy, it is therefore possible that they are relatively resistant to the disease and might act as reservoir hosts and potential disease vectors. Carrier (vector) amphibians appear to be the main way that the disease is spread from one country, or area, to another. In the Caribbean region, for example, eleutherodactylid frogs are frequently transported internationally within bananas and other produce. As much of Montserrat's fresh produce is imported from a known *Bd*-positive country (Dominica), this route of transmission is thought to be the most likely

way the fungus could have arrived into Montserrat, though there are many other possible routes.

The function of amphibian skin in regulating the exchange of respiratory gases, water, and electrolytes makes them particularly susceptible to skin infections and diseases. The skin disease, chytridiomycosis, is caused by the highly virulent fungal pathogen *Bd* and has been implicated in the decline and extinction of amphibian species worldwide. In infected amphibians zoospores can be found living in the keratinized tissues of the outer layer of skin and in the mouthparts of tadpoles. Changes to the skin associated with the presence of *Bd* are thought to disrupt physiological functioning of the skin resulting in electrolyte depletion and osmotic imbalance sufficient to cause mortality (Voyles *et al.* 2007). Some species are very susceptible to infection and are rapidly killed, whilst others are more resistant. These resistant species can act as carriers of the infection, acting as reservoirs to maintain it within a region and as vectors transmitting it to new areas. Although several species have been found that are resistant to the disease, many of these are killed by the infection under certain environmental (*e.g.* extreme weather) conditions.

Like many amphibians infected with chytridiomycosis, mountain chickens can display several clinical signs including muscle tremors, excess sloughing of the skin, lethargy and redness on the ventral side of the belly and legs (see Fig. 24) as well as behavioural changes. In order to diagnose and investigate levels of *Bd* infection the technique of real-time quantitative polymerase chain reaction (qPCR) was developed by Boyle *et al.* (2004). This technique uses dry swabs taken from the skin and can diagnose the presence of *Bd* and also quantify the level of infection. The development of this technique was important as it addressed the rapid increase of demand for a non-invasive method for diagnosing the disease and meant toe-clip samples are no longer necessary and large sample sizes can be analysed relatively quickly (Boyle *et al.* 2004).

2.3.2 Volcanic activity on Montserrat

The Soufrière Hills Volcano, located in the south of the island, began its first historic eruption for 350 years on 18th of July 1995 with a series of steam and gas explosions. Lava extrusion later commenced in November 1995. Following a series of short-term evacuations, a state of emergency was declared in April 1996. The capital Plymouth was abandoned along with all other communities located in the southern two-thirds of the island. In June 1997, a small dome collapse generated widespread pyroclastic flows to the north of the dome that killed 19 people in the village of Streattham. Pyroclastic flows from the same event also reached the W.H. Bramble airport to the NE of the dome,



Fig. 27. Frogs' legs prepared as a dish (this species is *Ptychadena mascareniensis* from Madagascar, a frog similar in size to the mountain chicken) (photo: G. Garcia/Durrell)

resulting in its permanent closure (Kokelaar 2002).

Between 1995 and 2010 there were five phases of volcanic activity lasting up to 3 years separated by periods of little or no activity of up to 2 years. Activity during these phases has included the repeated growth and collapse of a lava dome and associated pyroclastic flows, more than 100 large volcanic explosions and frequent ash falls, some of which affected areas in the Centre Hills and the north of the island. The last activity occurred in February 2010, ten months after *Bd* was first discovered on Montserrat, when a major dome collapse impacted 11 km² to the north and northeast of the volcano, including the Farm River Valley and Fairy Walk in the Centre Hills (Fig. 26). Pyroclastic flow deposits also added 1 km² of new land to the coastline between Trant's Bay and Spanish Point (Cole *et al.* 2010; Stinton *et al.* 2014a,b).

Since the collapse in 2010, there has been no evidence of further dome growth and volcanic activity appears to remain at a minimal level. However, an assessment issued in 2012 by the UK Scientific Advisory Committee on Montserrat Volcanic Activity (SAC 2012), indicated that the balance of probability is that the volcanic activity is paused, as it has done on previous occasions since the start of the crisis, rather than ceased and that the continuing venting of gases indicates a high probability that there will be renewed lava extrusion in the medium future. At present, nearly 60 % of Montserrat's land area is within the exclusion zone.

There is little data on habitat loss or habitat regeneration of the areas affected by the volcano since 1995. There was substantial defoliation after major ash falls, but this was followed by a rapid recovery (within weeks to a few



Fig. 28. Brown rat (left) feeding on fallen fruit in the Centre hills; black rat trapped as part of Centre Hills project control efforts to protect native forest species (photos: G. Garcia/Durrell)

months), and there was also some acid rain and ash damage during periods of chronic ash fall (C. Fenton *pers. comm.*).

Research indicates large but ephemeral effects of ash fall on canopy insects, with some suggestion that ground-dwelling insects were more seriously impacted (Marske *et al.* 2006) but recovery again appeared to be rapid. There were presumably consequent knock-on effects on vertebrate consumers, although Dalsgaard *et al.* (2006) showed that most bird populations in the Centre Hills were not strongly impacted overall.

It seems highly likely that the complete loss of habitat in the south of Montserrat resulted in the loss of mountain chickens in these areas and this led IUCN to infer a severe population decline as a result in their red listing of the species in the assessment of 2004. Data on the impacts of more ephemeral volcanic events (ash falls) do not exist. There are several anecdotal reports of mountain chickens found covered in ash, or in water acidified by ash, and, to outward appearances, healthy; but follow-up data on the fates of these individuals does not exist along with the effect of the ash on the presence of the chytrid fungus.

2.3.3. Unsustainable hunting

Unsustainable hunting had been identified as one of the most important threats to the survival of the mountain chicken, both on Dominica and Montserrat before the arrival of *Bd*. Mountain chickens were hunted for both domestic consumption as a traditional dish and also sold to restaurants where they are offered to tourists. Under the Forestry, Wildlife, National Parks and Protected Areas Ordinance, mountain chickens are listed as a partially protected wildlife, for which it is possible to have a closed

and open season. However, as was the case prior to the volcanic emergency, there are no enacted regulations in Montserrat on the hunting of the mountain chicken, for example there is no open and closed hunting season or licensing system. CEMA legislation in Montserrat which will give full protection to the mountain chickens has been submitted but is yet to be passed.

Prior to the volcanic emergency, it is believed that roughly 60-70 hunters in Montserrat were hunting regularly and about 15-20 restaurants and hotels were serving mountain chicken dishes. However, significantly more of Montserrat was at that time available to hunt in and local knowledge and data that have been collected since 1997 (see section 2.2.1), indicate that, since the emergency, in areas where hunters have easy access, the population of mountain chickens has declined, clearly suggesting the hunting in these areas is unsustainable. Since the arrival of the *Bd* fungus on Montserrat, the population of mountain chickens has declined to such drastically low numbers that hunting frogs is now an unreliable income source and no evidence of recent hunting activity has been reported.

Dominica provides an example of regulating the impacts of hunting on mountain chickens. Dominicans had traditionally hunted mountain chickens with no restrictions or regulations until the mid-1970s when the Forestry and Wildlife Act was enacted in July 1976. In the earlier days, most of the frogs hunted were for domestic consumption, as the frog is considered a delicacy and promoted as the island's national dish. However, over the years, with promotion and the development of eco-tourism, the demand for the frog by hotels and restaurants grew significantly, to the point where a local supermarket even sold local frogs' legs sometime in the late 1990's. In 1998, a survey of hunters and freshwater fishermen was



Fig. 29. Rat inflicted injuries on mountain chicken in Montserrat (left; photo: G. Garcia/Durrell) and pig damage to *Heliconia* species in the Centre Hills (right; photo L. Martin/DOE)

undertaken by the Forestry and Wildlife Division. The survey results identified the mountain chicken as one of the three most hunted game species on the island (McIntyre 2003).

The Dominican Forestry and Wildlife Act provides for the issuing of licences to hunt game wildlife (including mountain chicken) and the setting of open and close seasons for the taking of game wildlife. These measures – among others – first came into force in 1976. From this date until 1999, hunting of game was permitted for six months in any one year, from the first day of September of one year through the last day of February of the following year. The Act in its current form does not provide for the setting of bag limits or catch quotas, nor does it provide for regulating the sale of wild meat. New amendments to the legislation, expected to be enacted soon, are felt needed to address such issues.

Although the *Bd* fungus is believed to be the primary cause of the catastrophic decline in mountain chicken numbers on Dominica (Fa *et al.* 2013), it also rendered the frogs more lethargic and easier to catch and hunting was feared to be compounding the decline. From 1 January 1999, the Government of Dominica had imposed a total ban on the hunting of the mountain chicken and all other forms of wildlife on the island. However, as of 2000, this ban was temporarily lifted annually but for only two to three months of the year. But due to concerns for the mountain chicken population as a result of the outbreak of the chytridiomycosis disease among the frog's population in 2002/2003, the Government enacted Regulations to impose an indefinite ban on the hunting of the mountain chicken as of April 2004.

The enforcement of the provisions of the Forestry and Wildlife Act is carried out mainly by the Director and

officers of the Forestry, Wildlife & Parks Division, although Police Officers have similar enforcement powers under the Act. While regular forest offences may be “compounded” or dealt with by the Director of Forestry and Wildlife without the matter going to court, all wildlife cases, including those pertaining to the mountain chicken, must be dealt with in the Magistrate’s Court. In the period 1997-2004 12 wildlife cases went through the courts, though none relating specifically to mountain chickens. In 2013 there were two unofficial reports of continued illegal hunting however no evidence of this was ever received by the Forestry, Wildlife & Parks Division (A. Blackman and M. Sulton *pers. comm.*).

2.3.4. Invasive species

Several species of invasive alien mammal occur in Montserrat and Dominica, including rats (two species), domestic cats, dogs, pigs, goats, cows and donkeys. Both islands have been fortunate enough to escape having small Indian mongooses (*Herpestes javanicus*) introduced, unlike many islands in the Caribbean. Rats are among the most damaging invasive species and the multiple impacts of rats on island ecosystems have been described in many publications (Atkinson 1985; Atkinson and Atkinson 2000; Towns, Atkinson and Daugherty 2006; Global Invasive Species Database 2007). As abundant, opportunist omnivores, they predate many native invertebrates and smaller vertebrates, and have driven declines and extinctions of numerous species through processes such as competition, predation and modifying habitats. They are thought to have played a dominant role in the declines and extinctions of numerous New Zealand amphibian species (Towns and Daugherty 1994). Impacts are generally thought to be greatest on nocturnal amphibian species (Global Invasive Species Database 2007), although it is also believed that species on tropical islands

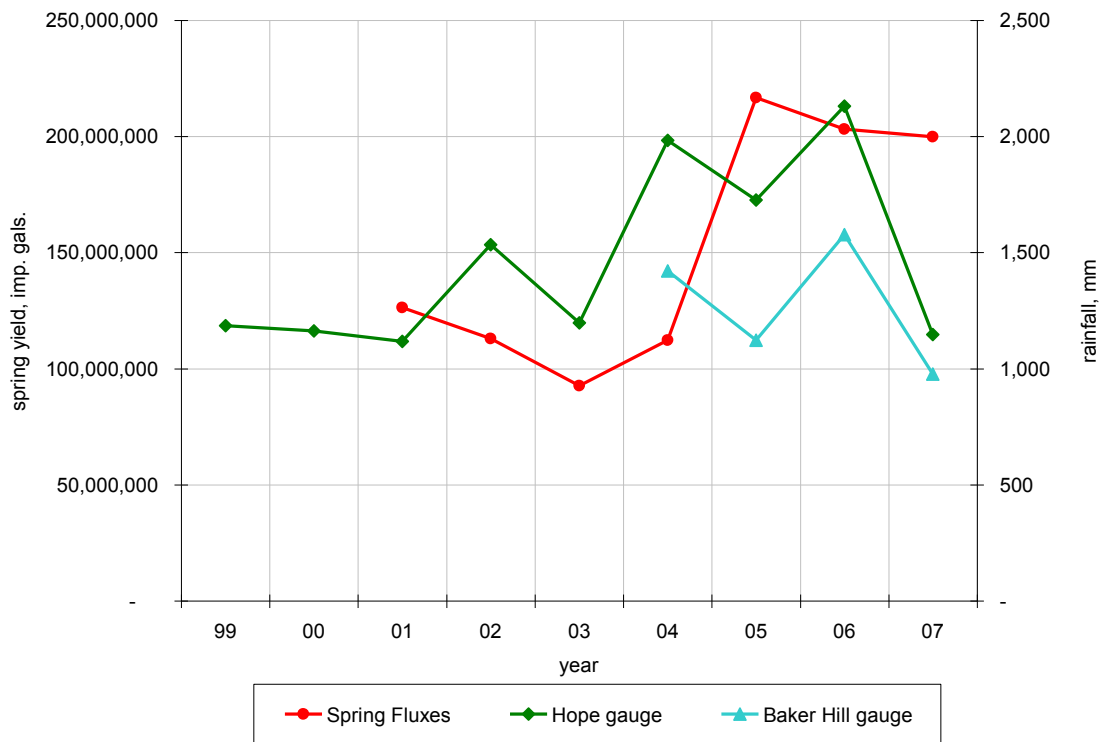


Fig. 30. Total Combined Spring Yield (red line; left axis) and Total Rainfall (blue and green lines; right axis) over the period 1999-2007 (from W. Tonge, MWA, 2007).

on which land crabs are native tend to suffer fewer impacts, because land crabs are ecologically rather similar predators (Atkinson 1985).

European boats brought brown rats (*Rattus norvegicus*) and black rats (*Rattus rattus*) to Montserrat and Dominica. Black rats reached the Caribbean as early as the beginning of the seventeenth century, with brown rats perhaps two centuries later (Varnham 2007). Both species of rats are currently very abundant in Montserrat's Centre Hills forests. Snap-trapping data indicates that, in the forest, black rats are somewhat more abundant than brown rats, although both are present throughout. In general in the Centre Hills, black rats are more abundant at higher altitudes, and are more arboreal, than brown rats. Both species' population levels at this site appear to be linked to the local abundance of large fruit trees and clearings (Young 2007). Rats, probably mainly brown rats, are also abundant in the settled lowland areas of Montserrat and Dominica. Captures of mountain chickens in Montserrat during the dry season 2005 showed a high percentage (5-27 % depending on capture sites) of frogs with old and, more commonly, fresh rat bites. Most of the bites were observed on the hind limbs (Fig. 29).

Since the late nineties, feral pigs (*Sus scrofa*) have spread rapidly through Montserrat's Centre Hills forest following the release of domestic pigs from farms evacuated in the

wake of the volcanic crisis. The main source of invasion is thought to have been from the Harris area to the south-east of the Centre Hills (J. Daley *pers. comm.*), and consequently the invasion has spread progressively from the south-east of the hills. Pigs were first noted as a substantial presence in the Centre Hills forests during 2001 (Buley 2001) and there is no evidence of a feral pig population in Montserrat prior to the volcanic crisis. In the following years they spread rapidly through most of the forest, but substantial control efforts by local forest rangers in 2004 and through a project led by the RSPB from 2009 to 2013, the population of feral pigs in the Centre Hills has been greatly reduced. In Dominica the presence of feral pigs in the forest has been identified as one of the biggest threats to farmers land, crops and private gardens, and as a result the Government declared it a pest in 1982 allowing it to be hunted without license.

Pigs can have a major impact as invasive species on some island tropical forests. Like rats, they are opportunistic omnivores, and can cause declines and extinctions in terrestrial animals that they prey on (Cruz *et al.* 2005 and references therein; Global Invasive Species Database 2007). However, there is little specific scientific information regarding their effects on amphibians. In some island forests, especially Hawaii, feral pigs have had profound impacts on the vegetation structure of the forest itself, through soil-rooting and consumption of seedlings, tree-

ferns, and through spreading propagules of invasive plants such as guava (*Psidium guajava*) (Global Invasive Species Database 2007).

In Montserrat, goats (*Capra hircus*) and cattle (*Bos taurus*) are also encountered in the Centre Hills forests. As with pigs cattle were released to fend for themselves when people were evacuated from the south in 1995 and their population has grown significantly over time (S. Mendes *pers. comm.*). Goats meanwhile have had free roaming populations for years prior to 1995 (S. Mendes *pers. comm.*). When introduced to islands, these two species can affect forest structure and native plant communities through their grazing and browsing, with knock-on effects for native animals (Atkinson and Atkinson 2000; Campbell and Donlan 2005; Global Invasive Species Database 2007). In Dominica, feral goats cause limited damage to farmer crops and private gardens but are not present in large enough numbers to be considered a major threat (M. Sulton *pers. comm.*).

There is almost certainly a feral cat (*Felis catus*) population in Montserrat, although this has not been confirmed by formal study, and anecdotal information rarely distinguishes between detections of wandering domestic cats and true feral animals. The distribution, population density and ecology of the feral population is not known. Feral cats are devastating invasive species on many islands, through predation on native vertebrate species. Mammals and birds are most commonly affected (Global Invasive Species Database 2007), and indeed, in some circumstances, feral cat predation on introduced rats may be beneficial to native island ecosystems by reducing rat impacts (Courchamp, Chapuis and Pascal 2003), but negative impacts on some island herpetofauna populations, such as various Caribbean island iguanas, have also been recorded (Varnham 2006).

On Dominica the common opossum (*Didelphis marsupialis*), known locally as the manicou, is widespread (A. Blackman and J. Spencer *pers. comm.*). Its impact on mountain chickens is currently unknown, but has a generalist diet, which includes small vertebrates such as frogs (Tyndale-Biscoe 2005).

Cane toads (*Rhinella marina*) have been introduced to Montserrat and are now widespread and common throughout the island. In the Centre Hills forests, they appear to be highly clustered around watercourses, rather than dispersed throughout, and this is in contrast to the (wet season) distribution of mountain chicken (DOE *pers. comm.*). The cane toad is a generalist and opportunist predator. It feeds nocturnally, primarily on terrestrial invertebrates and small vertebrates. It also produces toxins in its skin which can directly kill native predators. In Australia, it is thought to have important impacts on native

frog and toad communities, through a combination of predation and competitive interactions, but scientific studies confirming their impacts are lacking (Global Invasive Species Database 2007). Some cases of ticks found on mountain chickens in Montserrat could be a sign of the close contact with cane toads as this species shows a high prevalence of these parasites during all seasons. It is possible these ticks could have been transmitting a wide variety of pathogens to the mountain chicken (Liu and Bonnet 2014).

Cane toads have not been successfully introduced to Dominica. In 2013, however, a container which had travelled directly from Montserrat arrived at the port in Dominica carrying a number of live cane toads. The arrival of the cane toads was reported to Forestry staff and intensive surveys were immediately undertaken at the port and surrounding areas. A total of 26 toads were caught and removed from the port and there was no evidence to suggest the toads had spread to other areas (M. Sulton *pers. comm.*).

Finally, the agouti (*Dasyprocta antillensis*) was probably introduced by Carib Indians as a food source at some time before the arrival of Europeans, and is now widespread through forested areas of Montserrat (Young 2007). Agouti's like two other likely introductions; red-footed tortoises (*Geochelone carbonia*), and probably green iguanas (*Iguana iguana*), are not thought to impact native wildlife significantly and are not considered invasive.

2.3.5. Habitat degradation

Water availability As noted above, microhabitat studies (Daltry 1999) indicated that mountain chickens are associated with areas with permanent water, and it seems likely that moist conditions are essential for successful breeding. These conditions will depend upon, amongst other factors, the intensity and distribution aerial rainfall and the abstraction of water from capped springs for human consumption. Water conservation depends on spring yield and length of ash fall as demand can easily increase during dry periods and ash fall.

Increasing abstraction (Fig. 30, red line) tracked increasing rain fall (Fig. 30, green and blue lines) over the period 2003-2007. The average rainfall over the Centre Hills decreased substantially in 2007 (to levels similar to those found during 1999-2001) but without a corresponding decrease in abstraction (Fig. 30). As the Montserrat Water Authority (MWA) notes, we do not yet have data to indicate a minimum level of rainfall required to ensure suitably moist conditions for mountain chicken survival.

FOOD INVENTORY FOR MONTH ENDING

QUANTITY	PARTICULARS	SIZE	UNIT COST	TOTAL
	POULTRY			£ 15964 79
	Duckling			
	Turkey			
	Turkey Breast	43 LBS	3.65	157.65
	Whole Chicken	220.5	3.55	782.78
	Cornish Hen	24 LBS	6.94	167.16
	Chicken Legs			
	Chicken Wings			
	Chicken Back & Neck			
	Chicken Liver	39 LBS	2.00	78.00
	Mountain Chicken	45	10.00	450.00
	Grounded Turkeys	7 LBS	4.40	30.80
	LAMB			

Fig. 31. Inventory from Hot Springs Hotel restaurant showing stock of mountain chickens (photo: L. McClean)

In addition to the above mentioned, dome collapse at the Soufrière Hills volcano, would be expected to affect the availability of water, covering existing pools of water, and also increasing surface runoff which, by extension, will reduce water available for the persistence of suitable microhabitat.

Chemical contaminants Boone *et al.* (2007) review the impacts of contaminants on amphibian populations and conclude that there are serious gaps in current knowledge on what contaminants amphibians are exposed to in nature, and in what combinations, as well as on how contaminants interact with other stressors. But there is clear evidence that contaminants can impact amphibians at the individual, population, and community level.

At present, there is no evidence of any impacts of chemical contaminants on mountain chickens in Montserrat. However, a number of the agrochemicals currently in use in Montserrat are known to have adverse impacts on other amphibian species (e.g. glyphosate found in the herbicide Roundup or carbaryl in Sevin™ can both greatly increase tadpole mortality) or on their food source (insects and other invertebrates). The extent to which these potential impacts are being realised on Montserrat remains unknown.

Invasive species A number of invasive species (goats, cows, pigs) can severely modify habitats through grazing and (in the case of pigs) digging. Their faeces may also cause the eutrophication of water bodies. Grazing also prevents the regeneration of forests. As with chemical contaminants, there is currently no evidence of any impacts of grazing on mountain chickens in Montserrat.

Built development Development can result in the loss and



Fig. 32. Dominica's national coat of arms, showing a mountain chicken on the upper right of the escutcheon (shield)

degradation of mountain chicken habitat, the introduction of invasive alien predators (cats and dogs) and possibly chemical contaminants. Again, at present, there are no data to indicate whether such impacts are occurring on Montserrat although the boundary of the Centre Hills Reserve seems likely to be an area of high sensitivity in this regard. Montserrat's national GIS (housed at the Physical Planning Unit, PPU) may be able to provide a mechanism for monitoring such pressures, both from the recent past and in the future.

2.4 Red List Status

It was following the chytridiomycosis epidemic that had such a devastating effect on the mountain chicken populations in Dominica that the mountain chicken was assessed by the IUCN Red List of Threatened Species as Critically Endangered (i.e. "facing an extremely high risk of extinction in the wild"). This assessment was conducted in 2004 and was based on the "drastic population decline, estimated to be more than 80 % over the last ten years, inferred from the apparent disappearance of most of the population due to *chytridiomycosis* and volcanic eruptions" (Fa *et al.* 2007).

A draft reassessment of the mountain chicken was submitted to IUCN in January 2014 based on data collected during the Montserrat Darwin Project 2010-2013. Although the status of the species will not change (it can't be assessed as any more endangered) the new assessment will update the IUCN website which currently reports the population of the mountain chicken as being estimated at 8,000 - a gross overestimation based on the last assessment which was conducted before the *Bd* fungus arrived to Montserrat.

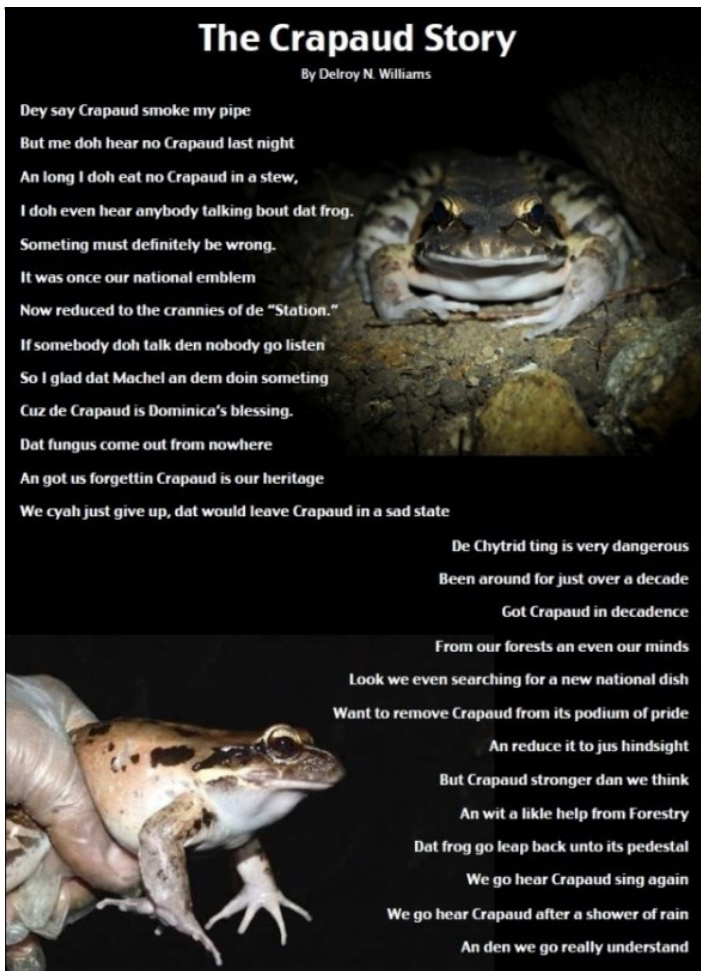


Fig. 33. Poem about the mountain chicken on Dominica by D. N. Williams (2013)



Fig. 34. Young artist "Sugar-T" singing the calypso "Save the mountain chicken" at the St. Patrick's Day Junior Calypso competition 2012 (photo: S.L. Adams/Durrell)

population numbers on both islands in the 2000's made hunting the frogs more difficult and a local campaign led by the Government of Dominica resulted in a ban, imposed in 2002, on hunting the frogs in Dominica following the arrival of *Bd* (Malhotra *et al.* 2007; Brueil 2009). This campaign was set up in an effort to protect the species and recognised the local interest in preventing extinction of the mountain chicken. In Montserrat, with the onset of the fungus, public education and outreach activities highlighting the current plight of the Mountain Chicken resulted in cessation of hunting. It is believed that hunting has not resumed since (G. Gray *pers. comm.*). Draft CEMA legislation will have the mountain chicken as a protected species (S. Mendes *pers. comm.*).

The long standing cultural importance of the species on both islands is reflected in Dominica's traditional proverbs and jokes, which are recorded in the local Kreolé language. Examples include "Sé lanng kwapo ki twayi kwapo" meaning, "It's Crapaud's tongue (croaking) that sold him out" and "Kwapo di sé mannyè i asiz ki fè tout fanm enmen 'y'", which translates to "Crapaud says that it's because of the way he sits that's why all women love him" (Sulton 2012). The mountain chicken also features in Dominican folk songs sung by the Siffleur Montagne Chorale of the 1970's including "Oh Dominica" and "Tou Sa Adan 'y'" (Sulton 2012). The mountain chicken is emblematic, used as a logo by the islands indigenous bank, a college and a guesthouse as well as on the Dominican coat of arms which was adopted in 1961 (Fig. 32).

More recently, a poem written by local author Delroy Williams (Fig. 33) describes the impacts of the *Bd* fungus on mountain chickens and focusses on raising local support awareness on the plight of species.

2.5 Cultural Values

Like many species transported around the Caribbean islands by the Amerindians, it is suspected that the mountain chickens were originally used by settlers as a source of food. The earliest record of these animals being eaten dates back as far as the 14th century (Evans and James 1997). Mountain chicken is a traditional Caribbean dish and the ongoing consumption of these frogs led to the development of the common name as they are reported to "taste like chicken" (Malhotra *et al.* 2007). In Dominica, mountain chicken was the unofficial national dish and large numbers were consumed during the Creole festival every November. During a study conducted in 2002, McIntyre conducted social surveys which calculated the annual harvest of mountain chickens as being between 18,000 and 36,000 frogs per year (McIntyre 2003). In Montserrat mountain chicken became the favourite dish of visiting tourists and was promoted locally by hotels (see Fig. 31) who would sell a dish for XCD 60 (L. Martin *pers. comm.*). This led to the species being of important social and economic value on both islands. The rapid decline in

In Montserrat the mountain chicken has been the musical inspiration for lyrics of many calypsos including “Da mountain chicken is sick” by Cecil Lake in 2011, “Save the mountain chicken” composed by Montserratian Justin “Hero” Cassell and sung by young artist Sugar-T in 2012 (Fig. 34) and the controversial “Mountain Chicken Fantasy” performed by Earle “Hustler” Browne in 1986 which draws parallels between calling mountain chickens and the ‘croaking’ of unsatisfactory politicians (<http://www.youtube.com/watch?v=ehJs918ErgU>).

2.6 Conservation and management

Conservation management of the mountain chicken on Montserrat and Dominica dates back many years, with a closed season on hunting mountain chicken in Dominica enacted in 1976, followed by a ban in 1999. An assessment of bushmeat resources (primarily mountain chickens and agoutis) in Dominica was completed in 2002, and recorded the first infection of the species by *Bd* (McIntyre 2003). In response to this, an ex situ biosecure population of mountain chickens was established at ZSL in 2002 and a project to build a conservation breeding centre on Dominica and to develop a regional *Bd* mitigation programme was implemented (Cunningham *et al.* 2008). In Montserrat, a long-term annual monitoring programme was initiated in 1998 (Daltry 1998) and a captive population overseas established in 1999 (Gibson and Buley 2004). Research into the biology and ecology of the species on Montserrat and in the overseas breeding population was conducted during the next six years (Gibson and Buley 2001; Gibson and Buley 2004; Garcia *et al.* 2007) and in 2007, a Species Action Plan (the predecessor to this plan) was developed for the Montserrat population from the outputs of this research and monitoring, with Dominican conservationists sharing their experiences of responding to the arrival of *Bd* (Martin *et al.* 2007). Despite this, *Bd* was recorded as being present in Montserrat in 2009 (Garcia *et al.* 2009; 2012) and, as a first response, DOE and Durrell evacuated 50 mountain chickens to establish a second, biosecure, breeding population in Europe. At this time, conservation efforts on Montserrat and Dominica were formally integrated into the MCRP and through a UK Government Darwin Initiative grant, a three year conservation project was focused on Montserrat with the goal of enabling the island to save the species. As of 2011, the breeding centre in Dominica has been operational, though not yet producing captive bred animals. Mountain chickens bred within the biosecure captive population have been released back into Montserrat in a series of closely monitored trials, taking place within a project that has also focused on monitoring the few remaining surviving *Bd* mountain chickens on

Montserrat and raising awareness about the species (Morton 2011; Adams 2012; Adams and Mendes 2011). This has been paralleled by renewed field monitoring in Dominica and a number of outreach initiatives (Spencer 2012; B. Tapley and M. Sulton *pers. comm.*).

2.6.1. Protection status

Under Montserrat’s Forestry, Wildlife, National Parks and Protected Areas Act Revised Edition (2008) the mountain chicken is listed as a partially protected wildlife, which means it can be subjected to a close and open season for hunting. The penalty for contravening the closed season, if convicted, is XCD 5,000 or six months imprisonment. “Wildlife” is not defined under this ordinance, but all listed species are birds, reptiles, mammals and amphibians. All wildlife is deemed to be the property of the Crown and a wildlife survey is required to be made every ten years. Wildlife are classified into three groups – protected, partially protected & unprotected species:

- Over 50 species of birds are protected, including the Montserrat oriole (*Icterus oberi*).
- All reptiles are protected, except the green iguana (*Iguana iguana*) which is partially protected, the Montserrat galliwasp (*Diploglossus montisserrati*) and Montserrat anole (*Anolis lividus*).
- All amphibians are protected, except the mountain chicken which is partially protected.

The Centre Hills Forest Reserve holds a significant proportion of Montserrat’s mountain chicken population and is mostly privately owned. Some management agreements have been reached between the DOE and private landowners to ensure sympathetic management and tax concessions are offered to land owners with land given protected status. During the development of the Montserrat Physical Development Plan 2012-2022 consideration was given to key sites and areas of importance for the mountain chicken. Using monitoring data provided by the DOE these areas are included in the plan to ensure conservation of the mountain chicken is taken into account during future planning applications. A revision of environmental laws in Montserrat is currently taking place as a draft of CEMA has been submitted to the legislative council and is now awaiting a response. This will have significant implications for protection of the mountain chicken as, given its cultural and economic significance to the island, it will be named as a fully protected species and it will become illegal to hunt the species year round. To allow for sustainable use of this species in the future, it will be possible to amend regulations pertaining to the mountain chicken’s

protection status.

In Dominica mountain chickens are covered under the Forestry and Wildlife Act (1976). Whilst this previously allowed an open season for the hunting of mountain chickens in April 2004 the Government of Dominica enacted Regulations to impose an indefinite ban on the hunting of the mountain chicken.

2.6.2. Relationship with other biodiversity conservation organizations, actions & strategies

The Department of Environment of the Ministry of Agriculture, Land, Housing & Environment (<http://www.malhe.gov.ms>) has responsibility for biodiversity conservation. The main conservation NGO in the Territory is the Montserrat National Trust (<http://www.montserratnationaltrust.com>). It is mandated to preserve and protect the natural, historical and cultural heritage of Montserrat. In Dominica the Forestry, Wildlife and Parks Division of the Ministry of Agriculture and Forestry (<http://agriculture.gov.dm/>) has responsibility for biodiversity conservation.

The Organisation of Eastern Caribbean States (OECS), the Government of Montserrat and the Montserrat National Trust have ongoing strategies for environmental management, biodiversity conservation and sustainable development. A National Tourism Strategy & Plan, developed in 2012, describes a vision for the development of tourism as a major contributor to the island's economy during 2012–2022. A substantial part of this plan focuses on the potential to increase nature tourism to the island, through provision of trails, guides, etc. The St George's Declaration of Principles for Environmental Sustainability in the OECS (SGD) (<http://www.oecs.org/esdu/SGD.htm>) is a commitment (made in April 2001) by Member States of the OECS, of which Montserrat and Dominica are members to the actions necessary to achieve development goals in ways that ensure that environmental quality is maintained or improved. By signing up to the SGD, Montserrat's Government committed itself to, developed and implemented a National Environmental Management Strategy (NEMS), which is the mechanism by which the SGD is given effect at the national level. The NEMS involves identifying environmental obligations, environmental management priorities, capacity for implementing and monitoring environmental management initiatives, adequacy of legal and institutional frameworks, financing and public awareness.

The Government of Montserrat has also adopted the UK Overseas Territories Environment Charter (<http://www.fco.gov.uk/Files/kfile/montserratcharter.pdf> and <http://www.fco.gov.uk/Files/kfile/montserratcommitments.pdf>), which sets out guiding

principles and commitments for sound environmental management. Among the guiding principles is to 'safeguard and restore native species, habitats and landscape features, and control or eradicate invasive species'.

Dominica is a signatory to the Convention on Biological Diversity (<http://www.cbd.int/>), the first guiding principle of which is the conservation of biological diversity. Following this Dominica facilitated the development of the Dominica Biodiversity Strategy and Action Plan (DBSAP) which was approved in June 2002. In 2003 Dominica signed up to the Stockholm Convention on Persistent Organic Pollutants (<http://chm.pops.int/>) which is important given Dominica's economic dependence on agriculture. Dominica are also signatories to the United Nations Framework Convention on Climate Change (<http://unfccc.int/>) and the Cartagena Protocol on Biosafety (<http://bch.cbd.int/protocol/>).

To date most funding for environment and conservation work in Montserrat has been received from international donor agencies and UK Government funds (Department for International Development (<http://www.dfid.gov.uk/countries/caribbean/montserrat.asp>) the Foreign and Commonwealth Office (<http://www.fco.gov.uk>), and Department for Environment, Food and Rural Affairs (<http://www.defra.gov.uk/wildlife-countryside/index.htm>, <http://www.darwin.gov.uk>). Several UK based non-governmental organisations have a long history of involvement in Montserratian conservation, working in partnership with the DOE and/or the National Trust. These are the Royal Society for the Protection of Birds (RSPB, <http://www.rspb.org.uk/>), the Royal Botanic Gardens, Kew (RBG-Kew, <http://www.rbgekew.org.uk/>), the Durrell Wildlife Conservation Trust (Durrell, <http://www.durrell.org/>) and Fauna and Flora International (FFI, <http://www.faunaflora.org>). Academic researchers have also been active in recent years, most notably entomologists from Montana State University (<http://entomology.montana.edu/>), bat experts from South Dakota State University (<http://biomicro.sdstate.edu/pederses/mnires.html>) and marine turtle experts from the University of Exeter (<http://www.seaturtle.org/mtrg>, and <http://www.seaturtle.org/mtrg/projects/tukot>). The UK Overseas Territories Conservation Forum (UKOTCF, <http://www.ukotcf.org>) brings together NGOs and other organisations involved with conservation in UK Overseas Territories.

In 2005, the Durrell Wildlife Conservation Trust (Durrell) coordinated the 'Montserrat Biodiversity Assessment' (MBA, <http://www.durrellwildlife.org/index.cfm?p=307>) in collaboration with MNT, MALHE and taxon experts from Jersey, the UK and USA.

The RSPB, with RBG-Kew, and Durrell, with funding from the



Fig. 35. Captive breeding facility (left; photo: J. Spencer/ZSL) with Dominican mountain chickens (right; photo: C. Fenton)

UK Darwin Initiative (<http://www.darwin.gov.uk/projects/details/14027.html>), have prepared a proposal, with Management Plan, to change the designation of the existing Centre Hills Protected Area from protected forest and forest reserve to National park. The Centre Hills is a protected area under current legislation. It is comprised of protected forest and forest reserve areas. Draft CEMA legislation will create 7 categories that part of or all of the current protected area can be classified as, including National Park. The issue of declaring part or all of the Centre Hills as a National Park will be addressed after CEMA has been passed.

Montserrat and Dominica form a part of the Caribbean Islands biodiversity hotspot as identified by Conservation International (<http://www.biodiversityhotspots.org/xp/Hotspots>). However, the Critical Ecosystems Partnership Fund (<http://www.cepf.net/xp/cepf>), a large-scale funding mechanism for hotspots, is not currently open for the region. Montserrat is also an 'Alliance for Zero Extinction' site (<http://www.zeroextinction.org/selection.htm>), as it is a discrete area with one endemic 'Critically Endangered' species. Other regional NGOs with an interest in the countries are the Island Resources Foundation (IRF) (<http://www.irf.org>) and the Society for the Conservation and Study of Caribbean Birds (SCSCB) (<http://www.nmnh.si.edu/BIRDNET/SCSCB/index.html>).

2.6.3. Conservation breeding programmes

Conservation breeding centre in Dominica

As part of a Darwin Initiative grant awarded to the Zoological Society of London (ZSL) in 2005, a specialised captive breeding facility was built in order to establish the capacity for a mountain chicken captive breeding programme on Dominica (Cunningham 2008). The facility

was based at the FWPD headquarters in the botanic gardens in Roseau (Fig. 35) and forestry staff were trained in the UK in the husbandry techniques required to keep mountain chickens in captivity (Cunningham 2008). The aim of the captive breeding facility was to breed wild caught Dominican mountain chickens *in situ* that could be introduced back into the wild without the issues of biosecurity experienced by populations bred in *ex situ* overseas.

After complications with the husbandry of local live food to feed the mountain chickens and the rapid decline of the species in the wild the captive breeding facility remained without frogs for several years (Cunningham 2008). However, the first mountain chicken was caught and placed in the facility in 2011 and as of January 2014 a total of five mountain chickens were successfully being maintained in captivity (M. Sulton *pers. comm.*). Whilst no successful breeding has yet occurred in the captive frogs, three infertile nests were discovered during the 2013 breeding season (M. Sulton *pers. comm.*). Other difficulties have also been experienced with some frogs contracting *Bd* whilst being kept in the facility, though once detected these animals are often treated successfully (M. Sulton *pers. comm.*).

Biosecure captive population and breeding programme

The first *ex situ* biosecure population of mountain chickens was established in 2002 when a safety net population was removed from the wild following the arrival of *Bd* to Dominica. In total 12 wild mountain chickens were captured in Dominica and relocated to specialised quarantine facilities at ZSL.



Fig. 36. Rescue operation evacuating 50 healthy mountain chickens from Fairy Walk ghaut to be transported to overseas quarantine facilities (photo: G. Garcia/Durrell)

The second population was established seven years later in March 2009 when the presence of *Bd* was confirmed in Montserrat. An emergency rescue operation saw 50 healthy mountain chickens (25 males and 25 females) evacuated and sent to customised quarantine facilities at Durrell in Jersey, Parken Zoo Eskilstuna in Sweden and ZSL in London.

The aim of these captive breeding populations were to maintain a viable population of mountain chickens free from disease and removed from *Bd* infected sites and also to provide a captive-breeding stock to use for experimental releases and to potentially restock depleted wild populations.

The success of the programme has so far been mixed. The Montserratian population has produced viable clutches every year since the programme began in 2009 and a total of 205 offspring produced and raised for release.



Fig. 37. Metamorphosed mountain chicken bred in quarantine conditions at the Zoological Society of London (photo: I. Stephen/ZSL)

However, the Dominican population has failed to produce any offspring since 2005 (G. Garcia *pers. comm.*). There are also many difficulties associated with the programme. Maintaining supportive partners has proved a challenge due to the high cost and space required to run long term biosecure facilities whilst maintaining high husbandry standards in order to produce healthy frogs. The captive populations experience low long term survival rates with only one of the original Dominican founders alive after nine years and seventeen of the original Montserratian founders alive after four years of being kept in captivity. It has also been difficult to control the breeding success of the programme along with trying to produce frogs when needed for experimental releases. Less than half of the original founders of 2009 have been successfully breeding (G. Garcia *pers. comm.*) These along with other factors mean there are a limited number of institutions able and willing to commit long term to the programme.

Non-biosecure captive population and breeding programme

At the request of the Government of Montserrat, Durrell took seven male and six female mountain chickens into non-quarantine captive breeding conditions in 1999. The aim was to provide a 'safety net' population should future volcanic eruptions threaten the mountain chicken in the wild, and to develop protocols for breeding the species in captivity in the event that a larger-scale breeding programme, capturing more of the genetic diversity in the wild population, is deemed necessary in the future. Mountain chickens were bred in captivity for the first time ever in 2000 (Gibson and Buley 2001). Observations using infra-red video cameras also provided insights into the unique parental care shown by this species (Gibson and Buley 2004). In 2006, the second generation of mountain chickens in this captive population were also bred. The offspring of this captive population have been circulated round at least 18 different institutions to promote public

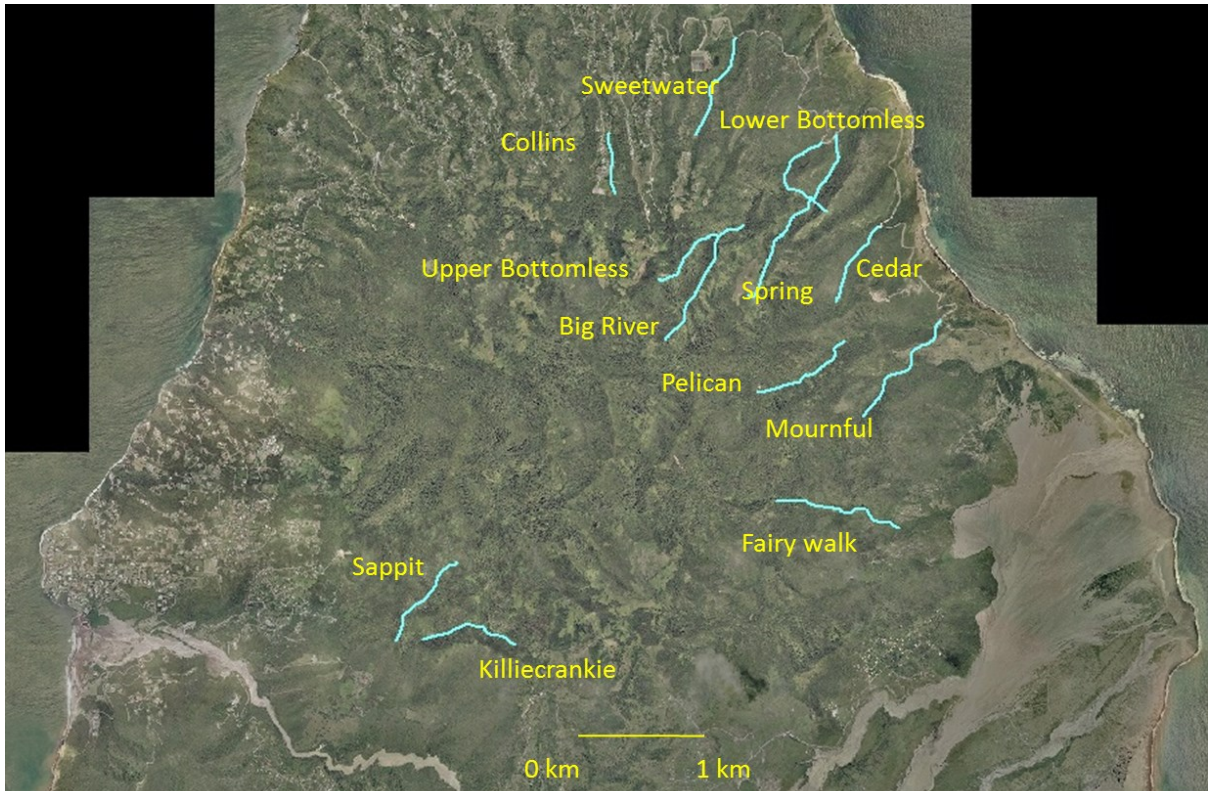


Fig. 38. Map of mountain chicken study sites in Montserrat

education and awareness and have also been used in research projects to conduct disease challenge experiments on the species. There are no longer any founder animals left alive (G. Garcia *pers. comm.*).

2.6.4. Management of wild populations

In situ anti-fungal treatment trial project conducted in Montserrat

The aim of this study was to determine if the *in situ* treatment of mountain chickens with the anti-fungal agent itraconazole could provide any protection at the population level against *Bd* during the initial epidemic phase following the introduction of the pathogen (Cunningham, Lopez and Terry 2009) by regularly bathing wild caught frogs with solution made up of a concentration of itraconazole and ghaunt water and comparing the to the survival rates of frogs in a bath-control group and a non-bath control group. The trials took place in Montserrat in 2009 shortly after the outbreak of chytridiomycosis in the wild populations and ended in 2010 following a two month monitoring period (M. Hudson *in prep.*).

Preliminary analysis of the data suggests that that after two months of the treatment phase, survival rates of treated frogs (55 % n=44) were higher than un-treated frogs (15 % n=6) (Cunningham, Lopez and Terry 2009). However, when treatment ceased the survival rate for the treated frogs

dropped to the same level as the control frogs (95.5% to 87.9%, Hudson *et al.* 2014). These results, together with a lack of surviving frogs in the study site suggests any protection at the individual level is sustained only by continuous treatment. Further investigation into the possible effectiveness of these treatments will be made once the results from the formal analysis of this trial are made available.

Experimental releases of captive bred mountain chickens into the wild

As part of a Darwin Initiative funded project awarded to Durrell in 2010, a series of experimental releases were conducted by reintroducing captive bred mountain chickens into the Centre Hills in Montserrat. The aim of these releases was to determine factors affecting variation in mountain chicken mortality when released into a positive *Bd* environment. Analyses are being conducted as part of a PhD investigating the ecology of *Bd* and interactions between the fungus and mountain chickens. Factors that were tested included the age of the frogs and the season of release (Morton, Adams and Terry 2013).

In total 121 frogs, bred in quarantine conditions as part of the biosecure captive breeding programme, were reintroduced into Montserrat over three releases conducted in 2011 and 2012 (Morton, Adams and Terry 2013).



Fig. 39. Treatment of a mountain chicken with an itraconazole solution (photo: G. Garcia/Durrell)



Fig. 40. Preparing a mountain chicken for release into Montserrat after a two day recovery from the flight in temporary ponds (photo: G. Garcia/Durrell)



Fig. 41. DOE forestry staff swabbing a released mountain chicken (photo: SL. Adams/Durrell)



Fig. 42. Montserratian field assistant Calvin Fenton training Dominican Forestry staff member Machel Sulton in PIT tagging a Dominican wild caught surviving mountain chicken (photo: B. Tapley/Durrell)

Released frogs were monitored intensively using radio-tracking. Before being transported from their quarantine facilities to the release site in Montserrat, each mountain chicken was surgically implanted with a radio transmitter which would allow field teams to track the frogs once released. In order to monitor *Bd* infection individuals were swabbed once a week and weight and body measurements were taken to monitor general health.

Over 12 months of intensive monitoring was completed during which 1,652 swabs were collected, along with habitat use data and GPS locations. Detection rates decreased significantly once the transmitters failed between 3-6 months making it difficult to determine long-term survival of the released frogs and the last live

mountain chicken from these populations was detected in November 2013.

The presence of *Bd* was observed in all three release populations. Analysis is underway though initial data supports the assumption that males are caught less frequently than females (M. Hudson *pers. comm.*). Initial analysis of location data shows differences in the movements between male and female mountain chickens; male frogs moved further away from point of release and in a more random direction than female frogs. Males also moved around across larger areas than females (Morton 2011), which may have implications for *Bd* transmission.

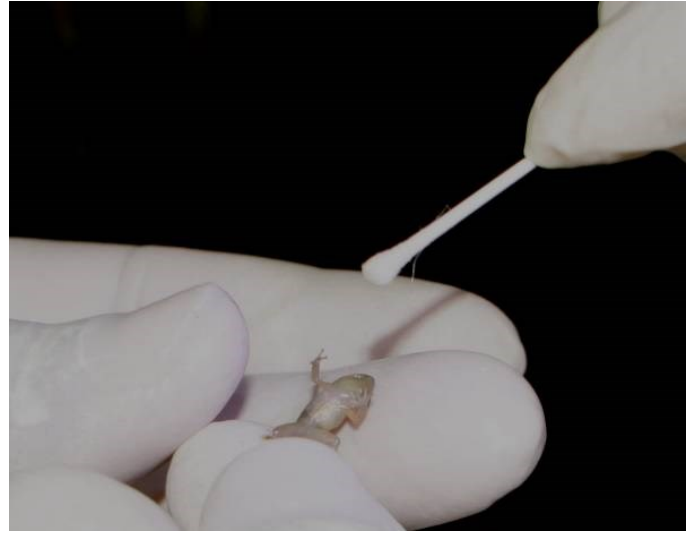


Fig. 43. Johnstone's whistling frog, *E. johnstonei*, (left; photo: S.L. Adams/Durrell) and swabbing a Johnstone's whistling tree frog for *Bd* (right; photo: J. Liman)

The data set is currently being analysed by a PhD student (M. Hudson) and in order to complete the comparative study, a fourth release was carried out in July 2014. The results will allow examination of factors under the control of conservation manager, such as season, that can be manipulated in order to maximise mountain chicken survival.

Monitoring mountain chickens surviving in the wild

Despite the devastating impact of the *Bd* fungus on the population of mountain chickens in Montserrat, surviving frogs were detected during a survey for a release site in November 2010 (Smith 2010). Intense surveys to search for and monitor surviving mountain chickens were then initiated in 2011 and continued until end of 2013 (see Fig. 38). The aim of these surveys was to monitor the status of the surviving mountain chicken population, to determine their infection status with regard to *Bd* and to research factors influencing their continued survival in areas known to be *Bd* positive.

Regular surveys of eight transects along ghauts on the eastern side of the island were conducted over the three year period. Each mountain chicken encountered was caught and PIT tagged for individual identification and data was taken to monitor infection rates, breeding status and general health.

In total, 174 surveys were conducted and the results indicated that numbers of surviving frogs in the sites monitored were decreasing from 14 individuals in 2011 to just four in 2013 (Morton *et al.* 2014). The analysis of the swabs is still taking place but early results indicate that many of the surviving individuals have been infected with low levels of *Bd* (M. Hudson *pers. comm.*).

In Dominica, surveys ceased in 2007 due to the low numbers of mountain chickens being detected on any of the transects. However, in 2011, following local reports of calling mountain chickens, the Dominican Forestry Department initiated surveys assisted by Montserratian project field assistant Calvin Fenton and ZSL volunteers. During three field nights, two adult male surviving mountain chickens were caught and tagged along with one juvenile, the first seen in nine years. After further searches in 2012 a further 31 adult surviving mountain chickens were captured and tagged for individual identification and 11 more juvenile frogs were detected showing evidence of active breeding. Whilst this shows a potential nascent recovery of the species locally data gathered in the first quarter of 2014 suggests those populations discovered in 2012 have significantly reduced (A. Blackman and M. Sulton, *pers. comm.*). However, new sites with frog populations have been located including juveniles between one and two years, indicating successful breeding activity continues (A. Blackman and M. Sulton *pers. comm.*).

In order to monitor the potentially changing status of the mountain chicken population in Dominica, an increase in monitoring of the surviving mountain chickens has begun in 2014 as part of a PhD. Surveys will be conducted along historical transects (Daltry 2002) and at established new sites and, as in Montserrat, surviving individuals will be caught and data taken in order to monitor infection status and general health of the animals.

Monitoring *Bd* prevalence in sympatric amphibian species

The Johnstone's whistling frog (*Eleutherodactylus johnstonei*) is native to the island of Montserrat and suspected to be a carrier of the *Bd* fungus (Henderson and Berg 2006). In order to increase understanding of the



Fig. 44. Education programme focusing on the conservation of the mountain chicken at a local school in Dominica (photo: A. Blackman/ZSL)



Fig. 45. Education programme focusing on the conservation of the mountain chicken at a local school in Montserrat (S. Mendes/DOE)

ecology of *Bd* on Montserrat and to investigate possible variation of levels of *Bd* over time and space, prevalence of *Bd* in *E. johnstonei* was monitored on Montserrat at three sites (Sweetwater, Collins, Fairy Walk) between 2011 and 2013 (see Fig. 38). Preliminary analysis of the data shows a peak in *Bd* occurs during the dry season, which could be a result of scarcity of water causing greater grouping of individuals and increased contact rates, (M. Hudson *pers. comm.*) and is similar to patterns reported in experimental studies e.g. Longo *et al.* (2010).

2.6.5. Education and outreach programmes

Both the Dominican Forestry, Wildlife and Parks Division and the Department of Environment in Montserrat have committed to raising awareness concerning the conservation of the mountain chicken locally and education and outreach programmes have been deployed in both islands

In Dominica outreach originally focused on reducing the hunting activity (McIntyre 2002) but since the arrival of *Bd*, more attention has been placed on the conservation efforts through the captive breeding facility and more recently on the surveys for surviving mountain chickens.

A Facebook page set up for the Dominican Mountain Chicken Project (<https://www.facebook.com/pages/Dominican-Mountain-Chicken-Project/136933839835254>) has proved a very effective tool at raising local and international awareness with additional local awareness raising through community walks, radio and television programmes and school visits. There is also an education centre at in the Botanical Gardens in Roseau where visitors can learn more about

the mountain chicken. Public engagement activities in Dominica include boards, posters, leaflets, radio and television, and giving talks to schoolchildren. A campaign entitled "Have you seen me? Have you heard me?" is currently being run, where people are encouraged to report mountain chicken sightings and vocalisations. This campaign included a series of public engagement events, such as a dance troop promoting the project in the 2012 carnival, a crapaud carnival queen in 2014, an annual mountain chicken hike on the island and an annual Mountain Chicken Day. The captive breeding centre has been a focus for many outreach activities and has been visited by many high profile supporters including Miss Dominica, various Ministers as well as media outlets such as Dominica News Online, the BBC & the Government Information Services (M. Sulton *pers. comm.*).

A communications strategy was produced for Montserrat in 2011 (Adams and Mendes 2011) to guide a comprehensive programme of education and outreach activities between 2011 and 2013. Activities included a series of radio and television programmes, production of educational posters and leaflets, community and school presentations, production of two calypsos, creation of a website and facebook page dedicated to mountain chicken conservation (<https://www.facebook.com/pages/Mountain-Chicken-Project/239351002809848>) and a forty minute wildlife documentary featuring the mountain chicken and the conservation efforts conducted by DOE and Durrell. Island wide surveys showed an increase in the knowledge, understanding and empathy towards the species was achieved over the three year project.

3. The Long-Term Recovery Strategy 2014 - 2034



Fig. 46. Mountain chicken on leaf litter (photo: E. Downie)

3.1 Justification

A considerable amount of effort has been put into conserving the mountain chicken on both Montserrat and Dominica and there is a strong desire to build upon this and continue from the partners involved. As part of the Darwin funded project on Montserrat a workshop was held in July 2013 to review the existing '*Species Action Plan for the Mountain Chicken in Montserrat*' and create a new action plan for the species across its whole range. This is a logical step for the action plan to take as activities carried out on both islands, as well as overseas are interlinked and essential for the species ultimate survival.

The primary threat facing the mountain chicken, the *Bd fungus* which causes chytridiomycosis, is the greatest disease threat facing any vertebrate group in the world. Globally, research into how *Bd* affects and interacts with amphibian populations in the wild and into actions to effectively mitigate and prevent its clinical effects is still in the early stages of which the MCRP is one of the leading programmes. Given the nature of this threat, the

importance and scale of the diverse research to be done in relation to it, workshop participants felt that a 5 or 10 year action plan would not be long enough to achieve a reasonable goal. For this reason it was agreed to develop a longer 20 year action plan. This allows setting an overall realistic time frame for an aspirational goal alongside shorter time frame objectives, milestones and reviews to provide structure and guidance for shorter term targets.

3.2 Vision, goals and objectives

3.2.1 Vision

"To have healthy populations of mountain chickens as a flagship species for the islands' natural and cultural heritage"

The vision is of populations on Montserrat and Dominica ("populations", plural) that are self-sustaining ("healthy") and either free from disease, or living and breeding with the disease present (also "healthy"). The vision is also for

the mountain chicken's cultural value to be retained and celebrated and "For the islands' ... heritage" means that people in Montserrat and Dominica benefit from this vision being achieved (this could include the idea that sustainable use of mountain chickens is possible once the vision has been achieved).

3.2.2 Goal

"There are healthy mountain chicken populations across their former year-2000 ranges on each of Montserrat and Dominica by 2034"

For the goal "healthy" does not necessarily mean *Bd*-free populations: it could be a *Bd*-free population, or one in which mountain chickens are able to live and breed in the presence of *Bd*. "Healthy" also refers to a viable population in the sense that it is breeding; but it may still require some management to sustain itself. "Year-2000 ranges" refers to the species 'pre-*Bd* ranges' in a way that can be measured i.e. we can estimate population sizes or areas of occupancy, in Dominica and Montserrat at that point in time.

The primary risks to achieving this goal are that research is not able to identify suitable management strategies in relation to *Bd* in this 20 year time frame and maintaining the motivation of partners and donors to support the programme over the plans time frame. The plan has specific objectives to address both these risks.

3.2.3 Objectives

Whilst all of the objectives listed below are needed to address all of the threats facing the mountain chicken, it was recognized during the development of this plan that the first four objectives are of overriding importance in attempting to recover the species and accordingly contain the highest priority actions (see Section 3.3).

Higher priority objectives

1. By 2020, the mountain chicken is a flagship species for global amphibian conservation, generating strong **motivation among all partners and stakeholders** to take the necessary steps to restore the species in the wild.

The 2020 milestone is set to coincide with global targets (Convention on Biological Diversity) and achieving global recognition here will motivate stakeholders and partners, including donors, to drive forward with the plan. Strengthening collaboration and cooperation between the range state countries and external partners will also maintain and develop momentum and motivation.

Key projects include developing a 5-year operational

plan; an international communication strategy; a 5-year fundraising strategy; establishing a training programme in the range state and establishing a project steering committee to oversee implementation.

2. By 2028, research has discovered or developed method(s) to **mitigate the impact of *Bd*** on mountain chickens in the wild.

2028 gives an ambitious 15 year period for research efforts to develop mitigation strategies and their subsequent implementation before the end of the plan. To aid in achieving this research efforts should be focussed on (a) a small number of frogs on Montserrat surviving in the face of *Bd* infection and (b) the apparent nascent recovery of frogs on Dominica, including direct management of these populations. Additionally, the programme will attempt to identify possible *Bd*-free sites (refugia) for releases.

Key projects include developing an overall research strategy; support the release plan in developing options to mitigate the effects of *Bd*; investigate factors affecting mountain chicken survival and response to *Bd* in the wild and the genetic and behavioural factors affecting mountain chicken survival and response to *Bd*.

3. **Establish growing populations** at 5 sites on each island through a combination of *in situ* and *ex situ* management.

This will be achieved by (a) increasing population growth rates, and (b) releases of captive bred frogs (augmentation). The balance between these two approaches will emerge from the ongoing research during the lifetime of this plan. To achieve this objective, wild populations will require hands-on management (conservation assistance, geography, demographics, inbreeding, behaviour).

Key projects include developing a release plan for mountain chickens; conducting experimental releases into *Bd* positive sites on both islands; conducting releases into identified *Bd* free refugia sites and undertaking hands-on management of wild and released populations.

4. **An *ex situ* breeding programme remains operational**, both within and outside of range state countries, until the other objectives of this plan have been met.

Although an *ex situ* programme is not an end in itself, the partners feel it justifies being an objective because, were it to fail to remain operational through the lifetime of this plan, all the other objectives could be achieved

but the overall plan could still fail because there was no assurance population producing frogs for release. To produce frogs for release, captive breeding facilities will be established on both islands, and the number of overseas participating institutions increased.

Key projects include evaluating the genetic health and viability of the quarantined breeding population; increasing the breeding success of the quarantine population; establishing breeding centres in both the range states; leading the management of all captive populations to ensure greater collaboration; ensuring the highest veterinary and health standards are maintained within the quarantine populations and explore ways which the captive programme can support restoration of the species in the wild.

Lower priority objectives

5. **The moratorium on hunting** in Dominica and Montserrat is maintained and enforced over the lifetime of this plan.

Mountain chickens have traditionally been hunted for food and this will maintain the legal protection, and raise the public perception, of mountain chickens to the same level as afforded to parrots on Dominica and orioles on Montserrat. The message on the need to suspend hunting will be included in school curricula and cultural activities. Awareness amongst tourists and other visitors (e.g. the Diaspora) will be raised, to reduce the demand for mountain chicken meat.

6. **The impact (number of deaths of mountain chickens) of invasive species** is estimated where possible and does not strongly limit the recovery of the mountain chicken population.

Invasive species such as rats are known to have significant impacts on fragile / low level native populations. Firstly the programme will establish the impact of current levels of invasive species on mountain chicken populations. Management of key invasive species populations, whilst also preventing the arrival of new invasive species will be done to maintain invasive species populations at a level at which mountain chickens can thrive.

7. **No net loss of mountain chicken habitat due to climate change** on Dominica and Montserrat.

Protecting key areas, ensuring no losses of valuable mountain chicken habitat and enhancement of key areas to mitigate the anticipated effects of climate change including hotter and drier weather; more wildfires; and greater risk of disease transmission through elevated aggregation of mountain chickens in fewer water bodies at critical times of year.

8. **Loss of suitable mountain chicken habitat because of other causes** on Dominica and Montserrat is minimized and does not strongly limit the recovery of the mountain chicken population.

Effective management, including of Protected Areas, and guidance ensures that there are no losses of valuable mountain chicken habitat, addressing issues of pollution, poor land use practice, development in and abstraction of water from mountain chicken habitat. Protected Area management will also address issues surrounding invasive species (Objective 6) and climate change mitigation and adaptation (Objective 7).

3.3 Project and Activity Tables

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 1	By 2020, the mountain chicken is a flagship species for global amphibian conservation, generating strong motivation among all partners and stakeholders to take the necessary steps to restore the species in the wild.						
1.1	Project 1: Raise and maintain high levels of public awareness and attitudes to the mountain chicken and its conservation issues in the range states						
1.1.1	Use a social anthropologist to design surveys to monitor public awareness and attitudes to the mountain chicken and its conservation on each island around core communities	Medium	ZSL, Durrell, DOE, FWPD, MNT	1-10	Start 2017 then every 2 years	Results from surveys analysed and indicate positive public attitude towards species and projects and changes in behaviour (e.g. hunting, forest use)	Lack of funding
1.1.2	Develop a comprehensive awareness raising strategy for both Montserrat and Dominica which identifies key target audiences and key conservation messages	Medium	DOE, FWPD, MNT, MCRP all	1-10	2017; reviewed every 5 years	Awareness raising strategy reviewed in line with results from survey	
1.1.3	Deliver key activities as identified in the awareness raising strategy to increase public awareness and improve attitudes to the mountain chicken and conservation projects	Medium	DOE, FWPD, MNT, MCRP, all	1-10	2017-2033 annual	Successful completion of key activities outlined in strategy; positive results from surveys	Sensitisation fatigue Awareness may not change behaviour A lot of groundwork done (esp. in Montserrat) to build on
1.1.4	Develop a local education programme for both Montserrat and Dominica that develops over time with project results (review and integrate within national curriculum)	Medium	DOE, FWPD, MNT, Ministry of Education, MCRP, all	1-10	2017-2033 annual	Education materials and structured classes are designed and incorporated into national curriculum in all primary schools in MNI and key identified schools in DOM.	DOE staff have previous experience of developing educational programmes for schools
1.1.5	Implement 2 joint 'Pride' campaigns one in each decade (before 2018, after 2023) with clear aims identified, in both islands.	Low	DOE, COD, Durrell, ZSL	10-50	2018; 2033	Materials, events held during campaign raise pride and understanding assessed through awareness surveys etc	

Objective 1. By 2020, the mountain chicken is a flagship species for global amphibian conservation, generating strong motivation among all partners and stakeholders to take the necessary steps to restore the species in the wild.

No.	projects and Activities	Priority	Responsible Agencies	Cost (USD k)	Timing	Measurable Indicators	Risks and opportunities
1.2	Develop and implement an international communications strategy						
1.2.1	Develop an international communications strategy through a participatory workshop attended by marketing staff from local and international partners	High	Durrell, ZSL, Chester, MCRP	1-10	2014; reviewed every 5 years	Workshop report and communications strategy printed and published online	
1.2.2	Key partners of MCRP to attend and present to at least 10 key global and regional conservation meetings to highlight project results and impacts	High	Durrell, ZSL, Chester, MCRP	1-10	2014-2033	Attendance at international and regional workshops.	
1.3	Develop the global programme steering committee (PSC) to guide the implementation of operational plans and monitor the progress towards the Goal of the Long-Term Recovery Plan						
1.3.1	All MCRP partners review, revise (if necessary) and adopt TOR / MOU	Critical	Durrell, ZSL, DOE, FWPD	0-1	2014	TOR / MOU signed and adopted by all MCRP member organizations	
1.3.2	Invite minimum of two influential external conservationists to sit on the PSC	Medium	Durrell, ZSL, DOE, DFWNP	1-10	2015	Written reviews.	
1.3.3	Hold annual project meetings with all partners	High	Durrell, ZSL, DOE, FWPD, Nordens Ark	1-10	2014 then annually	Meeting reports	
1.3.4	Set the 5 year operation plan for the MCRP	Critical	MCRP, all	-	2015 then every 5 years	Operation plan implementation shows effective use and delivery of plan's objectives	
1.3.5	Publish annual project report online	Medium	MCRP, all	0-1	2014 then annually	Report online	

Objective 1. By 2020, the mountain chicken is a flagship species for global amphibian conservation, generating strong motivation among all partners and stakeholders to take the necessary steps to restore the species in the wild.

No.	projects and Activities	Priority	Responsible Agencies	Cost (USD k)	Timing	Measurable Indicators	Risks and opportunities
1.3	Develop the global programme steering committee (PSC) to guide the implementation of operational plans and monitor the progress towards the Goal of the Long-Term Recovery Plan						
1.3.6	Presentations to range state government cabinets on project progress	High	DOE, FWPD, international partners	1-10	2014 then every 3 years	Reports	
1.4	Establish training programme for range-state partners						
1.4.1	Training needs assessment completed and used to develop a training programme for the range-state partners	High	Durrell	1-10	2014; then every 3 years	Training needs assessment	
1.4.2	Training programme developed and delivers ongoing training to projects	High	Durrell, Chester, ZSL, DOE, FWPD, MNT	10-50	2014-2033	Courses completed by range-states staff, reports from visits by overseas staff to range states etc	High staff turnover limits impacts or use of skills
1.4.3	One person from range states on graduate level course (and internship) every 3 years	Low	Durrell, DOE, FWPD, MNT	1-10 per person	2020	Course attendance records and post-course skills development identified.	No suitable candidates identified
1.4.4	Manage an ongoing volunteer programme on each island to support conservation efforts including summer attachments from secondary school/college to local partners	Medium	MCRP, CCC	1-10 per person	2014-2033	Volunteer/intern attendance; Articles and training (in line with TNA) are delivered by volunteers	CCC in place Seek support from European Voluntary Scheme (EVS), British Council

Objective 1. By 2020, the mountain chicken is a flagship species for global amphibian conservation, generating strong motivation among all partners and stakeholders to take the necessary steps to restore the species in the wild.

No.	projects and Activities	Priority	Responsible Agencies	Cost (USD k)	Timing	Measurable Indicators	Risks and opportunities
1.5	Develop and implement a 5 year fundraising strategy						
1.5.1	Identify local, regional and international funding sources for project activities under the plan	Critical	ZSL, Durrell	0-1	2014	A list of potential funding sources	
1.5.2	Develop a zoo-based supporters programme	High	Chester, Durrell	1-10	2014–2016	Network of zoos: providing annual financial support.	May not be priority fund-raising project for some zoos
1.5.3	Annual budgeting for next year's project costs	Critical	MCRP PSC	0-1	Annually starting 2014	Budgets available for submission to donors	
1.5.4	Seek local sponsors for awareness programmes in Montserrat and Dominica	Medium	DOE, FWPD MNT	0-1	Annually starting 2015	Local companies using the mountain chicken in marketing and supporting the project	
1.5.5	Develop and submit at least 3 funding proposals per year	Critical	Durrell, ZSL	1-10	Annually starting 2014	Proposals submitted	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 2	By 2028, research has discovered or developed method(s) to mitigate the impact of <i>Bd</i> on mountain chickens in the wild						
2.1	Develop Research Strategy to guide ex situ and in situ research efforts						
2.1.1	Complete analysis and publish results of fungicide treatment trials	High	ZSL, Durrell	Un-certain	2014	Peer reviewed paper published	PhD student in place
2.1.2	Complete analysis and publish results of data collected during the Montserrat Darwin project in line with Chytrid Ecology PhD	Critical	ZSL, Durrell	Un-certain	2014-2015	Peer reviewed paper published	4 th release delayed to 2014 PhD student in place
2.1.3	Develop a Research Strategy and adaptive management plan through a participatory workshop that includes <i>ex situ</i> research and in situ management	Critical	ZSL, Durrell, Chester	1-10	2015	Research strategy Release Plan Workshop report/minutes	
2.1.4	Review progress of the Research Strategy at annual MCRP meetings	High	Durrell, ZSL, Chester, GOM, COD	1-10	2014-2028	Meeting minutes/Reports	
2.2	Support the Release Plan in developing methods to mitigate the impact of <i>Bd</i> through the analysis of data produced by adaptive management trials						
2.2.1	Purchase, install and man a qPCR machine in Dominica to handle swabs from region	Medium	COD, ZSL	>50	by 2015	Real-time qPCR machine purchased and functioning in lab in Dominica Trained personnel employed in lab.	
2.2.2	Analyse data collected during experimental releases under Objective 3 and feed results back into Release Plan.	Critical	ZSL, Durrell, GOM, COD	>50	2028	Papers published Reviewed release plan Management methods adapted	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 2	By 2028, research has discovered or developed method(s) to mitigate the impact of <i>Bd</i> on mountain chickens in the wild						
2.2	Support the Release Plan in developing methods to mitigate the impact of <i>Bd</i> through the analysis of data produced by adaptive management trials						
2.2.3	Analyse data collected from identified <i>Bd</i> refugia sites and feed results back into Release Plan. Analyse radiotracking and <i>Bd</i> sampling collected in adaptive management plan	Critical	ZSL, Durrell, GOM, COD	>50	2028	Papers published Reviewed release plan	
2.3	Investigate factors affecting mountain chickens' survival and response to <i>Bd</i> in the wild						
2.3.1	Conduct longitudinal population monitoring and <i>Bd</i> sampling of surviving mountain chickens on Montserrat and Dominica to increase understanding of the interaction between mountain chickens and <i>Bd</i> and investigate infection dynamics in the wild	Critical	ZSL, Durrell, DICE, DOE	>50	2014-2028	Longitudinal data available Peer reviewed papers published	No surviving frogs Volcanic activity restricting access Protocols and staff training in place.
2.3.2	Conduct longitudinal sampling of sympatric amphibians in Montserrat and Dominica to increase understanding of infection dynamics of <i>Bd</i> and amphibians in Montserrat and Dominica	Critical	ZSL, Durrell, DICE, DOE	>50	2014-2028	Longitudinal data available Peer reviewed papers published	No surviving frogs Volcanic activity restricting access Protocols and staff training in place.
2.3.3	Conduct longitudinal recording of key environmental data at sampling sites on Montserrat and Dominica	High	ZSL, Durrell, DICE, GOM	>50	2014-2028	Data available Peer reviewed paper published	Volcanic activity restricting access Collection of some parameters already in place.

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 2	By 2028, research has discovered or developed method(s) to mitigate the impact of <i>Bd</i> on mountain chickens in the wild						
2.4	Investigate genetic and behavioural factors affecting mountain chickens' survival and response to <i>Bd</i>						
2.4.1	Capture and analyse samples collected from surviving frogs in Montserrat and Dominica and from those that died of chytridiomycosis	Critical	ZSL	10-50	2015-2020	Data available Peer reviewed paper published	Incorrect genetic factors tested
2.4.2	Investigate links between differences in Montserrat and Dominica genes and survival	High	ZSL	1-10	2020	Published papers/ dissertations	Availability of samples, quality of analyses
2.4.3	Investigate impacts of bottlenecks on mountain chicken survival	High	ZSL	1-10	2020	Published papers/ dissertations	Availability of samples, quality of analyses
2.4.4	Conduct <i>ex situ</i> behavioural study	Medium	Durrell, Chester, ZSL	1-10	2015-2020	Data available	Captive populations (biosecure and non-biosecure) available
Obj. 3	Establish growing populations of mountain chickens at 5 sites on each island through a combination of in situ and ex situ management						
3.1	Develop a Release Plan based on research and adaptive management to guide experimental management activities and monitor progress towards achieving established growing populations of mountain chickens in the wild						
3.1.1	Develop Release Plan during participatory workshop which incorporates results from research strategy and adaptive management techniques	Critical	Durrell, ZSL, Chester, GOM, COD	1-10	2015	Release plan Workshop minutes	
3.1.2	Review Release Plan at annual partners meetings to include results from research and management activities Include Release Plan in fundraising plan and operational plan	High	Durrell, ZSL, Chester, GOM, COD	1-10	2014 then annually	Meeting reports	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 3	Establish growing populations of mountain chickens at 5 sites on each island through a combination of in situ and ex situ management						
3.1	Develop a Release Plan based on research and adaptive management to guide experimental management activities and monitor progress towards achieving established growing populations of mountain chickens in the wild						
3.1.3	Create a risk assessment to be conducted before each proposed in situ management action	High	Durrell, ZSL, Chester, GOM, COD	1-10	2015	Risk assessments	
3.1.4	Identify at least 5 sites per island suitable for the establishment of mountain chicken populations and put measures in place to protect if necessary	Critical	GOM, COD, ZSL, Durrell, Chester	1-10	2016	Site reports Protective legislation Media from public engagement	
3.1.5	Deliver a population viability assessment to guide the numbers of mountain chickens that will need to be released to establish a growing population at each of the 5 sites	High	Durrell, ZSL, Chester, GOM, COD, DICE	1-10	2016	Published report on modelling	Demographic data may not be available to construct PVA
3.1.6	Develop appropriate population indices to assess status at each site	Critical	Durrell, ZSL	10-50	2020	Statistical analyses and reports on population status produced	Sample sizes or model assumptions not met
3.1.7	Create habitat suitability assessments for both Montserrat and Dominica incorporating results from research conducted on environmental data	Critical	GOM, COD, ZSL, Durrell	1-10	2016	Report and data on assessed habitats	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 3	Establish growing populations of mountain chickens at 5 sites on each island through a combination of in situ and ex situ management						
3.2	Conduct experimental releases of captive bred mountain chickens into <i>Bd</i> positive sites on both islands to test release and management methods proposed by the research strategy and release plan						
3.2.1	Identify at least one suitable test release site in Montserrat and Dominica that will allow intensive monitoring	High	Durrell, ZSL, GOM, COD	1-10	2016	Assessment criteria Reports Test release sites identified	
3.2.2	Develop rigorous transportation and holding protocols if bringing captive animals for release from overseas	High	Durrell, Chester, ZSL	1-10	2014	Transportation and holding protocols for both Montserrat and Dominica	
3.2.3	Develop intensive monitoring techniques (radio-tracking etc) of released and surviving mountain chickens including testing monitoring methods identified by 4.6.3	High	Chester, Durrell, ZSL	1-10	2018	Monitoring protocols developed Improved monitoring data collection	No experiments or research questions forthcoming from researchers or field staff. Lack of capacity and resources to conduct trials.
3.2.4	Facilitate at least 2 visits from local forestry staff between islands during releases to increase training and skills	High	GOM, COD, ZSL, Durrell	1-10	2016	Visit reports	High staff turnover means benefits from visits are lost Some exchange visits have already taken place
3.2.5	Develop communications structure between field managers and researchers to facilitate the exchange of data and results to ensure these feed back into the adaptive release plan	High	Durrell, ZSL, Chester, GOM, COD	1-10	2014, then annually	Drop boxes Email lists Reports Results Reviewed adaptive management plan	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 3	Establish growing populations of mountain chickens at 5 sites on each island through a combination of in situ and ex situ management						
3.3	Release mountain chickens in <i>Bd</i> free refugia sites identified on Montserrat and Dominica						
3.3.1	Identify and sample potential refugia sites within historical range for presence of <i>Bd</i> and assess suitability for release of mountain chickens	High	GOM, COD, ZSL, Durrell	1-10	2018	Results from <i>Bd</i> sampling Habitat suitability assessments	
3.3.2	Use infrastructure provided by project 3.2 to support test releases into <i>Bd</i> refugia sites and post-release monitoring	High	Durrell, ZSL, GOM, COD	1-10	2020	Release reports Monitoring data from surviving mountain chickens	
3.3.3	Use results from test releases to assess management needs of surviving populations and implement if necessary	High	Durrell, ZSL, GOM, COD	1-10	2025	Report from test releases Management protocols developed	
3.4	In situ management of surviving mountain chickens in Montserrat and Dominica						
3.4.1	Create and conduct risk assessments for at least 2 different management options to protect and improve survival of established, non-released wild mountain chickens (considerations include predator control, moving surviving mountain chickens together, treatment pools etc.)	High	Durrell, ZSL, GOM, COD, Chester	1-10	2015	Testable management options identified and included in release plan and operational plan	
3.4.2	Based on results of risk assessment, implement testing of management options on surviving mountain chickens with guidance from the research strategy	Critical	Durrell, ZSL, GOM, COD, Chester	10-50	2018		

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 4	An <i>ex situ</i> breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met						
4.1	Evaluate the genetic health and viability of the quarantine breeding population.						
4.1.1	Using microsatellites developed for mountain chickens assess the level of genetic variability within and between populations in each island.	High	ZSL, Durrell, Chester	10-20	2014-2016	Genetic study completed and report delivered to partners.	The microsatellites have been developed already
4.1.2	Run a comparison analysis of the identities of biological samples held and their representation within the studbook.	High	ZSL, Durrell, Chester	10-20	2014-2016	Collated spreadsheets showing individual identities and what data we hold on each frog.	Staff time needed to run this Could be a volunteer or intern role to collate data
4.1.3	Assess the level of genetic variability captured within the quarantine and non-quarantine breeding populations.	High	ZSL, Durrell, Chester	10-20	2014-2016	Analyses completed and report published	Funding and student availability
4.1.4	Using population modelling tools assess the demographic viability of the captive populations of mountain chickens.	High	ZSL, Durrell, Chester	10-20	2014-2016	Analyses completed and report published	Funding and student availability
4.1.5	Identify and set breeding and institutional targets for the quarantined breeding programme.	High	ZSL, Durrell, Chester	0-1	2014-2016	Recommendations developed from research and adopted by partners	
4.1.6	Identify the need and feasibility of introducing genes (individuals) from the non-quarantine population into the quarantine breeding programme to increase genetic variation.	Medium	ZSL, Durrell, Chester	1-10	2015	Analysis and short workshop completed with recommendations adopted by partners	Lack of engagement from non-quarantined holding institutions. Lack of funding to facilitate the movement of animals.

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 4	An <i>ex situ</i> breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met						
4.2	Increase the breeding success of the quarantine population to reach the output target of 100 animals from at least 3 clutches per year						
4.2.1	Identify the housing conditions needed to maximise breeding success within mountain chickens and publish as husbandry guidelines.	High	Durrell, ZSL, Chester,	1-10	2014-2016	Report completed and presented to partners. Husbandry protocols changed to reflect recommendations	Lack of capacity to lead the analysis and deliver recommend actions
4.2.2	Explore the role that cross-fostering can play in integrating offspring from genetically important individuals.	Low	Chester, Durrell, ZSL	1-10	2015	Experiments completed and results written up and published	Lack of capacity or resources to conduct trials.
4.2.3	Within existing conditions, prioritise breeding efforts for key F0 individuals and then within 2-5 years focus on breeding F1, following results of Activity 4.1.	High	Durrell, ZSL, Chester,	10-20	2014-2016	Increase in breeding success among remaining F0 frogs.	
4.2.4	Ensure that there is a central group of 5 international partner institutions supporting breeding efforts for the quarantine breeding programme.	High	Chester, all partners	1-10	2014-2016	5 partner institutions actively engaged and managing frogs.	Lack of institutional buy-in.
4.3	Establish captive breeding centres within the mountain chicken range states						
4.3.1	Identify a location within Montserrat for the establishment of a breeding centre and agree parameters with local partners	High	Durrell, GOM, MNT	1-2	2014-2017	Site located in Montserrat and funds secured to build centre by 2016.	Site not available, lack of funds to build a centre, lack of capacity to staff the centre.
4.3.2	Test the feasibility of transferring the live food cultures developed in Dominica to Montserrat	High	Durrell, GOM, MNT, ZSL, COD	1-10	2014-2016	Sustainable live food cultures active in Montserrat, with Dominican assistance.	Montserrat cultures have to be started and take a long time to become sustainable.

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 4	An <i>ex situ</i> breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met						
4.3.3	Support regular exchange of staff between Montserrat and Dominica to build local husbandry skills within Montserratian team	Medium	Durrell, GOM, MNT, ZSL, COD	1-10	2014-2024	Annual exchanges are active between the two islands (and visit reports produced)	No staff available to make the exchange or lack of funds to support the trips.
4.3.4	Develop capacity within Dominica to breed mountain chickens within the established centre.	Medium	COD, ZSL, Chester, Durrell, GOM	1-10	2014-2016	Frogs breed in the centre and staff able to provide essential care.	
4.3.5	Provide expert training and regular reviews to support the development of capacity within the breeding centres.	High	Durrell, ZSL, Chester, GOM, MNT, COD	10-20	2014-2024	Annual review mission sent from international partners to either Montserrat and/or Dominica to help evaluate performance of centres.	Lack of funds or capacity to send staff to the in situ captive breeding centres.
4.4	Lead the management of the quarantine and non-quarantine breeding programmes to ensure committed engagement among existing and new partners						
4.4.1	Manage the population as an EAZA EEP and develop an international studbook for the species.	Medium	Chester, Durrell, ZSL, GOM, COD	1-2	2014	EEP active and reporting regularly at EAZA meetings.	Lack of capacity to complete and maintain process
4.4.2	Develop and test a voluntary funding mechanism for holding institutions to contribute to the management of the species.	Medium	Chester, Durrell, ZSL, GOM, COD	1-2	2014-2016	Funds generated through studbook institutions support field conservation	Institutions not willing to contribute financially. Lack of incentive to support institutions to join.
4.4.3	Engage institutions to act as rearing facilities to hold juvenile mountain chickens bred within the programme.	High	All partners	1-5	2014-2019	At least 2 institutions are holding juvenile frogs by the end of 2015	No frogs to give to institutions; lack of engagement from institutions to hold juvenile frogs.

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 4	An <i>ex situ</i> breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met						
4.4.4	Develop and implement an agreement with rearing institutions concerning the management of the frogs	High	All partners	0 -1	2015-2020	At least 2 agreements signed with holding institutions	No frogs to give to institutions; lack of engagement from institutions to hold juvenile frogs.
4.4.5	Use both the non-quarantine and quarantine populations to support the delivery of research identified within Objective 2	Medium	All partners	5-10	2015-2025	At least 2 institutions are contributing frogs or samples to support research projects by 2015.	Lack of ethical approval from contributing institutions, lack of willingness to contribute frogs, lack of engagement from research community.
4.4.6	Develop protocols and policy on management of offspring within the captive population and endorsed by range states	High	Durrell, ZSL, Chester, GOM, MNT, COD	0-1	2014	Protocol completed and approved by all partners.	Failure to agree between captive institutions and range state partners.
4.5	Ensure the highest veterinary and health standards are maintained within the quarantine captive breeding programme						
4.5.1	Develop and publish a set of minimum standards agreed between vets for transport of animals between biosecure facilities and have them endorsed by range states.	Medium	Durrell, ZSL, Chester, GOM, MNT, COD	1-2	2014	Standards written, agreed with range states and published.	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 4	An <i>ex situ</i> breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met						
4.5.2	Maintain regular (annual/biannual) health -screening for the captive institutions	High	Durrell, ZSL, Chester, GOM, MNT, COD	5-10	2014-2024	Regular health screening reports submitted to partners.	Lack of resources or common protocols to ensure comparable assessments.
4.5.3	Provide regular training for veterinary staff in Montserrat and Dominica, or identify regional veterinary expertise that can support the development of capacity within the two islands.	Medium	Durrell, ZSL, Chester, GOM, MNT, COD	5-10	2016-2021	At least one veterinary staff member from each of Montserrat and Dominica receives formal training within partner institutions.	Lack of staff available to receive training; lack of funds to support training.
4.6	Explore broader possibilities for the captive programme to support the restoration of the species in the wild.						
4.6.1	Scope the feasibility of engaging historic range state countries in the captive breeding of mountain chickens	Medium	Chester, ZSL, Durrell	5-10	2015-2017	Scoping trip report complete and recommendations adopted by all partners to hold frogs in a former range state.	No suitable partners identified.
4.6.2	Test effective methods to transport frogs internationally that minimises the risk of injury or death during the shipping process.	High	ZSL, Durrell, Chester	1 - 5	2014	Appropriate shipping method identified and tested by return transport to Montserrat or Dominica	No suitable methods can be identified due to a lack of time, capacity or funds to test the approach. Ethics committees / Veterinary authorities refuse permission to transport animals.

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 4	An <i>ex situ</i> breeding programme remains operational, both within and outside of range state countries, until the other objectives of this plan have been met						
4.6.3	Support the evolution of field monitoring techniques using animals within the captive collections of participating institutions.	Low	Durrell, ZSL, Chester, GOM, MNT, COD	1 - 10	2015-2018	Specific experimental designs identified and tested with results applied to field monitoring.	No experiments or research questions forthcoming from researchers or field staff. Lack of capacity or resources to conduct trials. Lack of ethical approval
4.6.4	Within the international zoo network, raise the profile of the mountain chicken as a flagship species for zoo-based conservation efforts.	High	Durrell, ZSL, Chester, GOM, MNT, COD	1 - 10	2014-2024	At least one annual presentation at a zoo/conservation event by partners. Communications distributed through third party networks to peer institutions.	Lack of willingness from third parties to host talks or distribute communications. Lack of capacity or funds to prepare necessary communications.
Obj. 5	The moratorium on hunting in Dominica and Montserrat is maintained and enforced over the lifetime of this plan.						
5.1	Moratorium on hunting maintained in Dominica and Montserrat at least until the goal of this 20 year strategy is met	Critical	COD, GOM	0-1	2014-2034	Moratorium recorded in Government Gazettes	
5.2	Enact environmental legislation	Medium	COD, GOM	0-1	2014 in Montserrat † 2016 in Dominica	Legislation enacted	
5.3	Patrols and surveillance for hunting activity	Medium-Low	COD, GOM	1-10	2017-2033 annual	Patrol reports Hunting activity statistics	

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
5.4	Public awareness campaign on the need to suspend hunting and eating mountain chickens	Medium -Low	COD, GOM	1-10	Ongoing	Educational materials; indicators from 5.3 (to show any behaviour changes)	
Obj. 6	The impact (number of deaths of mountain chickens) of invasive species is estimated where possible and does not strongly limit the recovery of the mountain chicken population						
6.1	Impact and risk assessments of invasive species on Montserrat and Dominica	Medium	COD, GOM, Durrell	1-10	2015; review every 5 years	Impact assessments Risk assessments	These have a much wider applicability than mountain chickens
6.2	Response readiness plan including threshold which will trigger response	Medium	Durrell, COD, GOM	1-10	2015; review every 5 years	Response readiness plans incorporated into DOE, FWDP work plans	
6.3	Monitor levels of high risk invasive species at critical mountain chicken sites	Medium	COD, GOM	10-50	Annually	Simple indices of IAS levels accumulated in database	
6.4	Develop a National Invasive Species Strategy (NISS) and enact invasive species legislation	Medium -Low	COD, GOM, Durrell	1-10	2015	NISS's adopted by COD, GOM Invasive species bills enacted by COD, GOM	Templates available from other countries in the region (e.g. Saint Lucia)
Obj. 7	No net loss of mountain chicken habitat due to climate change on Dominica and Montserrat						
7.1	Legislative review	Medium -Low	COD, GOM, legal consultant	1-10	2015	Review assesses current land use and PA management resilience to climate change	This can be incorporated with Activity 5.2
7.2	Awareness campaign on impacts, causes and mitigations of climate change	Medium -Low	COD, GOM, ZSL	1-10	2018	Educational materials Increase in mitigating behaviours by people	Already a priority for COD, GOM

No.	Project and Activities	Priority	Agencies responsible	Cost (USD k)	Timescale	Indicators	Risks and opportunities
Obj. 7	No net loss of mountain chicken habitat due to climate change on Dominica and Montserrat						
7.3	Identify mitigative measures to increase resilience to climate change	Medium-Low	COD, GOM, ZSL, Durrell	1-10	2014 then annually	Meeting reports	Already a priority for COD, GOM
7.4	Train DOE, FWPD staff in climate change mitigative forest management approaches	Medium-Low	COD, GOM, ZSL, Durrell	10-50	2015 then every 5 years	Training needs assessment Training manual Climate change mitigative management built into DOE, FWDP workplans	Already a priority for COD, GOM
Obj. 8	Loss of suitable mountain chicken habitat because of other causes on Dominica and Montserrat is minimized and does not strongly limit the recovery of the mountain chicken population.						
8.1	Produce guidance materials on agricultural (including agroforestry) best practices	Medium-Low	COD, GOM, ZSL, Durrell	1-10	2018	Guidance on subsistence agriculture; agroforestry; pest management; livestock management.	DoE, FWDP and parent Ministries have a lot of existing knowledge and capacity
8.2	Awareness and outreach for staff and public on best practices	Medium-Low	COD, GOM	1-10	2018	Educational materials Increase in mitigative behaviours by people	Could be incorporated with Activity 7.2
8.3	Agreement with MUL to allow 20% runoff of water from capped springs	High-Medium	GOM	0-1	2016	Agreement signed and adhered to	
8.4	Conservation of water use measures in place (Montserrat)	Medium-Low	GOM	0-1	2016	Bottling company protocol operational	

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