

Species Action Plan for the Montserrat Galliwasp



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Trust

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New Information

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Acronyms and abbreviations

CHP	Centre Hills Project
CEMA	Conservation and Environmental Management Act
DOA	Department of Agriculture, Montserrat (MALHE)
DOE	Department of the Environment, Montserrat (MALHE)
Durrell	Durrell Wildlife Conservation Trust
EAZA	European Association of Zoos and Aquaria
FWNP	Forestry, Wildlife, National Parks and Protected Areas Ordinance
GIS	Geographical Information System (software)
GOM	Government of Montserrat
IAS	Invasive Alien Species
IUCN	World Conservation Union
MALHE	Ministry of Agriculture, Land, Housing & Environment, Montserrat
MEEP	Montserrat Environmental Education Project
MNT	Montserrat National Trust
MOU	Memorandum of Understanding
MTB	Montserrat Tourist Board
MUL	Montserrat Utilities
NEMS	National Environmental Management Strategy
PPU	Physical Planning Unit
RSPB	Royal Society for the Protection of Birds
RBG-K	Royal Botanical Gardens, Kew
SAP	Species Action Plan
SGD	St George's Declaration of Principles for Environmental Sustainability
SIG	Species Interest Group

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Foreword

At Home in the Centre Hills

It is some three years since I made my home in Woodlands, in the foothills of the Centre Hills. It is awe inspiring, it is magical. The first week of exploring my garden I uncovered a rock, part of a stonewall. I saw small reptiles darting from under the rock going in separate directions. I did not recognise the species and went searching in various books trying to identify it. These were similar to lizards, but small and brown with no legs or arms. It was some weeks later before I found out they were young Montserrat galliwasp, a very rarely seen and poorly documented species.

During the next few weeks I saw a small number of galliwasp, from distance, but sadly as I made myself more at home, they made themselves scarcer, and no doubt the arrival of my two dogs from Montserrat Animal Protection Society's dog shelter did not help.

The Hills contain many interesting habitats and animals. From the large nocturnal gecko (locally known as a wood slave) to the tiny pygmy gecko, the Montserrat oriole and, of course, the elusive Montserrat galliwasp. In trying not to change the terrain where I now live, but make it pretty enough to be bring a different kind of wonderness from the immediate surroundings, I realised there were also many species of plants shrubs that were not known to me. You only have to walk a few yards from the residences at Woodlands to feel as if you are in a different world.

Again this is the wonder of Montserrat and the Centre Hills. It is place that we are to treasure for generations to come. We must all learn to respect the environment, we must also be mindful that animals we domesticate do not in time destroy the natural habitat of the Centre Hills and endanger species such as the Montserrat galliwasp which could so easily be lost to us forever.

The efforts of this project, sponsored by the UK Government's Overseas Territory Environment Programme and the Balcombe Trust, and all those who have worked on producing this plan, are vital. But most of all, it is the residents, present and future, of Montserrat – and especially Woodlands – whose support will be essential if we are to save animals like the Montserrat galliwasp.

Dulcie James

Woodlands resident

Montserrat Animal Protection Society

Executive summary

The Critically Endangered Montserrat galliwasp is found only on Montserrat and, even here, is known only from a tiny area – Woodlands Estate – of a few hectares. With funding from the Overseas Territories Environment Programme (OTEP), this SAP was developed at a participatory workshop in Montserrat, as a five-year plan of action to ensure the future conservation of the mountain chicken. The workshop was attended by Montserratian and UK experts and other stakeholders. The workshop was supported by an intensive field effort to assess the status of this species in 2007-08. Its biology and ecology, however, remain largely unknown. Consequently, this Species Action Plan (SAP) also assesses findings from a review of all 44 known galliwasp species in the hope of gleaned additional insights into the requirements of the Montserrat galliwasp and the threats facing it.

The SAP summarises the current state of knowledge of the Montserrat galliwasp's population status, taxonomy and ecology, and of the threats facing it, making inferences from what is known of the biology of other galliwasp species when little or no data on the Montserrat galliwasp is available. The plan describes the institutional framework for conservation management in Montserrat. It lists the key stakeholders in the Plan, and the opportunities for, and threats to the Plan's progress. A Problem Tree and Solutions Tree are used to describe key problems affecting the species, and their solutions. Finally, the vision, aims, objectives and activities of the Plan are reported. Each activity has a responsible institution(s), an approximate costing, and a time-frame.

The Montserrat galliwasp's Critically Endangered status is conferred by the species' tiny global range, at a single known location. Threats are not known, but potential threats are discussed in detail in this SAP. It seems most likely that the most important threats to the survival of this species are the depredations of introduced predators and the modification and loss of habitat, primarily at Woodlands Estate, for residential development.

The Plan's Vision is of "a secure, self-sustaining population of wild Montserrat galliwasp, co-existing with people, and nationally and globally valued" Its aim is to "increase the size of the Montserrat galliwasp's global range and establish an *ex situ* breeding programme" over the next five years. The main objectives, to be achieved by 2016 are to:

1. Raise national and international awareness of the value and status of the Montserrat galliwasp and its habitat to ensure support for, and participation in, conservation activities.
2. Manage the Forest Reserve, plus additional land outside the Forest Reserve – through acquisition and/or agreement – by a community based organization (CBO) facilitated by DOE.
3. Reduce the impact of invasive alien species (IAS) on Montserrat galliwasp by establishing a fenced reserve free of target species.
4. Establish a captive-breeding programme, with trained staff, in Montserrat with the aim of releasing galliwasp into the wild in Woodlands and/or a second site.
5. Declare a Montserrat galliwasp reserve in the Woodlands area, under the CEMA (Conservation and Environmental Management Act).
6. Develop a research and a monitoring scheme to underpin management decisions and allows success to be monitored.

It is recognized that the third objective needs to be carefully scoped to determine whether it is financially and logistically feasible. In the event it proves not to be, an alternative objective of reducing IAS impacts on galliwasp through IAS control is suggested.

1. Introduction

The Montserrat galliwasp, *Diploglossus montisserati*, is a nocturnal lizard that lives in amongst the leaf litter and rock crevices of Montserrat's mesic forest. It is the only member of its family to occur in the Lesser Antilles. Since its discovery in the 1960s there have been only twelve confirmed sightings and almost nothing is known about its biology and behaviour.

This endemic lizard is currently listed as 'Critically Endangered' (i.e. "facing an extremely high risk of extinction in the wild" IUCN 2001). This is because the known population is believed to be only found within a 1.5ha area, making it one of the world's most restricted vertebrate species. Its highly limited range is likely due to intensive predation from introduced species such as rats, cats, and feral pigs. Suitable habitat is also threatened by encroaching urban development, capping of streams for human consumption, and volcanic activity. Further research on the ecology and conservation needs of this little-known species is essential. All available evidence, however, strongly suggests the Montserrat galliwasp is on the brink of extinction and conservation action to improve its status is urgently required.



A glimpse of a Montserrat galliwasp in the Woodlands area in 2006. Photo: A. Ogradowcyk / Durrell

A Species Action Plan (SAP) is a 'scientifically authoritative, strategic document that defines specific, measurable objectives and actions for conserving priority species. It should be achievable, time-bound and involve all appropriate stakeholders'. An SAP aims to increase the effectiveness of conservation action by taking a strategic approach to the problem, setting clear, measurable targets and involving all relevant stakeholders.

The Species Action Plan for the Montserrat galliwasp was developed at a participatory workshop, held in April 2008 in Montserrat. A wide range of interests was represented at the workshop, reflecting the many links between the species, its environment, and Montserratian society. Effective implementation of this plan will need the support of Montserratian government and civic society, with the assistance of international partners.



The Centre Hills forest after heavy ashfall from the Soufriere volcano. Photo: S.L. Smith / Durrell

2. Background information

2.1 Taxonomic status and biogeography

The galliwasp is a member of the widespread lizard family the Anguillidae, or “glass lizards”, found in Europe, Asia, Southeast Asia, the Americas and the Caribbean (JCVI 2010). Their smooth glossy skin gives them the name glass lizards, with many having small limbs, or even lacking limbs altogether, and using snake-like movements of the body to move around. The Anguillidae consists of approximately 120 species (JCVI 201) grouped into three sub-families: the Anguillinae (including glass lizards and slow worms), the Diploglossinae (the galliwasp and glass snakes), and the Gerrhonotinae (the alligator lizards).

The Montserrat galliwasp, *Diploglossus montisserrati*, was first described by Underwood (1964) from a single specimen collected at Woodlands Spring, Montserrat and is only known from this island. Beyond this original description, and a recent note on a few observations by Ogradowczyk et al (2006), nothing further has been published on the

species. Given this paucity of information, background information was evaluated on all 44 galliwasp species in the hope that similarities within this group will provide some insights into the Montserrat galliwasp until such time as more data is available on this enigmatic species.

It should be noted, however that a dearth of information appears to exist for almost all the 44 galliwasp species currently described. What data has been located by the current authors is summarized in Annex 6, with the proviso that access to some literature was not available to us.

For the purposes of this document, the word “galliwasp” – of Jamaican origin (Cassidy & Le Page 1980) – is taken to include all the species of two of the three genera in the Diploglossinae: *Celestus* (33 species, including one extinct species, *C. occiduus* from Jamaica) and *Diploglossus* (11 species). These two genera include all the Diploglossines found in the West Indies. The lizards in these two genera have limbs, albeit small, whilst the four species of *Ophiodes* (glass snakes) that make up the third genus in this subfamily are near-limbless.



Fig 1: Photos to illustrate some of the larger (“giant”) galliwasp (see section 2.3.1). Clockwise from top left: dotted galliwasp, *Diploglossus millepunctatus*, Malpelo Island, Colombia (no credit); A preserved specimen of the extinct Jamaican giant galliwasp, *Celestus occiduus*, last recorded in 1840; *D. monotropis*, male, Central and South America (both photos: D. McGinnity / Nashville Zoo); Montserrat galliwasp (photo: K. Buley, Durrell).

During the 20th Century, there was some uncertainty about which species within *Celestus* and *Diploglossus* belonged in which genus (Savage et al 2008) and a number of species are referred to by different authors in both genera at different times. The classification of Savage et al (2008), which allocated species according to whether their claws are sheathed by scales (*Celestus*) or not (*Diploglossus*), is largely consistent with Henderson & Powell (2009), Hedges (2010) and JVC1 (2010). It is followed here, but with the minor exceptions noted in Annex 5.

The galliwaspas are well represented within the West Indies, with 21 *Celestus* and 5 *Diploglossus* species (64% and 45% of each genus respectively) being found in the region. All of these 26 West Indian galliwaspas are single island endemics (though some are found, as well or instead, on offshore islets of these islands). Some of the Western Caribbean islands have multiple endemic galliwaspas (12 species on Hispaniola, 8 on Jamaica – one extinct – and 3 on Cuba). Puerto Rico and the Cayman Islands (Little Cayman, Cayman Brac) have a single endemic galliwasp each, with the Montserrat galliwasp being the only Eastern Caribbean species. The remaining 18 galliwaspas (41% of all galliwaspas) are found in Central and South America, many with restricted distributions and one, *C. millepunctatus*, being another single island endemic (restricted to Malpelo Island, Columbia).



Fig. 2. Montserrat galliwasp photographed at Woodlands 2005, April 2005, 11:48. Photo: B. Beattie

Underwood (1964) notes a number of anatomical resemblances with the Montserrat galliwasp and the rose-sided galliwasp *D. monotropis* (Figs. 1, 3), known from Central and South America, and proposes they may share a common mainland ancestor. Hass et al (2001) and Savage et al (2008) conclude the two major groupings within the West Indies are the two genera *Diploglossus* and *Celes-*

tus. As the only recorded Eastern Caribbean galliwasp, Underwood (1964) describes the Montserrat galliwasp as a relict and suggests it may be “a survivor of the pluvial period, which has persisted in a favourable habitat in spite of the recent climatic changes”. Underwood also speculates it may once have occurred on other Eastern Caribbean Leeward Islands with moist forest, at least before the introduction of small Asian mongooses (*Herpestes javanicus*), although he presents no evidence for this.



Fig. 3. *D. montropis*, female (see also Fig. 1: male). Photo: G. McGinnity / Nashville Zoo.

Breuil (2002), however, has suggested that a species of Anguid lizard once resided in Guadeloupe based on his study of the texts and plates of Rochefort (1658) and Du Tertre (1667). Du Tertre (1667) described “skinks” on Guadeloupe which are (in loose translation)

“fleshier than other lizards, have larger tails, and short legs that they use to crawl against the earth. Their skin is covered with an infinity of small scales like grass snakes, but they are of a more yellow colour, more silvery and shinier, as if they had been greased in oil”.

Breuil (2002) cites Daudin (1802) considering the descriptions of Rochefort (1658) and Du Tertre (1667) as being of “a large Jamaican gally-wasp skink” (see Fig. 4).

In a similar vein, Burton (1711) describes the “Land-Pike” from Nevis as a

“strange Reptile so called from its likeness to that Fish, but instead of Fins it hath four Feet, which are so weak that they only crawl on the Ground, and wind their Bodies as Pikes newly taken

out of the Water, the longest are about sixteen Inches and proportionably big; their Skin is covered with little Scales which shine extreamly, and are of a silver grey colour, in the Night they make a hideous Noise from under the Rocks, and the Bottoms of hollow places where they are lodg'd; it is more sharp and grating to the Ear than Frogs or Toads, and they change their Notes according to the Variety of the Place where they lurk, they are seldom seen before Night, and when met in the Day their Motion is apt on a sudden to affright the Spectator."

This description contains a number of correspondences with reported aspects of galliwasp biology (see below) although no other reports of vocalisations, for any galliwasp species, have been found. Rochefort (1658) also provides an illustration (reproduced in Breuil 2002, p. 16) of a "brochet de terre" (land pike).

The origin of the common name galliwasp is unclear. Cassidy & Le Page (1980) note similarities to Spanish American terms for lizards *garrobo* and *guaripéte*, but also the old English verb *gally* to scare or frighten. This may stem from the mistaken belief that these lizards are venomous with a lethal bite (Shaw 1802; Lynn & Grant 1940, cited in McGinnity 2002). *D. monotropis* is known in Panama as *escorpion coral* or *madre de culebra* and *madre (de) coral*, the latter two names meaning "mother of coral snakes" (Myers 1973). Locally, the Montserrat galliwasp is sometimes referred to as "snake with leg" because of its serpentine body and movements, though it is probably stretching a point to refer to this a "common" name as very few Montserratians report ever having seen a galliwasp (Willock & Williams 2006).

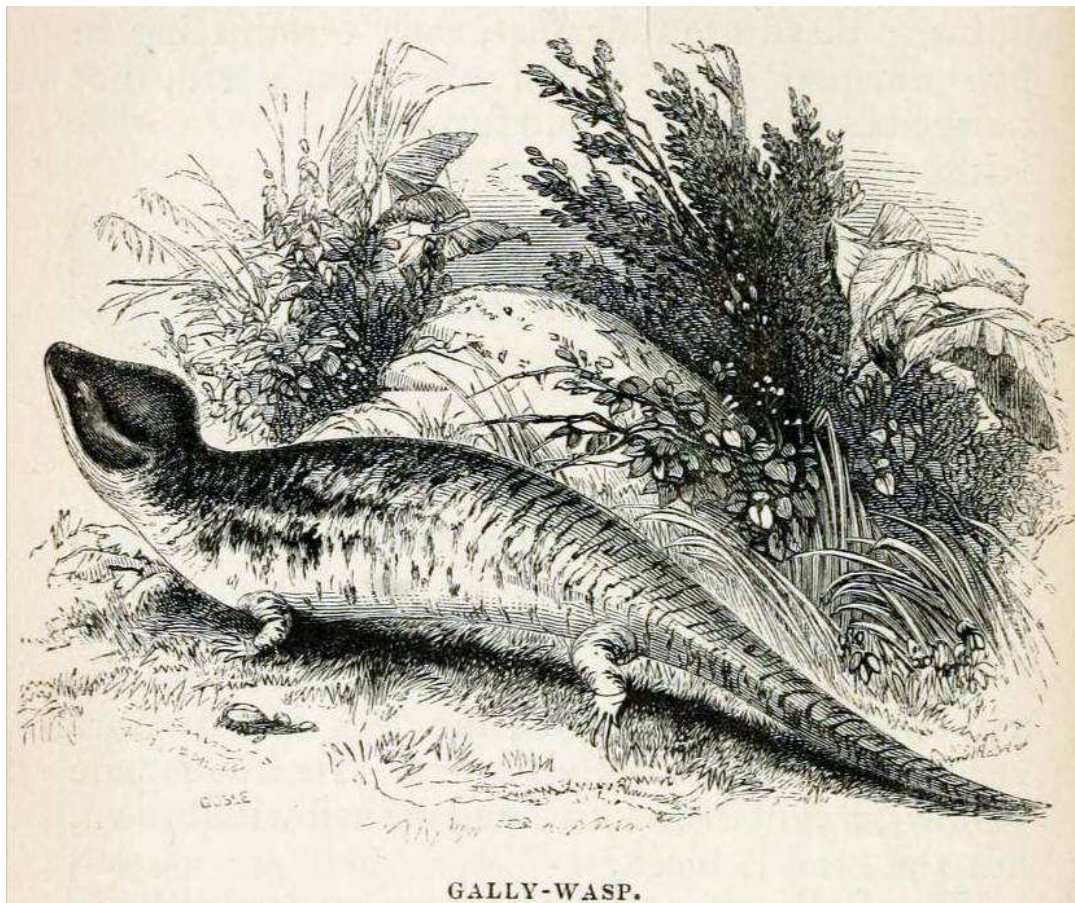


Fig. 4. Jamaican "gally-wasp" *C. occiduus* (now believed extinct) from Gosse (1850)

2.2. Distribution, abundance and population trends

2.2.1. Distribution

All available anecdotal data suggest that the Montserrat galliwasp only occurs in a tiny area (see Fig. 5) of mesic forest, at roughly 180m above sea level, in the western foothills of the Centre Hills that abuts a residential area known as Woodlands Spring (hereafter referred to as 'Woodlands', as it is known locally). The area (of a minimum convex polygon) encompassing all the points in Fig 5 (with the exception of the point at sea level - see later in this section) is 12.9 hectares. Sightings from 1983 to the present day occupy an area of just 1.5 hectares¹. Underwood (1964) locates the type specimen he describes as coming from "Woodlands Spring" but refers to the area as draining into "a small stream called Runaway Ghaut". This location

is in fact about 300 m to the south of the more recent sightings at Woodlands, in an area now known as Duberry Estate. For the purposes of establishing a known range, Duberry Estate, rather than Woodlands, is taken as the location of Underwood's (1964) sighting (see white +, Fig. 5), although this may in fact be *exaggerating* the size of the species' range.

To date, only 12 confirmed sightings (including photographs or captures) of this species have ever been made (Corry et al in prep), and one, probably two, of these include repeat sightings of the same individual. In addition, Stevens & Waldman (2001) report from personal communications with R. I. Crombie observations from 1973 and 1983 (Fig. 5). Crombie also reports sightings in 1983 as "(from) St. George's (parish): not uncommon at several springs along the western slopes of the Centre Hills" (pers. comm. cited in Stevens &

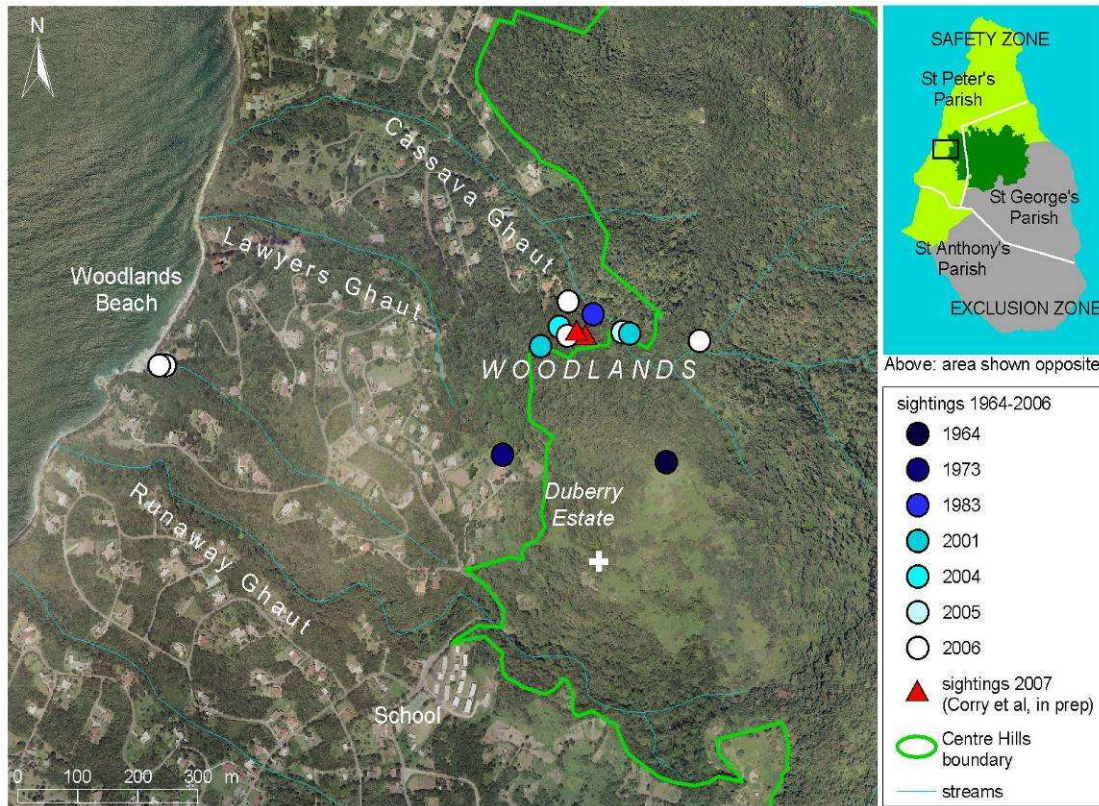


Fig 5: Montserrat galliwasp sightings recorded by Corry et al (in prep). The location of the sighting of the type specimen, shown by the dark blue circle, is located using Underwood's (1964) not very precise coordinates (16° 45½' N, 62° 13' W). However, Underwood (1964) describes this location as draining into Runaway Ghaut. The nearest point in the watershed of Runaway Ghaut, and under forest canopy, is shown by the white +. The two reports of sightings in 2006 near Woodlands Beach were judged not reliable by Corry et al (in prep); a second report judged unreliable (from Duck Pond) is not shown on this map; it is approximately 1.1 km to the south of the main cluster of sightings shown here, on the edge of the Centre Hills protected forest boundary.

¹ If the outlying observations reported from 2006 from Duck Pond and Woodlands Beach are included, the minimum convex polygon is 66.8 ha in area

Waldman 2001). As the inset map in Fig. 5 shows, the western slopes of the Centre Hills are in St. Peter. Assuming a typographic error in reporting Crombie's 1983 sightings, this does suggest a slightly larger range prior to the volcanic eruptions in 1995, as well as the presence of what sounds like higher numbers. Contradicting this somewhat, however, members of Montserrat's Department of Environment (DOE; G. Gray, pers. obs.) report extensive searches for the Montserrat galliwasp in the 1970s and 1980s which failed to find any in these areas, suggesting the species was not very common then.

In 2006, the Centre Hills Project (Montserrat Centre Hills Project, 2006) carried out a series of interviews with local residents to ascertain their knowledge and attitudes to the natural environment of Montserrat (Willcock and Williams 2006). When presented with a photo of a galliwasp only 20% of respondents correctly identified the animal. 26% assumed it was some form of lizard or snake whilst 37% did not know. None of those who correctly identified the galliwasp had ever seen any in the wild, rather only in photos displayed by Montserrat Ministry of Agriculture, Land, Housing and Environment (MALHE) or the Montserrat Tourist Board.

A more focused survey was conducted in 2008 within the residential area of Woodlands (Corry et al in prep). Interviewees were asked to identify which reptiles they have seen around their property from a series of photos. Two out of the five households in this small area had seen a galliwasp in their garden between 2004 and 2007. These reported sightings are also shown in Fig. 5, along with additional sightings reported to Corry et al (in prep).

Corry et al (in prep) also collected three reports of sightings from outside, but nearby, Woodlands, all dating to 2006 (the year of a large dome collapse of the volcano; Montserrat Volcano Observatory 2010). One of these reports came from Duck Pond and two from Woodlands Beach (Fig. 5). Corry et al (in prep) judged these reports (unsupported by specimens or photographs) to be likely in error because they were lacking in detail and may have represented misidentifications of teiid ground lizards (*Ameiva pluvianotata*). The Woodlands Beach reports, however, do bring to mind Underwood's collector, a Mr Kingsley Howes, who collected the type specimen at Woodlands and reported only ever seeing one other specimen "about 25 years ago (i.e. in the 1930s)...at sea level near the estuary of (an unidentified) stream" (Underwood 1964). The Duck Pond observation is also consistent with Crombie's report of sightings at several springs along the western slopes of the Centre Hills (Stevens & Waldman

2001). A two month island-wide herpetological survey in 1995 (Daltry 1999) failed to find any Montserrat galliwasp, however; and Buley (2001) found one individual. Surveys in 2005-06 (Ogrodocky et al 2006; Young 2008) and 2007-08 (Corry et al in prep) found only two and one individuals respectively in Woodlands and none at Duck Pond or Woodlands Beach despite focussed searching for this species in these areas.

2.2.2. Abundance

No historical or current estimates of population size exist for the galliwasp in Montserrat. There have never been more than four confirmed sightings in a year, and in most years none at all have been recorded (Corry et al in prep). In 2007-08, a study was conducted to determine whether occupancy (MacKenzie et al 2006) could be estimated (as proportion of area occupied - in this case, the land in the western half of the Safety Zone between 100 and 320 m above sea level, and within 100m of ghaat bottoms). This method was investigated as an alternative to estimating abundance to provide a measure of the state of the Montserrat galliwasp population. However, no valid estimates were obtained because the encounter rate was so low: there were only two encounters, both of the same individual (Fig. 6) - recognizable from an old scar - during 105 days of surveying (Corry et al, in prep).



Fig. 6. Galliwasp photographed at Woodlands, 2nd November 2007. Volcanic ash is visible on the surrounding leaf litter. Photo: E. Corry / Durrell.

We have found no reported population density estimates for any other galliwasp species. *C. badius* and *C. millepuctatus* are described as ubiquitous and abundant (Hendersen & Powell 2009; Kiestler 1975) although both are restricted to small uninhabited islands (Navassa Island, 5.2 km², and Malpelo Island, 1.2 km², respectively). How-

ever, most of the 44 galliwasp species are known only from one or a few specimens and recorded sightings, and they appear to be either very rare, or very elusive, or both. At least one species is believed extinct (World Conservation Monitoring Centre 1996; see Fig. 4).

2.2.3. Population trends and status

The Montserrat galliwasp was assessed as Critically Endangered based on the species' extremely restricted range (Day 1996), rather than based on any population trends which remain unknown. Due to the complete absence of population data, it is not possible to infer any historical trend for the Montserrat galliwasp population. However, the extremely small size of the species' range does imply a severe contraction of the population has occurred at some point in the past. Given the habitat it is found in (moist broadleaf forest, in common with most galliwasp species; see section 2.3.2 below), it seems inherently unlikely that this large-bodied lizard did not once occupy a much larger range on the island. Crombie's observations from the 1970s and 1980s (Stevens & Waldman 2001) and Howe's from the 1930s (Underwood 1964) provide some support for the idea of a range contraction during the 20th Century, though both are vague.

It is probable that the introduction of invasive predators has had a severe negative impact on

the galliwasp population, as has been the case with many other reptile species in the insular Caribbean (see section 2.4.2.2). The very small range of the species also allows us to infer that the population is most likely very small, although despite the concerted efforts of Corry et al (in prep; see Fig. 7) it has proved impossible to quantify this.

Eleven species of galliwasp have been assessed for IUCN's red list and are shown in Table 1 (section 2.4.1). Populations of *C. enneagrammus* and *C. legnotus* (both of Least Concern) were assessed as stable, whilst *C. rozellae*, *C. anelpistus*, and *C. warenni* populations were assessed as declining. No assessments of population trends for the other species in Table 1 are recorded. *D. pleii* has not been assessed for IUCN's red list but was considered to be "stable" by Moreno in 1991 (cited in Hendersen & Powell 2009). In general, however, no data or opinions on population trends in most galliwasp species have been reported.

2.3. Biology and ecology

The literature on any aspect of the Montserrat galliwasp, and for most other galliwasp species, is extremely sparse. Hence, the following sections draw on what information has been found on sister species (of both *Diploglossus* and *Celestus*) in order to make cautious inferences on the biology and ecology of the Montserrat galliwasp.

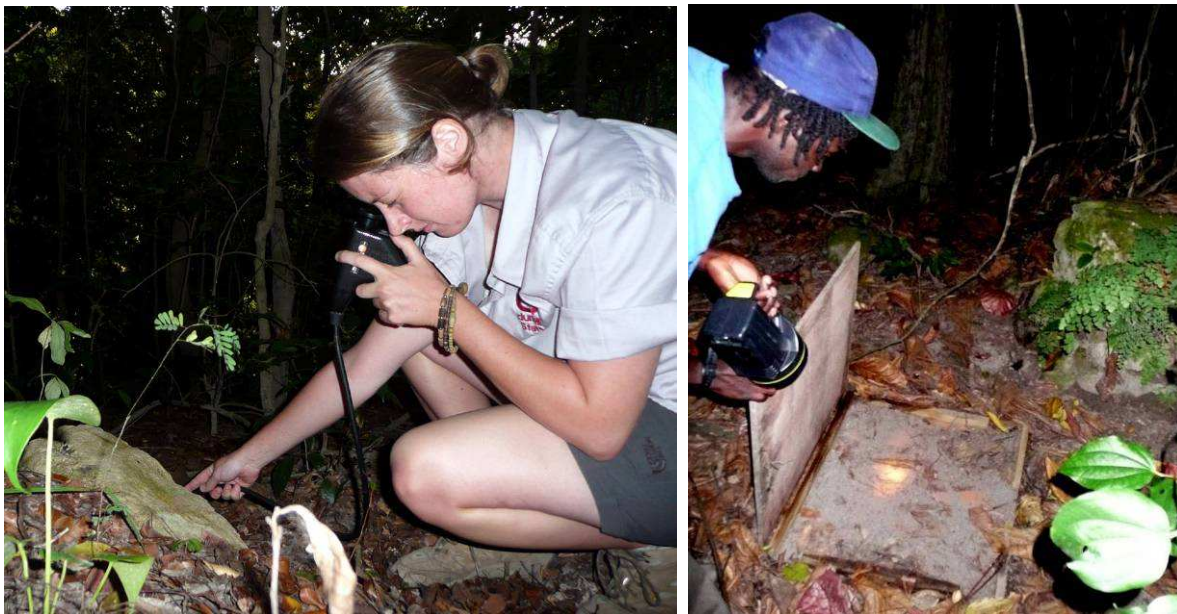


Fig. 7. Surveys for the Montserrat galliwasp during 2007-2008. Left: Liz Corry searches rock crevices using an endoscope during a daytime search. Right: Calvin Fenton, inspects the contents of a "galliwasp hotel" (one of many artificial refugia deployed) during a nocturnal survey. Photos: C. Fenton, E. Corry / Durrell.

2.3.1. General biology and behaviour

Underwood (1964) described the Montserrat galliwasp, from a single male specimen captured at Woodlands Spring, as “a large, strong-limbed *Diploglossus*, with sheathed claws”. The sheathing of the claws, with scales, refers to a feature used to classify galliwasps into *Celestus*, with unsheathed claws, and *Diploglossus* in which they are sheathed (Savage et al 2008; see Fig. 8). This individual had a snout-to-vent length (SVL) of 180 mm and the length of its regenerated tail was 165 mm.



Fig. 8. Sheathed claw of *D. montisserrati*. Photo: G. Garcia / Durrell

The only other specimen described in the literature (Ogrodowczyk et al 2006) was also a male, also with an SVL of 180mm, and having a 230 mm tail; it weighed 170 g. Montserrat galliwasp scales are smooth and have osteoderms (bony plates in the skin) underneath – as do all galliwasps (JVCI 2010) – possibly for protection during intraspecific fights (G. Garcia, pers. obs.).



Fig. 9. Adult Montserrat galliwasp (supposed female) caught at Woodlands in 2001. Photo K. Buley / Durrell

The Montserrat galliwasp is one of the larger galliwasps (Fig. 9); only five of the 43 other species are larger (see Annex 5). Most galliwasps are small

lizards: 24 species (55%, nearly all *Celestus* species) have a SVL of less than 110 mm.

Adult colouration of the Montserrat galliwasp is medium brown, and paler to whitish around the lips and throat. The flanks of the body tail, and the limbs, have a pattern of speckles: a white and a dark brown speckle together against the medium brown background (see Fig. 10). The underside of the body is pale and unspeckled. In some other *Diploglossus* species juvenile colouration is different to adults, for example *D. montropis* (Savage 2002) and *D. bilobatus* (Lotzkat et al 2010). Vitt (1992a) has proposed that the distinctive banding found on the juveniles of *D. fasciatus* and *D. lessonae* mimics the appearance of toxic millipedes as a way of deterring would-be predators. However, reported sightings of the Montserrat galliwasp have not noted juvenile colouration in the Montserrat galliwasp as being different to that of adults, although these sightings have been fleeting.

Sexual dimorphism is relatively subtle in some galliwasps (Cousens 1956; Greene et al 2006), though males have larger, wider heads than females in at least two of the larger species: *D. millepunctatus* (Kiestler 1975) and *C. warreni* (Goetz 2008). Males of *D. montropis*, another large galliwasp, are larger than females and have different colouration (Savage 2002). Goetz (2008) notes that the dimorphism in head size in *C. warreni* is only clear when comparing individuals of similar age. A comparison of specimens (the only two known specimens are both male) with photographs by K. Buley in 1998 suggests sexual dimorphism in head size in the Montserrat galliwasp (Fig. 11).

Ogrodowczyk et al (2006) report the Montserrat galliwasp is considered nocturnal and report three sightings, on different nights, at 18:00 (dusk), 18:30 and 19:15. These authors also record the personal communication of a sighting by R. Allcorn in 2004 “at night”. Corry et al (in prep) collected reports of an additional seven sightings that they judged to be reliable, dating from 2002-2008. One was made “in the early morning”, one at “approximately 16:00”, one “at dusk”, and one “at night”. These four sightings were of active animals. Two more were made “during daytime” but these may be of animals disturbed in refuges: one was of an adult in a pile of chopped timber, another of juveniles seen in a crevice between boulders. One sighting however was reportedly at 11:48 and in the photo that was taken (see Fig. 2) appears to show an active adult.

Reports of activity periods were found for 13 other galliwasp species (see Annex 5): Ten are reportedly diurnal, whilst an eleventh (*D. bilobatus*) is described by Savage (2002) as diurnal in Costa



Fig. 10. Montserrat galliwasp (adult male) colour and patterning. Photo: A. Ogradowczyk / Durrell



Fig. 11. Comparison of head shape in confirmed male Montserrat galliwasp (left) and supposed female (right). Photos: A. Ogradowczyk / Durrell; K. Buley / Durrell

Rica. Lotzkat et al (2010), however, give more detailed observations of nocturnal activity in this latter species in Panama, finding it active between 20:15 and 01:30. A twelfth species (*C. anelpistus*) is described as nocturnal by Schwartz et al 1979 (cited in Henderson & Powell 2009). The remaining species, *C. warreni* is described as probably crepuscular or nocturnal by McGinnity (2002), although Schwartz & Hendersen (1991) report they are “observed outside burrows during day and on asphalt roads at night”. It seems some species are

active by day and night, although some diurnal observations may simply reflect the time of day at which herpetologists made collections.

The Montserrat galliwasp appears to be a terrestrial species (Underwood 1964) and semi-fossorial, assumed to forage in as well as on the surface of leaf litter (Ogradowczyk et al 2006; Corry et al, in prep; Fig. 12). All other personal communications to Ogradowczyk et al (2006) and Corry et al (in prep), of nine sightings in total, refer to individuals

seen on or near the ground (one was lying on a pile of chopped timber, another on a derelict stone wall). The Montserrat galliwasp's serpentine movements (Figs. 12 and 13) are typical of many galliwasp species.

The habit of 36 galliwasp species has been reported (see Annex 5) with 29 (81%) being terrestrial. Four (11%) are reportedly arboreal (one, *C. fowleri*, being known only from bromeliads on trees; Schwartz 1971) and three (8%) reportedly both terrestrial and arboreal. All the arboreal and



Fig. 12. Montserrat galliwasp at Woodlands in 2007, moving through leaf litter and surface debris. Photo: E. Corry / Durrell



Fig. 13. Montserrat galliwasp at Woodlands in 2006, showing the lizard's sinuous body form. Photo: A. Ogrodoczyk / Durrell

partly arboreal species are medium-sized (SVL 100-130 mm) *Celestus* galliwasp, though the medium-sized (SVL 100 mm) *D. montisilvestris* has been caught on a tree-trunk about one metre off the ground and its long claws may suggest arboreality (Myers 1973). None of the larger (SVL > 150 mm) galliwasp, including the Montserrat galliwasp, are known to be arboreal.

Of the 21 species for which authors have reported some degree of burrowing behaviour, or at least foraging or hiding in leaf litter, 16 (76%) are reportedly semi-fossorial, three fossorial (14%) and two possibly fossorial (10%; see Annex 5). In most cases semi-fossoriality refers to hiding in or moving through leaf litter and other surface debris (see section 2.3.2 below) rather than creating burrows, although Schwartz & Hendersen (1991) report that *D. delesagra* is occasionally uncovered by ploughing. Powell (1999a) describes *C. badius* as appearing to “swim” along (below the surface of leaf litter), “producing a ‘wake’ on the surface, and occasionally ‘surfacing’ to scan the vicinity”.

2.3.2. Habitat use

With two exceptions, all the known sightings of the Montserrat galliwasp have been made between 140 and 200 m above sea level in the Woodlands area (see section 2.2.1). A minimum convex polygon touching all the outermost of these point locations encloses an area of 6.1 ha (Corry et al, in prep). The two exceptions are Underwood’s (1964) frustratingly vague report of a sighting “at sea level near the estuary of (an unidentified) stream” dating from the 1930s, and a report of two sightings collected by Corry et al (in prep) of a sighting from 2006 in leaf litter at a wooded area with stone tables near Woodlands Beach. Corry et al (in prep) judged this likely to be a sighting of a Montserrat ground lizard (*Ameiva pluvianotata*), an animal of similar size and (in females) colour to the Montserrat galliwasp.

The Woodlands area is an area of mesic forest, near the transition from dry to mesic forest (Mansat 2007) which immediately abuts the back yards of a small number of residences. Sightings of Montserrat galliwasp come from both these backyards and the adjacent wooded area (Fig. 14). Neighbouring Duberry Estate is likewise an area of mesic forest immediately adjacent to residential properties, though the sole record from here (Underwood 1964) appears to have been in the wooded area. All sightings at both sites have been in close proximity to ghauts (watercourses). The forest at Woodlands and Duberry is characterised by rocky terrain, with a high density of large boulders, extensive leaf litter and a closed canopy. There are ruins at Duberry and a derelict wall

at Woodlands, both within the wooded area.

For most galliwasp species (43 out of 44, see Annex 5), the vegetation where they have been found has been described to at least some degree. Thirty seven (89%) occur in forested areas, although 17 of these (40%) are also reported in, or in forest immediately adjacent to, open or edge habitats, with seven of those also found in areas of disturbed habitat. Three more (7%) are reported only from open habitats and one (2%) only from disturbed habitat. Twenty nine species (69%) are reported from mesic habitats, nine (21%) in dry habitats and 4 (10%) in both. As for most galliwasp, the Montserrat galliwasp is reported as a species of mesic forest in this classification, though the sightings from back yards in Woodlands – albeit back yards with leaf litter and other cover, and under forest canopy – indicate it has persisted (to the extent that it has) in the face of some degree of habitat disturbance. *D. monotropis*, which Underwood (1964) considered most closely related to the Montserrat galliwasp, also occurs in mesic forest but is “found in disturbed or ‘edge’ situations more often than in heavy forest” (Myers 1973).

Roughly 21% of the original vegetation cover within Montserrat’s Safety Zone is mesic forest (Mansat 2007), with just over 50% of that included within the Centre Hills protected area boundary. Most of this mesic forest, including Woodlands, is secondary, with many exotic fruit trees; outside of the Centre Hills, much has been cleared for agriculture or residential development. Nonetheless, the extent of standing mesic forest is in stark contrast to the 0.2% of the Safety Zone known to be occupied by the Montserrat galliwasp.

Montserrat galliwasp have been found in rock crevices and cavities formed by exposed tree roots, as well as in a derelict stone wall and a garden rockery (Corry et al, in prep). On one occasion an individual was seen on a pile of chopped timber sometime between 14:00-16:00, possibly also a refuge. Corry et al (in prep) compared a number of microhabitat variables that describe substrate and cover at both Woodlands and Duberry and a selection of random locations, in both dry and mesic forest, on the western side of the Safety Zone. The microhabitat variables included those listed in Fig. 15.



Fig. 14. Forest at Woodlands and Duberry Estate. Top left: boulder pile where juvenile galliwasp were seen, Woodlands. Top right: Geoff Hilton and Philomen 'Mapie' Murrain point to where an adult galliwasp was found in 2006. Bottom right: leaf litter and boulders at Woodlands; in the foreground, partly covered is a "galliwasp hotel" – an artificial refuge used in an attempt to attract (without trapping) Montserrat galliwasp. Bottom left: ruins and holes in amongst tree roots at Duberry estate. Photos: top right, M. Morton / Durrell; all others, E. Corry / Durrell.

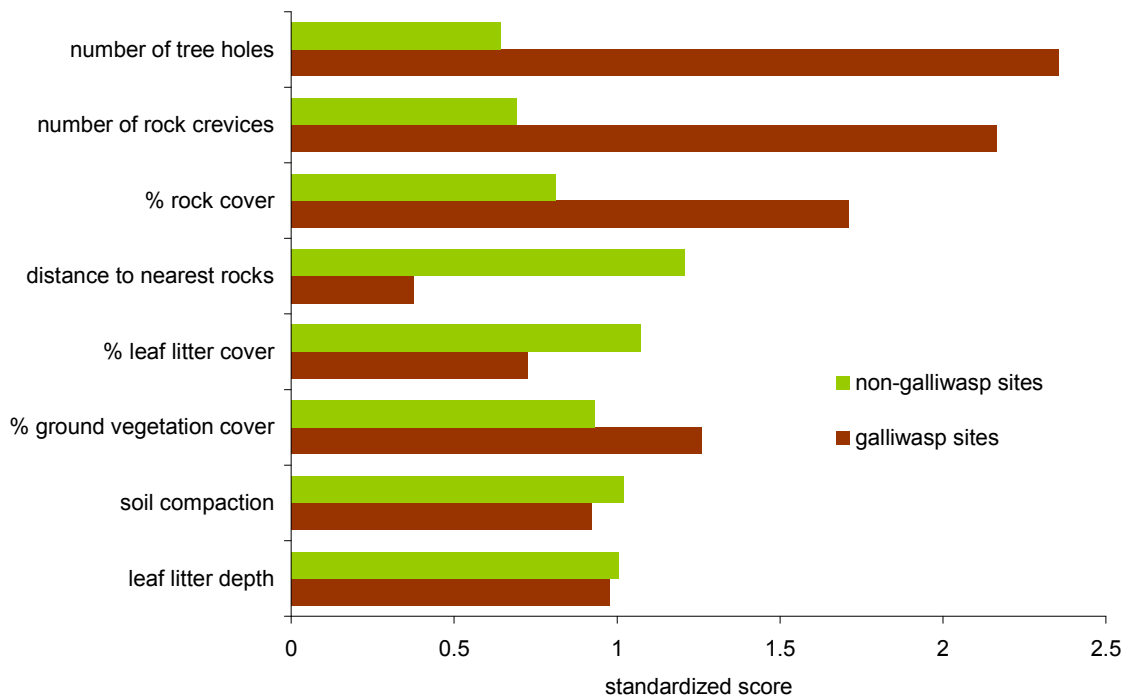


Fig. 15. Substrate and cover variables at Montserrat galliwasp sighting locations and random forest locations in north west Montserrat (from Corry et al, in prep). Scores for each variable are standardized (as average divided by total average) to make scores for different variables comparable.

The biggest differences between known galliwasp and non-galliwasp (random) locations were in percentage rock cover, number of rock crevices, distance to nearest rock and number of tree holes (defined as equal or more than 4 cm width – wider than Montserrat galliwasp head-width – deeper than 15cm, and found at the base of the tree or in amongst tree roots); Fig. 15. At galliwasp sites, both percentage rock cover and the number of rock crevices were significantly higher, and mean distance to the nearest rock was significantly lower (meaning a higher density of rocks at galliwasp locations; Corry et al, in prep.). There was weaker evidence for a higher number of tree holes occurring at known galliwasp locations compared with random locations (the evidence for this relationship was possibly weaker due to small sample size). We speculate that an abundance of hiding places in the Woodlands area allows the Montserrat galliwasp to escape a sufficient number of predation events by introduced predators to maintain a population (section 2.4.2.2).

Finding other galliwasp species under surface debris such as leaf litter, coconut husks, logs, moist sawdust and cut boards is reported for 21 of the 38 species (55%) for which authors have commented on substrate (see Annex 5). Eight (21%) of

these species are also associated with rocks as are an additional nine others (42% of all species) for which surface debris is not recorded. The remaining 21% are reported from in grass, roof thatch, bromeliads, under bark and on tree trunks. Foraging in leaf litter has been noted in the Montserrat galliwasp (section 2.3.1) but it may be that a large number of rock crevices – and particularly amongst large immovable boulders, as at Woodlands – has been of especial importance in avoiding the depredations of introduced predators (see section 2.4.2.2).

Five galliwasp species, including the Montserrat galliwasp, are reportedly found in close proximity to streams. Schwartz & Inchaustegui (1976) describe *C. marcano* from an area having “numerous creeks, and the soil is wet, even swampy, in some places... The *D. (sic) marcano* were collected on the north slope of the valley, between two creeks. The soil was locally dry and with a large number of rocks”. This is reminiscent of the Woodlands/Duberry locale, as is Franz & Cordier’s (1996) description of finding “the majority of (*C. stenurus*) specimens in piles of rocks along the (Grande Ravine) stream channel, particularly in association with dense bracken fern glades”. Underwood’s collector, Mr. Howe, reports both his

sightings of the Montserrat galliwasp were near fresh water (Underwood 1964).

2.3.3. Breeding and demography

Nothing has been published on reproduction in the Montserrat galliwasp, although Corry et al (in prep) collected two reports – one from a Woodlands resident, one from DOE staff accessing the Centre Hills – of small groups (numbers not specified) of juveniles sighted at Woodlands. One group was seen in large crevice created by a boulder pile next to a footpath (see Fig. 14); the other group was in the company of an adult galliwasp as they fled from a rockery in a Woodlands resident's back yard, disturbed by the resident pruning plants. This latter sighting is suggestive of the possibility of parental care. Greene et al (2006) report parental care in four other *Diploglossus*, as well as eleven other Anguid species. Female *D. bilobatus* and *D. monotropis* have been observed aggressively guarding eggs (the latter in captivity), as has a male *D. nigropunctatus*. A female *D. fasciatus* and four young were found together on a tree, an occurrence more likely to reflect post-natal care than simply a chance observation of a very recent birth (Greene et al 2006). In contrast, male *C. warreni* have been known to eat their offspring in captivity, although it is not known whether this is an artifact of captive conditions (D.



Fig. 16. Hatchling *D. monotropis* (in captivity) with eggshell. Photo: D. McGinnity / Nashville Zoo.

McGinnity, pers. comm.).

Amongst other galliwasps, all the *Celestus* for which mode of reproduction has been reported (12 species; see Annex 5) give birth to live young. Mode of reproduction is reported for seven of the 11 *Diploglossus* species (not including the Montserrat galliwasp): six lay eggs (Fig. 16), but the seventh (*D. pleii*) is live-bearing. Nests containing eggs have been found under logs (*D. bilobatus*, Taylor

1956, cited in Savage 2002) and under stones rotting wood and a stone (*D. nigropunctatus*, Barbour & Shreve 1937; Barbour & Ramsden 1919).

Clutch size (number of eggs or young) has been reported for 12 *Celestus* and five *Diploglossus*, though typically with very few observations (often a single clutch) per species. Number of young generally increases with body size amongst *Celestus* species (see Annex 5). For example, two wild-caught female *C. anelpistus* (maximum SVL 285 mm) gave birth to 42 young between them (Schwartz et al 1979, cited in Hendersen & Powell 2009), whilst the medium-sized *C. stenurus* (maximum SVL 172 mm) have five or six young (Schwartz & Hendersen 1991) and the smaller *C. curtissi* (maximum SVL 89 mm) and *C. cruscus* (maximum SVL 90 mm) have 2-4 and 2-5 young respectively (Greer 1967). Within *C. warreni* (maximum SVL 279 mm), clutch size (8-34) is positively correlated with female SVL (Incháustegui et al 1985, cited in Hendersen & Powell 2009).

This pattern of clutch size related to SVL is less clear in the five *Diploglossus* species for which clutch is reported, but these five are all small to medium-sized galliwasps (maximum SVL 92-125 mm) and have clutch sizes from two to six, with the exception of *D. bilobatus* (the smallest, with a maximum SVL 92 mm) laying 6-15 eggs (Savage 2002). Pregnancy has been reported to last 90 for *C. warreni* and incubation of eggs (once laid) in *D. monotropis* 72 days with a copulation to egg lay period of 84-101 days (D. McGinnity, pers.



Fig. 17. *C. warreni* mating in captivity (male on top). Photo: G Garcia / Durrell

comm.).

Age of first breeding is reported for *C. warreni*, one of the larger galliwasp species, at 3-4 years in captivity (McGinnity & Powell 2004); it appears that *D. monotropis* is of reproductive age at 3 years too

(McGinnity, pers. comm.). Limited data is also available for a few species when gravid females and/or newborn young are found in free-living galliwasp populations (see Annex 5). For these nine species, it appears that births occur during the latter half of the year – during the wet season when food resources are likely to be more abundant – with gravid females being found towards the end of the preceding dry season, and sometimes in the wet season too. A sighting of juvenile Montserrat galliwasp was recorded in October (wet season) by Corry et al's (in prep) questionnaire of Woodlands' residents.

At least some galliwasp species may be territorial. Male *C. warreni* will fight, with larger males sometimes killing smaller ones, if kept together in captivity (McGinnity, pers. comm.; Goetz 2008; Lawler & Norris 1979 cited in Hendersen & Powell 2009). An increased incidence of male deaths, usually of smaller, older males presenting bite injuries, has been noted in May-June at Nashville Zoo (*D. McGinnity, pers. comm.*). Male *D. monotropis* are also known to fight in captivity (*D. McGinnity, pers. comm.*). A fight between two free-living males of *D. bilobatus* in Costa Rica is also recorded by Savage (2002).

There appears to be very little published information on the lifespans of galliwasp species and what there is all comes from individuals in captivity. There is some indication though that some at least have the potential to be relatively long-lived. *C. costatus* has been reported still alive at 12.3 years (K. Wright cited in Hendersen & Powell 2009), whilst a maximum of 12.3 years is recorded for *D. monotropis* (de Magalhaes & Costa, J. 2009). *C. warreni* has been known to live at least 12.3 years in captivity without yet attaining the large jowl and head size of some of the old giant males collected in the field and so they may live considerably longer (30-50 years; *D. McGinnity, pers. comm.*). No records were found of galliwasp survival and longevity in the wild.

2.3.4. Diet

No data exists on the diet of the Montserrat galliwasp. On examination of the specimen described in Underwood (1964) the stomach was found to be empty. Underwood's collector, Mr. Howes, comments "I did not see either of (the two galliwasp species he reports) feeding, but it is possible that the second was feeding on young crayfish which were scurrying around in the wet rocks where it was found" (Underwood 1964). At least two other galliwasp species are known to eat crustacea: both Slevin (1928) and Dunn (1939, cited in Kiester 1975) found crab remains in the stomachs of *D. millepunctatus*, and Kiester (1975) observed them

scavenging dead crabs (*Gecarcinus malpilensis*, which have a carapace width of 5-82 mm; López-Victoria & Werding 2008). *D. monotropis* will enthusiastically eat land crabs in captivity in Costa Rica (*D. McGinnity, pers. comm.*).

More generally, amongst species for which dietary items have been recorded, galliwasp species appear to be opportunistic feeders, eating primarily leaf litter invertebrates. Even *D. pleii* – possibly a millipede specialist (Thomas & Gaa Kessler 1996) – is also known to take a wide variety of leaf litter arthropods, and additionally slugs. Amongst the ten species whose diet has been reported (see Annex 5), nine eat leaf-litter arthropods, with centipedes and beetles (larvae and adults) appearing most commonly in lists of dietary items, but also millipedes, scorpions, tarantulas and other spiders, beetles (adults and larvae), crickets, ants, termites, earwigs, bugs and roaches. Earthworms have been found in the diet of three species and *C. haetianus* takes snails. Grant (1940, cited in Hendersen & Powell 2009) reports that the stomachs of *C. hewardii* contained "flat slug-like animals known locally (in Jamaica) as 'cow's tongues'". In Montserrat, E. Corry (pers. obs.) found millipedes, centipedes, beetles, cave crickets and tailless whip scorpions all to be abundant in leaf litter at Woodlands. Captive *C. warreni* have been successfully raised on a diet of insects and other invertebrates, neonate mice and a ground turkey meat 'sausage' (*D. McGinnity, pers. comm.*; Goetz 2008).

A few galliwasp species are reported to eat vertebrates in the wild: dwarf geckos, *Sphaerodactylus armstrongi*, are eaten by *C. costatus* (Schwartz & Hendersen 1991); *Anolis sp.* and another galliwasp, *C. costatus*, by *C. warreni* (Cooper & Bradley 2009, cited in Hendersen & Powell 2009). Feathers of Greater Antillean grackle (*Quiscalus niger*) were also found in the stomach contents of *C. warreni* by Cooper & Bradley (2009; op. cit.) and *D. millepunctatus* is described scavenging dead blue-faced boobies (*Sula dactylatra*) on Malpelo Island by Keister (1975). Keister (1975) also reports that fish regurgitated by boobies for their young provides a substantial amount of food for *D. millepunctatus*, and that the galliwasp may time its own breeding to coincide with that of the birds and hence a time of high food availability. Two galliwasp species are reportedly omnivorous, including fruit in their diet: *C. costatus* (Burns et al 1992, cited in Hendersen & Powell 2009) and the extinct *C. occiduus*, (Shaw 1802). McGinnity (pers. comm.) reports that *C. warreni* will also eat mango in captivity.

2.4. Threats, potential threats and limiting factors (problem analysis)

2.4.1. Red List status

The Montserrat galliwasp is listed in the IUCN Red List of Threatened Species as Critically Endangered (i.e. “facing an extremely high risk of extinction in the wild” IUCN 1994, 2001) based on an assessment by Day (1996), that is annotated “needs updating”. The full listing is CR B1+2c where criterion B refers to an “area of occupancy estimated to be less than 10 km²” and criteria 1 and 2c refer, respectively, to a species population that is “severely fragmented or known to exist at only a single location” and showing a “continuing decline, observed, inferred or projected, in (c) area, extent and/or quality of habitat” (IUCN 1994). A continuing decline is not known to be occurring, although that is because very little is known of the Montserrat galliwasp, as evidenced in the preceding sections. An inferred decline might be justifiable given that it is highly unlikely that the current occupied area is the historical occupied area, and that the causative agents have not been removed. An alternative classification would thus be Data Deficient, but IUCN caution: “It is important to make positive use of whatever data are available. In many cases great care should be exer-

cised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified” (IUCN 2001). Given this caution and the fact that some argument, albeit weakly supported because of the general dearth of data, for an ongoing decline may be inferred, a continuing listing of Critically Endangered appears warranted by the authors of this plan. Underwood (1964) speculates that “the *montisserrati* stock” may have occurred more widely through the Eastern Caribbean (supported to some degree by the accounts of Burton, 1711; Rochefort, 1658; and Du Tertre, 1667; see section 2.1). This could mean that the current range on Montserrat represents an even more drastic range contraction from historical times, although “the *montisserrati* stock” could also refer to additional, putative (and presumably now extinct) *Diploglossus* species.

Ten other galliwasps, all *Celestus* species, have been assessed against Red List criteria (see Table 1). The listings for *C. duquesneyi*, *C. fowleri*, *C. microblepharis* (all Data Deficient) and *D. montisserrati* are flagged as out of date. Hendersen & Powell (2009) consider that available evidence suggests that *C. duquesneyi* should be listed as Criti-

Red List Category	Species	Range	Threats
Data Deficient	<i>C. duquesneyi</i>	Jamaica	Not known
	<i>C. fowleri</i>		
	<i>C. microblepharis</i>		
	<i>C. ingridae</i>	Mexico	
Least Concern	<i>C. enneagrammus</i>	Mexico	None known
	<i>C. legnotus</i>		
Near Threatened	<i>C. rozellae</i>	Belize; Guatemala; Honduras; Mexico	Logging • forest conversion to agriculture
Critically Endangered	<i>C. anelpistus</i>	Hispaniola	Introduced predators • forest conversion to agriculture • human persecution
	<i>C. warreni</i>	Hispaniola	
	<i>D. montisserrati</i>	Montserrat	Not known
Extinct	<i>C. occiduus</i>	Jamaica	Introduced predators

Table 1. Red list assessments of galliwasp species. Threats are as identified in each species’ red list assessment (Campbell 2007; Canseco-Márquez et al 2007; Day 1996; Gibson 1996a, b, c; Lee & Calderón Mandujano 2007; McGinnity & Powell 2004 a, b; World Conservation Monitoring Centre 1996)

cally Endangered; *C. fowleri* may be Endangered; and *C. microlepharis* is possibly Extinct. Many, if not most, of the remaining 33 galliwasp species probably warrant Red List assessments given the rarity of sightings, restricted known ranges, and exposure to the threats identified in Table 1 of most of these species.

2.4.2. Inferred causes of decline in the Montserrat galliwasp population

As noted above, a decline in the size and range of the Montserrat galliwasp is inferred – rather than established by any evidence – from its apparently extremely restricted global range of less than 10 hectares. Likewise, the causes of this inferred decline are also, necessarily, inferred. Day (1996) does not cite any threats to the Montserrat galliwasp in his Red List account, and no other published references to threats to this species have been found, although Underwood (1964) speculates:

“The *montisserrati* stock may well have been more widely distributed in the Leeward Islands ... Survival on the limestone Leeward Islands, from Anguilla to Marie Galante, is unlikely; they are low lying and dry. Some of the volcanic Leeward Islands, from Saba to Basse Terre (Guadeloupe), on the other hand, have some good wet forest on their higher slopes. Montserrat is one of the islands on which mongoose have not been introduced and this may have been a factor in its survival. Both St. Kitts, Nevis and Guadeloupe have mongoose... Saba and St. Eustatius have no mongoose but they have very limited moist forest”

This speculation identifies habitat availability (i.e. the continued presence of mesic forest) and the presence of introduced predators as likely limiting factors on the occurrence of the Montserrat galliwasp, and this is consistent with what is known of threats to other galliwasp species and what can be inferred of threats to the Montserrat galliwasp. Introduced predators – notwithstanding the absence of mongooses on Montserrat – and deforestation and habitat modification are inferred as the most severe threats. The active volcano on Montserrat remains an ever-present threat, although its impacts on the Montserrat galliwasp to date are inferred to be less severe. Finally, the presumed very small population size of the Montserrat galliwasp makes the species highly prone to extinction through stochastic (unpredictable) events.

2.4.2.1. Deforestation and habitat modification.

Whilst some galliwasp species appear to persist in the face of some degree of habitat disturbance, most appear to depend upon forest habitats, albeit sometimes in “edge” situations (see section 2.3.2). Deforestation has been recorded as a threat to some species: *C. anelpistus* and *C. warreni* (Powell et al 2000, McGinnity 2002, Powell & Hendersen 2003); and also *C. duquesneyi* (Wilson & Vogel 2000). More generally in the Eastern Caribbean, Powell & Hendersen (2005) recognize habitat alteration or loss as a major threat to a wide range of reptile species. These authors highlight in particular the negative impact of deforestation on species that depend on leaf litter, noting the Montserrat galliwasp and also ecologically equivalent skink species such as the silverback skink (*Mabuya mabouya*) that appears to have severely declined or even disappeared from a number of Eastern Caribbean islands including Montserrat.

Although the Montserrat galliwasp has persisted in an area adjacent to, and including, the back yards of residential properties, this area (as its name, Woodlands, suggests) is nonetheless well-wooded, with a largely closed canopy and extensive leaf litter. The abundance of boulders and large rocks in this area appears also to be of great importance to this species (see sections 2.3.2 and 2.4.2.2). The habitat clearance associated with built development is likely to be exerting a strong pressure on the Montserrat galliwasp if, as appears to be the case, the population is restricted to the Woodlands area. This area was sub-divided into plots for residential development in 1960s. The area is considered upscale in Montserrat with relatively high real estate values. Construction in this area began in the 1960s and continues to the present day with several new houses built in the last few years. Construction typically involves clearance of an entire plot, with removal of all trees and boulders. Clearance of such rocks to prepare land for development is likely to present a severe threat to the Montserrat galliwasp. Current planning regulations in the Physical Planning Act require that construction has to begin with 12 months of a landowner receiving planning permission. In practice this often means that land is cleared – even without any immediate intention to build on it – to comply with these regulations. Piles of stone or rock, and derelict dry stone walls (also potential galliwasp refugia; see section 2.3.2) are sometimes taken apart by agouti hunters or removed by residents gardening, thereby likely degrading Montserrat galliwasp habitat.

Land tenure in the area around the focus of all known Montserrat galliwasp sightings is complex

(Fig. 18), with much of it subdivided for residential development. In addition to the residential parcels, part of this land is Crown Land that is currently not under any management for biodiversity conservation but is not used for and has, for now at least, been set aside (without being gazetted) as 'wilderness'. However, part of this crown land falls, along with other privately owned parcels, within the boundary of the Centre Hills Reserve, which is managed for biodiversity conservation by DOE, although not as yet specifically for Montserrat galliwasp conservation. Under the yet to be enacted Conservation and Environmental Management Act (CEMA; see section 2.5), the Centre Hills protected boundary could be extended to include this land.

Human development also brings with it introduced predators, both intentionally, as with domestic cats and dogs, and unintentionally, for example rats and feral fowl. It appears a number of Woodlands residents – who are primarily ex patriates – are reluctant to fence their yards (and hence con-

trol their dogs' access to the Montserrat galliwasp site) for aesthetic rather than economic reasons, or simply because they enjoy allowing their dogs to roam free. An additional problem, reported by residents of the Woodlands area, is the unmanaged and reckless use of poisons. This includes the use of 'home made recipes', including the use of mercury, cement and battery acid mixed in with bait and the use of poisoned bait not delivered in bait stations, designed to minimize non-target casualties, but left out in the open available to any species that may happen upon it. This may impact not only domestic cats and dogs – making residents much less supportive of any poisoning efforts to control feral introduced predators – but possibly Montserrat galliwasp directly as well.

Finally, the practice of capping springs for abstraction may reduce habitat suitability for Montserrat galliwasp inasmuch as they appear to be a species, like the majority of galliwasp, found primarily or entirely in moist forest habitats (see section 2.3.2).

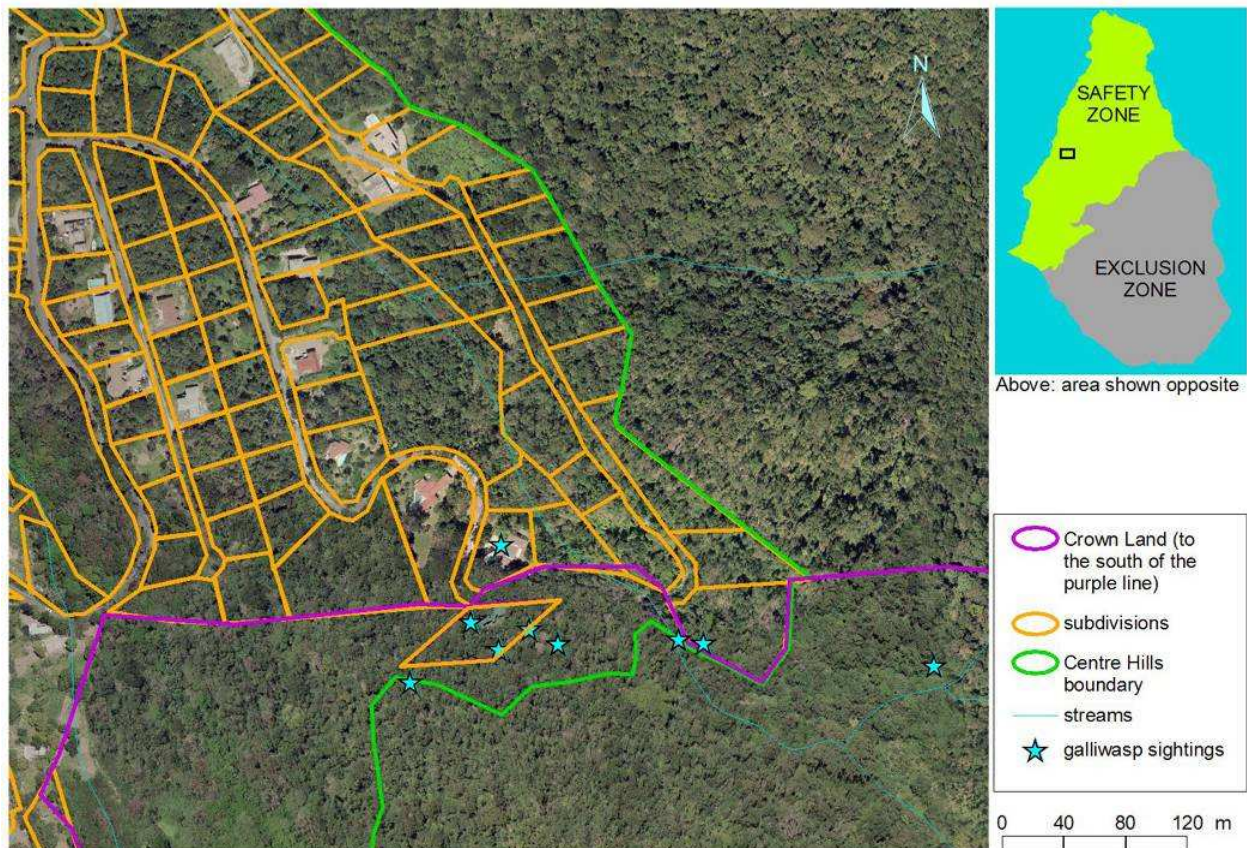


Fig 18: Cadastral map of Woodlands showing recent Montserrat galliwasp sightings plus residential subdivisions Crown Land and the Centre Hills protected area boundary. The area shown in this map is about 2.5 km from the nearest point on the boundary of the Exclusion Zone (see inset).

2.4.2.2. Introduced predators.

Powell & Hendersen (2005) emphasize the importance of threats from introduced predators when they describe the introduction of the mongoose as being “the single event most responsible for the extirpations and declines of many Lesser Antillean reptiles”. The small Asian mongoose (*Herpestes javanicus*) has never been introduced to Montserrat and, as noted above, Underwood (1964) attributed the occurrence of the only known galliwasp in the Eastern Caribbean to the absence of mongooses.

Several species of alien mammal occur in Montserrat including two species of rat, (Norway rats *Rattus norvegicus* and ship rats *Rattus rattus*), domestic cats, dogs, pigs, goats, cows and donkeys. Rats (Fig. 19) are among the most devastating of invasive alien species on islands. Their multiple impacts on island ecosystems have been described in many publications (Atkinson 1985; Atkinson & Atkinson 2000; Towns, Atkinson & Daugherty 2006; Global Invasive Species Database 2010). 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 habitat modification. Towns et al (2006) identified “reptiles that are nocturnal, ground-dwelling, have low annual reproductive output and are oviparous, laying eggs in rookeries” as a group particularly vulnerable to the impacts of rats. All of these characteristics are known or inferred to associated with the Montserrat galliwasp. The more terrestrial nature of Norway rats compared with ship rats, and their ability to enter narrow openings, is likely to give them easy access to Montserrat galliwasp in many situations. They are also likely to be competitors by depleting the Montserrat galliwasp’s invertebrate food.

European boats brought Norway rats and ship rats to Montserrat. Ship rats reached the Eastern Caribbean as early as the beginning of the seventeenth century, with Norway rats perhaps two centuries later (Varnham 2007). Both species of rats are currently very abundant in the Centre Hills forests (Young 2008). Snap-trapping data indicates that, in the forest, ship rats are somewhat more abundant than Norway rats, although both are present throughout. In general in the Centre Hills, ship rats are more abundant at higher altitudes, and are more arboreal, than Norway rats. Both species’ population levels appear to be linked to the local abundance of large fruit trees and clearings (Young 2008). Rats – most likely predominantly Norway rats – are also abundant in the settled lowland areas of Montserrat.

Fig. 19. Right: Ship rat (photo: J. Daltry / Fauna & Flora International) Below: Brown rat, photographed foraging by day at Woodlands (photo: G. Garcia / Durrell).



Domestic cats (*Felis catus*) and dogs (*Canis familiaris*, Fig 20) are likely to present a serious threat to the Montserrat galliwasp. This is especially so given the immediate proximity of the galliwasp’s range to human residences, which are known to be home to both these domestic species. Cats and dogs are known to prey on a wide variety of reptiles in the West Indies, leading to population declines in several species, and are implicated in the extermination of at least one (reviewed in Hendersen & Powell 2009). During the Species Action Planning workshop for this species in 2008, an unconfirmed report was made of a domestic dog resident near the Woodlands area having, a few days previously, brought home a dead “snake with leg”. As noted above (section 2.4.2.1), domestic dogs in the Woodlands area tend not to be penned or leashed. In addition, the footpath through the forest at Woodlands is popular with local dog walkers. Although there are no data on predation, it seems likely that domestic cats and dogs, along with rats, are the introduced predators having the most severe impacts on the Montserrat galliwasp.

There is also a feral cat population in Montserrat (Fig 21), although distinguishing between wandering domestic cats and true feral animals is difficult. The distribution, population density and ecology of the feral population are not known. Feral cats are devastating invasive species on many islands, predated native vertebrate species. Mammals and birds are most commonly affected (Global Inva-

sive Species Database 2010), and indeed, in some circumstances, feral cat predation on introduced rats may be beneficial to native island ecosystems by reducing rat impacts (Courchamp, Chapuis & Pascal 2003). But negative impacts on some island herptile populations, such as various Caribbean island reptiles, have also been recorded (Varnham 2006, Henderson & Powell 2009). Elsewhere, lizards have been found to form a significant part of the diet of feral and free-ranging domestic cats and dogs (e.g. Arnaud et al 1993; Campos et al 2007; Nogales & Medina 2009; Phillips et al 2007). For the Montserrat galliwasp, the impacts of cats and dogs whether feral or domestic will be most likely be the same. Only the relative degree of impact will differ and, given Woodland's residential setting, it seems likely that the negative impact from domestic cats and dogs will be greater.



Fig. 20. Free-roaming or feral dog photographed by camera trap at Bugby Hole in the Centre Hills (see Gray et al 2010 for details of camera trapping). Photo: Montserrat DOE

Since around 1998, feral pigs (*Sus scrofa*, Fig. 22) have spread through the Centre Hills forest following their escape from farms abandoned in the wake of the volcanic crisis. There is no evidence of a feral pig population in Montserrat prior to the volcanic crisis. Pigs were first noted as a substantial presence in the Centre Hills forest during 2001 (Buley 2001). In the following years they spread through most of the forest, until a substantial control effort by local forest rangers in 2004 greatly reduced the population. From 2005, there has been a renewed spread of pigs into the forest from the surviving population in the volcanic exclusion zone to the south. Control using hunting dogs and guns continues at a low intensity, but pigs are now present through a large (but unmapped) proportion of the forest. In 2009, the RSPB and the Government of Montserrat initiated

a three year project aiming to establish a sustainable, locally managed programme to minimise the destructive impacts of feral livestock in and around the Centre Hills (Gray et al 2010).



Fig. 21. Feral cat photographed by camera trap on top of Katy Hill, the highest point in the Centre Hills (see Gray et al 2010 for details of camera trapping). Photo: Montserrat DOE

At the time of writing, feral pigs are not known from the Woodlands area (R. Bunting, pers. comm.), but there appear to be no barriers to them invading this area. During the period 2009 to 2010, a survey of feral livestock in and around the Centre Hills found pigs, goats (*Capra hircus*) and cattle (*Bos taurus*) to be widespread, although pigs were at lower densities than expected (attributed to hunting) and goats, cattle and donkeys (*Equus africanus asinus*) at higher densities (Gray et al 2010). Feral or free-roaming cats and dogs were also photographed by camera traps in the Centre Hills during this period (R. Bunting, pers. comm.). Populations of pigs and cattle were found to be much higher in the Exclusion Zone (Gray et al 2010) where at present they cannot easily be hunted.

Pigs can have a major impact as invasive species on some island tropical forests. Like rats, they are opportunistic omnivores, known to eat lizards (Atkinson 2001) and can cause declines and extinctions in terrestrial animals that they prey on (Cruz et al. 2005 and references therein; Global Invasive Species Database 2010). Jolly et al (2010) estimate the impact of feral pig predation on native reptiles and amphibians in Australia. 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 (for example, guava *Psidium guajava*) (Global Invasive Species Database 2010).



Fig. 22. Feral pig photographed by camera trap at a wallow (left of photo) in forest above the abandoned village of Streatham in the Exclusion Zone (see Gray et al 2010 for details of camera trapping).
Photo: Montserrat DOE

Feral fowl have reportedly increased in numbers in Montserrat in recent years, including around the Woodlands area. Chickens are known to kill and eat snakes and lizards (Arshad et al 2000; Brock & Howard 1962; Collias & Collias 1967; Collias & Saichuae 1967; Guthrie 1932) and so are a potential threat to Montserrat galliwasp, and maybe to juveniles especially.

Although not predators, when introduced to islands, goats, cattle and donkeys can affect forest structure and native plant communities through their grazing and browsing, with knock-on effects for native animals (Atkinson 2001; Atkinson & Atkinson 2000; Campbell & Donlan 2005; Global Invasive Species Database 2010).

Gray et al (2010) have developed a five year Feral Livestock Action Plan for controlling the negative impacts of feral animals in and around the Centre Hills, although this restricts itself to mammalian livestock (i.e. not including cats, dogs, fowl or any undomesticated species).

Cane toads (*Bufo marinus*; Fig. 23) have been introduced to Montserrat and are now widespread and common throughout the island. In the Centre Hills forest, 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. comms.). 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 2010). It seems likely that an adult cane toad could eat a juvenile Montserrat galliwasp, although as with all putative predators, no evidence exists.

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 2008); like the red-footed tortoises (*Geochelone carbonia*) and green iguanas (*Iguana iguana*) (also likely and possible introductions respectively) they are not thought to impact native wildlife significantly and are not considered invasive on Montserrat.

The control of introduced predators in particular – rats, cats, dogs and pigs – is likely the most urgent threat to the Montserrat galliwasp that needs to be addressed and will be a highly challenging undertaking. Box 1 reviews some of the strategies that have been used with success in other countries.



Fig. 23. Cane toad, commonly found at Woodlands during searches for the Montserrat galliwasp (photo: E. Corry / Durrell)

Box 1. Reducing impacts of introduced predators: pest-proof fencing and alternative strategies.

Geoff Hilton

Pest-proof fencing is a relatively new conservation management tool, and involves enclosing an area within a fence, eradicating the chosen pest-species from inside the fenced area, and then maintaining the fence as a pest-proof barrier in the long-term. It effectively creates a 'mainland-island', protecting native species that are vulnerable to invasive mammals when an island-wide eradication is impossible. This approach has been largely developed and used in New Zealand, where invasive mammal species are the main threat to biodiversity.



*Perimeter predator-proof fence around Maungatautari mountain.
Photo: Maungatautari Ecological Island Trust*

Fence design has been the subject of considerable research, aimed at ensuring that they are 100% effective at pest exclusion, long-lasting, and relatively easy to build and maintain. The chief design features are:

- (1) a mesh small enough to exclude juveniles of the smallest pest to be kept out;
- (2) the fence is high enough to prevent invasives leaping over it;
- (3) the fence is buried sufficiently deeply to prevent invasives from burrowing under it
- (4) the fence cannot be climbed by the invasive species
- (5) there are no weak links, for example around the fence-posts or at corners, which might allow invasives to climb
- (6) overhead vegetation is cleared so that invasives cannot cross the fence by climbing/ jumping through trees
- (7) specially designed sections allow the fence to cross streams, steep areas and road-access points while still being pest-proof.

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It is now a standard and widespread technique in New Zealand, with at least two commercial fence-making companies, and several thousand hectares of land now enclosed by fences. Examples include the Maungatautari fence, which runs for 47 km, and encloses 3,400 ha of a forested mountain. This project was developed by a local Trust. The Karori Sanctuary is in the heart of Wellington, New Zealand's capital, and has an 8.6 km fence enclosing 252 ha of predator-free area.

There have been relatively few fences built outside New Zealand, but the technology is starting to spread. Of particular relevance to Montserrat are fence developments in Mauritius and Hawaii, both of which are mountainous islands with tropical rainforest. In Japan cheaper, more flexible fences, primarily aimed at excluding mongooses.

Alternatives and comparisons

The main alternative to fencing is to maintain ongoing pest control. This is essentially what the Centre Hills project has achieved in the Fogarty Experimental Area. Rats, pigs and cats can all be controlled in the long-term, using established techniques. In New Zealand, very large areas are unfenced, but non-native mammals are continuously controlled to very low levels. Ongoing control has the advantage of far lower initial capital costs. However, running costs are much higher. For both fences and control, the cost per unit area goes down markedly as the area protected goes up. This is because the ratio of the circumference to the area gets smaller as the area gets bigger. For fences, less fence per hectare enclosed is needed in a big area. For control, the core area of a large area is relatively big, and the edge – where the invasion of mammals from outside comes from – relatively small.

For control to work there needs to be continuous close management by qualified staff, to ensure that enough control effort is being put in, and sufficient available motivated field staff to undertake the control work in all conditions. Thus strong institutions are needed. However, the same is equally true of fences, although maintenance costs are typically much lower than control costs. Fence patrol and rapid response to a fence breakage is essential.

An analysis in New Zealand suggested that at areas above 100-1,000 ha, fences become cheaper than control over a 25-year period, whereas at areas less than 100 ha, control is usually cheaper.

However, control has higher risks to non-target animals and is subject to public controversy. It is generally now possible to control rodents, cats and pigs without serious non-target impacts, because a large amount of research has been conducted into how to achieve this. However, non-target risks are not zero, and cannot be discounted. There may be considerable public distaste for ongoing killing of mammals, especially if poisons are used, and this may lessen support for conservation.

Finally, target alien species within the fenced area will be absent, whereas in an unfenced control area, they will always be present, albeit at greatly reduced numbers. If even low densities of aliens can cause significant ecological damage, then fencing is preferable. In Montserrat, the relationship between alien species density and damage to native wildlife is not well understood and therefore difficult to demonstrate.

Considerations and options for Montserrat

Any fence designed to protect galliwasp, and perhaps other threatened native wildlife in Montserrat, would probably need to be rodent-proof, as well as excluding the larger mammals such as cats and ungulates. This is because rats are extremely abundant, and are likely to be the single most harmful invasive. If rats and mammalian predators are to be excluded, then mice would probably need to be excluded too, because their populations can explode if they are the only mammals present in an area. Mouse-proof fences are the most expensive and complex. There

may be some benefits in developing cheaper ungulate- (and perhaps cat-) proof fences in some areas. Pigs are currently only present in part of the Centre Hills, and their numbers are probably a long way short of the peak they will reach if not controlled. However, if they do increase and spread, their impacts could overwhelm those of other invasive species, being especially important for ground-dwelling herptiles like mountain chickens and galliwasp. They might also contaminate water sources.

There would be some practical difficulties with constructing a fence that encloses an area of land within the Centre Hills forest. Fence construction is much easier if a small bulldozer track can be constructed to allow easy access and mechanised digging. This would clearly be difficult in many parts of Montserrat because they are too steep – though perhaps the galliwasp range in Woodlands would be one of the easier areas. Difficult areas can be constructed by hand, without vehicle access; in some areas fences have even been built on slopes so steep that abseil access was needed. However, all of this is more labour-intensive, and hence expensive. It might also be considered undesirably intrusive to create a clear-felled track a few metres wide in the Centre Hills.

Fence construction in Montserrat would almost certainly have to use existing New Zealand expertise, probably one of their commercial companies. These companies would supply the design, and materials could be shipped from New Zealand. Staff from the companies would come out to guide and supervise fence construction by local labour. The involvement of local staff would of course be critical to ensuring that the fence can be maintained into the future.

Fence maintenance and durability on Montserrat might also be unusually difficult. Volcanic ash and acid rain might result in unusually high corrosion rates. Relatively high rates of soil erosion on steep volcanic soils might also create problems around the fence base. Flash flow in streams might also create problems, causing heavy stones and sticks to crash into the fence. Periodic tree-fall onto the fence is more or less inevitable, though it can be minimised by controlled removal of trees that are in danger of falling. However, major hurricanes that bring down very large numbers of trees on a single occasion, while creating institutional chaos that slow down response times, are possibly a major risk.

If a relatively small fence were constructed around the galliwasp known range, there might be some risk of splitting populations of key native species. This might apply in particular to Mountain chickens and galliwasp. A mouse-proof fence has no holes larger than 6 mm diameter. Such an aperture would probably allow juvenile herptiles to pass through (though this would need to be established) and so retain gene exchange, but certainly not adults. Thus, existing home ranges of individuals might be divided, and localised movements of the population prevented. We know too little about the ecology of the galliwasp to know whether this might be a problem. The obvious solution is to build a fenced area big enough that this is less of a concern.

Costs

The capital cost of building pest-proof fences is very high. However, maintenance costs, while not trivial, are relatively low. For building the fence, costs per metre have been informally estimated as ~80-200 GBP per metre by Xcluder, including all vegetation clearance, earthworks, materials, construction labour and freight. It is likely that costs in Montserrat would be towards the upper end of this range, because of the difficult terrain and the remoteness of the location.

Since the area of a circle is proportional to the square of the circumference, the cost per unit area of a fence drops substantially as the area enclosed gets larger. In particular, fences that enclose less than ~5 ha have costs per ha which are much higher than for larger fences.

In general terms, the cost of a perfectly circular 5 ha and a 10 ha fence, for example in a high priority galliwasp area, might be £60,000 - £150,000 or £90,000 - £220,000 GBP respectively (but note that since the enclosure would not be perfectly circular, actual costs would be substantially

Continued...

higher). For comparison the cost of fencing the part of Cassava Ghaut watershed that lies within the Centre Hills Forest Reserve (~80 ha) would be £390,000 - £980,000. The cost of fencing the entire Centre Hills Forest Reserve (1,169 ha) would be between £1.9 million and £4.8 million (the latter costs are based on the real shape of the watershed and reserve respectively, rather than on assuming a circular shape).

Fences need maintenance, and this is an unavoidable ongoing cost. No fence should be built without consideration being given to how this maintenance cost will be sustained. Essentially, fence lines need checking on a very regular basis – perhaps weekly. After storms, or any other conditions in which tree-fall is suspected, the response needs to be extremely fast. Therefore materials, staff and know-how to make rapid repairs needs to be instantly available.

Conclusions

Pest-proof fencing is now an established technique that is known to be feasible and to be capable of delivering huge conservation benefits in areas where native wildlife is severely threatened by invasive alien mammals. Fencing could probably be built successfully on Montserrat, but it is likely to be towards the higher end of the cost scale, and the long-term durability of fences in Montserrat is not clear.

Fences should not be built unless Montserratian institutions can maintain them, including repairing them in the event of a major hurricane (and the invading animals removed). Conversely, a fenced area in Montserrat might be seen as an extremely exciting conservation initiative that would capture the imaginations of funders and the public, and deliver major conservation benefits. Given the desperate status of the galliwasp, it might be worth a relatively large capital investment to secure its range free of mammalian predators.

Right: Snap trap used to remove rats in the Centre Hills (not at Woodlands) during a biodiversity assessment (Young 2008; photo: G. Garcia). Note that the trap is enclosed to minimize the risk of collateral damage to non-target species such as ground-foraging birds. The ability of galliwasp to access small crevices would mean that special care would need to be applied to making lethal traps (or poison bait) accessible to rats but not galliwasp.



In many respects, not least the low capital costs, ongoing control of invasive mammals might seem a more viable option than fencing in Montserrat. However, there are major issues of sustainability and public acceptance that would have to be resolved before it is worth commencing a serious control programme.

The final decision regarding how best to resolve invasive mammal problems in the Centre Hills requires more detailed analysis of more specific options. It would be prudent to commission a site visit by a relevant expert, to assess the possibilities for fencing and control and their probable conservation impacts.

Further information

Clapperton, B. K. & Day, T. D. 2001. *Cost-effectiveness of exclusion fencing for stoat and other pest control compared with conventional control*. DOC Internal Science Series 14. New Zealand Department of Conservation, Wellington, N.Z.

Continued....

Saunders, A. J. 2000. *A review of Department of Conservation mainland restoration projects and recommendations for further action*. New Zealand Department of Conservation, Wellington, N.Z.

Karori Wildlife Sanctuary, Wellington, <http://www.sanctuary.org.nz/index.html>

Maungatatauri Ecological Island, <http://www.maungatrust.org/home/index.asp>

Pest-proof fence commercial companies:

<http://www.pestproofences.co.nz/ourdesign.html> and <http://www.xcluder.co.nz/>

2.4.2.3. Volcanic activity on Montserrat

The Soufrière Hills Volcano at Castle Peak erupted on 18th of July 1995 for the first time in 350 years. A state of emergency was declared in August of that year and thousands evacuated from the south of Montserrat. The capital Plymouth was abandoned along with the southern two-thirds of the island. In June 1997 the Soufrière Hills volcano erupted killing 19 people; Montserrat's airport was closed, leaving only helicopter or boat access to the island. There were major collapses of the volcano's magmatic dome in July 2001, and in July 2003, accompanied by extensive ash falls affecting the Centre Hills. The 2003 eruption was the largest since 1995 and destroyed many buildings on the edge of the Safety Zone. In July 2005, Gerald's Airport opened, replacing W. H. Bramble airport destroyed in the 1997 eruption. Further major dome collapses occurred in 2006, 2008 and 2009 with the most vigorous activity of the whole eruption during the period October 2009 to February 2010 when the most recent major dome collapse occurred. A detailed chronology of all the volcanic events from 1995 to the present is available online (Montserrat Volcano Observatory 2010).

At present, nearly 60% of Montserrat's land area is within the Exclusion Zone. The Montserrat galliwasp's known range has remained within the Safety Zone throughout the emergency, although this is an area only 2.5 km from the edge of the Exclusion Zone at its nearest point (see Figs. 18, 24, 25).

There is little data on habitat loss or habitat regeneration over the history of the volcanic emergency 1995 to the present, but it seems the forests of the South Soufrière Hills themselves are mostly completely destroyed by pyroclastic flows, as opposed to being degraded by ash falls as has happened in the Centre Hills. An area of surviving forest in the South at Roche's Estate has been estimated at roughly 137 ha from aerial photographs.



Fig. 24 Collapsed volcanic dome, Soufrière Hills.
Photo: G. Garcia / Durrell

It is reported, anecdotally, that during the period 1996-1998 there was a high frequency of ash fall and explosive events resulting in a near-continual high level of ash in the north, with a widespread albeit not deep coverage. There is suspicion, again based on anecdotal reports, that this had a strong effect on arthropod and probably other invertebrate populations in the north of Montserrat. Research on canopy insects indicates large but ephemeral effects of ash fall on canopy insects, with some suggestion that ground-dwelling insects were more seriously impacted (Marske 2004, Ivie et al 2008). Recovery appeared to be



Fig. 25. Heavy ash fall at Fairy Walk, February 2010. Woodlands has experienced similar ash falls over the past 15 years, as well as numerous lesser ash falls. Photos: S. L. Smith.

rapid (within weeks to a few months). There were presumably consequent knock-on effects on vertebrate consumers, although Dalsgaard et al. (2007) showed that most bird populations in the Centre Hills were not strongly impacted overall.

The Woodlands area has been relatively little impacted over the past few years, though foliage, leaf litter and soil continue to receive light dustings of acidic volcanic ash. It seems likely, from what little historical data is available, that the present

restriction of the Montserrat galliwasp to a very small area is not the result of the current volcanic emergency but was the case prior to the 1995 eruptions. However, any additional impacts that this volcanic activity may have had on the galliwasp population remain unknown, and the possibility of future eruptions destroying the current range of the Montserrat galliwasp remains.

2.4.2.4. Human persecution and unintentional killing.

Although other galliwasp species are feared by people – based on the mistaken belief they are venomous – and, as a result, persecuted (Shaw 1802; Lynn & Grant 1940, cited in McGinnity 2002; Myers 1973), there are no reports of such threats to the Montserrat galliwasp. Presumably the extreme rarity of sightings on Montserrat, if nothing else, would account for this. On a related point, the (unproven) possibility of accidental poisoning of galliwasp in the Woodlands area through reckless pest control efforts has already been mentioned (section 2.4.2.1).

2.4.2.5. Inferred small population size.

Given the apparently extremely small global range of the Montserrat galliwasp (section 2.2.1), the population is inferred to be, inevitably, very

small (albeit of undetermined size; section 2.2.2). This small population, and the fact that it is known only from a single location, makes the threat of stochastic (unpredictable) events to the population very severe. These events could be catastrophic – such as hurricanes, volcanic events, wildfires, or any other potential catastrophes – or simply random demographic effects associated with small populations.

One response to the threat of extinction through stochastic events could be to establish an ex situ (captive) “safety net” population. Recent efforts at Nashville Zoo (McGinnity 2002) and Durrell (Goetz 2008) have successfully bred the giant Haitian galliwasp *C. warreni*. This species could be viewed as an analogue for the Montserrat galliwasp and the breeding programme for it considered a model for an ex situ intervention. More details of this programme are shown in Box 2 and Goetz’s (2008) husbandry guidelines are appended (Annex 6).

Box 2. The ex situ component of a conservation plan for giant galliwasp

Gerardo Garcia

Nashville Zoo has been keeping and breeding this species since 2000. Over 300 offspring have been produced from the founder population from the nine males and nine females originally taken from the wild the Come Hombre forest in the Dominican Republic. As an extension to this effort, Durrell has produced 97 offspring from two females breeding over a three year period. *C. warreni* has been successfully bred in captivity, producing an F2 generation (“grandchildren”) and with a low mortality rate (less than 4% at Nashville Zoo; 0% at Durrell in three years).

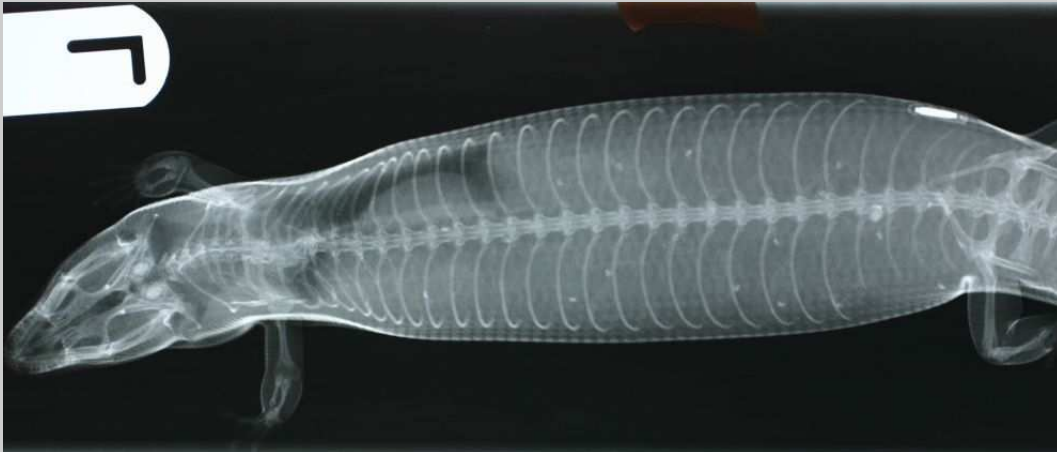


C. warreni breeding facility at Durrell, 2007. Photo: G. Garcia / Durrell

Continued....

Durrell's breeding programme successfully achieved a number of objectives:

- Maintaining and breeding adult *C. warreni* and their offspring successfully for 3 years.
- Continuing the development of feeding techniques (using live invertebrates and a tailored meat mix formulation) for adults and juveniles.
- Developing ex situ procedures (some of which may have in situ applications) including techniques for:
 - Individually marking galliwasps using implanted passive infrared transponders
 - Health screening (blood sampling from the tail)
 - Monitoring pregnancy using ultrasounds and x-ray.



X-ray of pregnant *C. warreni*. The white speckles between the ribs are the skulls of developing embryos. Photo: J. Lopez / Durrell

A number of factors have contributed to the success of the breeding programme:

- Low cost of facilities and maintenance.
- Extremely high fecundity and survival rate of *C. warreni*.
- Small size of the species and relatively straightforward food, space and general maintenance requirements.
- High degree of predictable behaviour and physiology in the species (as long as certain basic environmental parameters are replicated in captivity).
- Little veterinary intervention required.

The rapid success of the captive programme, easy setup of facilities and modest space required

Continued....

to maintain a head starting and/or captive breeding programme of the species – achievable either within the host country and/or overseas – demonstrate the potential value of an ex situ for maintaining “safety net” populations and producing stock to augment in situ populations.

The guidelines developed by Goetz (2008) have proven easily portable to other institutions (four in total in Europe). Treating *C. warreni* as an analogue species, it is believed these guidelines would also be straightforward to port to the husbandry of any ex situ populations of the Montserrat galliwasp.



C. warreni hatchlings bred at Durrell. Photo: G. Garcia / Durrell

There are plans to develop a similar breeding programme for the egg-laying species *D. monotropis* (considered by Underwood (1964) to be the Montserrat galliwasp’s closest relative, although it is not established whether the latter is egg-laying or live-bearing) although there have been problems with successfully hatching eggs (McGinnity, pers. comm.). This will be used as an analogue species for *D. millepunctatus*, another species which – although at high densities – is restricted to a very small range and thus susceptible to population declines or extinction through stochastic events.

Further information

McGinnity, D. 2002. *The conservation initiative for giant galliwasp at Nashville Zoo: A preliminary account*. International Zoo News 49: 396–403.

Goetz, M. 2008. *Hispaniolan galliwasp Celestus warreni husbandry guidelines*. Unpubl. Report. Durrell Wildlife Conservation Trust. 1-3.

A copy of Goetz’s (2008) husbandry guidelines is appended (Annex 6). Note that Nashville Zoo do not rear offspring separately from mothers as has been done at Durrell (D. McGinnity, pers. comm.)

2.5. Protection status

The laws of Montserrat are comparable to those of other Commonwealth Caribbean Countries, some (e.g. Beach Control, Agricultural Small Holdings legislation) being enactments common to several countries. Some (e.g. Fisheries, Pesticides, Physical Planning legislation) are based on OECS Model Acts, designed for Small Island Developing States (SIDS). Hence, existing laws provide a comprehensive framework for governance, but are not specifically designed for Montserrat. One strength is that the law provides key elements of a legal framework for biodiversity conservation:

- *In situ* conservation of species, including endemic, endangered and threatened species
- Conservation of critical habitats
- Designation and Management of Protected Areas
- Control of influx of exotic organisms
- Regulation of natural resource use/exploitation
- Fulfilment of international legal obligations

Under Montserrat's Forestry, Wildlife, National Parks and Protected Areas Ordinance (1996) the Montserrat galliwasp is, apparently in error, not listed as protected or partially protected wildlife, which means any hunting or otherwise killing of it cannot be regulated. All wildlife is deemed to be the property of the Crown and a wildlife survey is required to be made every 10 years. Wildlife are classified into 3 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 iguana, the Montserrat galliwasp and the Montserrat anole *Anolis lividus*, the latter two endemic to Montserrat.
- All amphibians are protected, except the mountain chicken.

The known cluster of Montserrat galliwasp sightings lies largely outside the current boundary of the Centre Hills Protected Forest, gazetted in 2000 (see Figs. 5 (inset map) and 26). Most of the Reserve is privately owned. Some management agreements have been reached between the DOE and private landowners, to ensure land management prescriptions that are beneficial to biodiversity,



Fig. 26. The Centre Hills, Montserrat. Photo: R. Young / Durrell

and tax concessions are offered to land owners with land given protected status. Once enacted, the Conservation and Environmental Management Act (CEMA; see below) will provide a mechanism for extending the protected forest boundary.

Montserrat is not yet included in the UK's ratification of the Convention on Biological Diversity (CBD), though it is hoped this is will eventually be done. It is included in the UK's ratification of the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES). The enabling legislation for CITES is the *Endangered Animals and Plants Ordinance* (1976). However, the Montserrat galliwasp is not listed under any CITES schedule as there is believed to be no significant international trade in this species.

A revision of environmental laws in Montserrat has been completed as part of the Centre Hills Project to produce CEMA, which currently exists as a bill and regulations. Once enacted, CEMA will rectify the anomaly of the Montserrat galliwasp being unprotected and confer on it the full protection of being a protected species of wildlife. CEMA will have other implications for protection of the Montserrat galliwasp. For example, the act calls for the development of a National Parks & Protected Areas (NPPA) Plan and requires that land must be designated to protect biodiversity (which would include the Montserrat galliwasp). It also allows for Protected Areas to be gazetted prior to completion of the NPPA plan and makes provision for a number of types of Protected Areas, at least two of which have potential for extending further protection to the Montserrat galliwasp: Nature Reserves and National Parks.

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

The Department of Environment of Montserrat's Ministry of Agriculture, Lands, Housing & The 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.

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 2004, describes a vision for the development of tourism as a major contributor to the island's economy

during 2004–2010. 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 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'.

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 & 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.faunaflo.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, Durrell coordinated the 'Centre Hills Biodiversity Assessment' (CHBA, <http://www.durrellwildlife.org/index.cfm?p=307>) in collaboration with MNT, MALHE and taxon experts from Jersey, the UK and USA. Two Montserrat galliwasp were found during the herpetological surveys of this assessment. Durrell also collaborated with DOE on Corry et al's (in prep) 2008 survey searching for the Montserrat galliwasp.

Montserrat forms a part of the Caribbean Islands biodiversity hotspot (<http://www.biodiversityhotspots.org/xp/Hotspots>), as identified by Conservation International. The Critical Ecosystems Partnership Fund (<http://www.cepf.net/xp/cepf>), a large-scale funding mechanism for hotspots, is due to open for the Caribbean in July 2010. Montserrat is also an 'Alliance for Zero Extinction' site (<http://www.zeroextinction.org/selection.htm>), as it is a discrete area with more than one endemic 'Critically Endangered' species. Other regional NGOs with an interest in Montserrat 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>)

2.7. Stakeholder Analysis

People and groups who have a stake in the implementation and outcome of the plan have been identified (Annex 3. Stakeholder analysis), along with their interests, activities, how their activities impact on the species (positive or negative), intensity of the impact, and proposed mitigating action(s). Most of the stakeholders identified will contribute positively to the project and there are a large number of local organisations that could assist in raising awareness.

A number of stakeholders did not participate in the SAP workshop, including a few who had been invited but were unable to attend, most importantly land owners and residents from Woodlands Spring. A focus group discussion for these stakeholders was also not well attended, but those who

did attend provided a lot of valuable information and insights to this Plan, particularly as it relates to how Woodlands residents can contribute to the survival of the Montserrat galliwasp. This information is recorded in Table 2: Projects and Activities.

2.8. Factors influencing success of action plan implementation

The Montserrat galliwasp is little known in Montserrat or in the wider world and a lack of awareness is one of the first challenges to the successful implementation of this Plan. However, it is important to consider all the risks and opportunities affecting the implementation of the plan. These are summarised in Annex 4 (Factors affecting action plan implementation), which indicates the positive or negative impact of each factor.

One factor essential to the successful implementation of this plan is the capacity within Montserrat required for delivery. Effective coordination and monitoring from within Montserrat will be crucial. In support of this, we see the appointment of an SAP Manager – to manage and, crucially, raise funds for both this Plan and the others produced by the project of which it is a part² – to be a keystone action. The success of this, and the other SAPs, will depend on achieving this action.

Two areas of this plan are likely to be very expensive, namely the acquisition of undeveloped private land parcels and the establishment of an area protected by a predator-proof fence. The latter action will require careful scoping to evaluate feasibility. If a predator-proof fence is considered unfeasible, a contingency action will need to be identified and implemented; some alternative options to a physical fence are outlined and discussed in Box 1.

In the wildlife conservation sector in Montserrat, there is currently a heavy reliance on a very small number of key individuals. At the same time, there are many urgent priorities for resources on Montserrat due to the volcanic crisis. As a UK Overseas Territory, Montserrat is excluded from some funding sources, such as the Global Environment Facility, while current UK Government funding is small, relative to that provided for nature conservation in the 'metropolitan UK' (Pienkowski 2005, UKOTCF 2005).

² The other SAPs developed under this project are for the mountain chicken (*Leptodactylus fallax*) on Montserrat, the orchid *Epidendrum montserratense* and the shrub *Rondeletia buxifolia*, and the yellow-shouldered volcano bat, *Sturnira thomasi vulcanensis*.

3 Action programme

3.1. Vision, aim and objectives

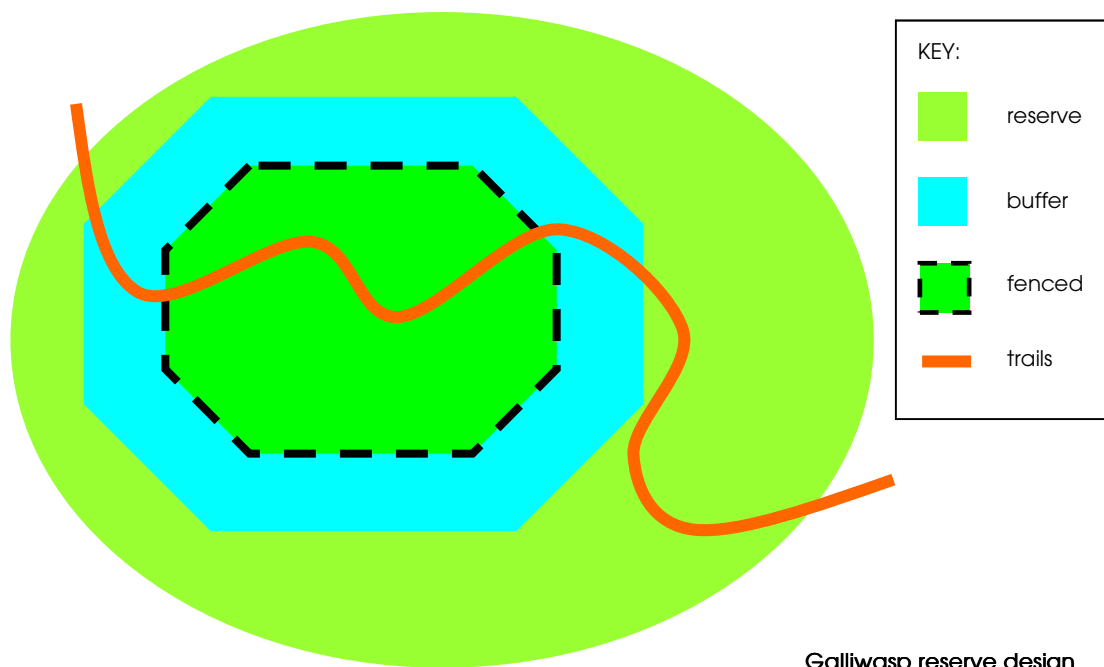
The vision for this plan looks 20 years ahead into the future. The aim is time-bound to the five year duration of this plan and can be monitored and evaluated using measurable indicators.

Development of the objectives in this programme was guided by the problem and solution trees pro-

duced during the workshop (see Annex 1). Objec-

tive 0 (zero) is not an end in itself but was identified as essential to ensure the other objectives are met.

Throughout this plan, reference is made to a *galliwasp reserve*, a *fenced area* (within which all target alien invasive species are to be eradicated) and a *buffer zone*. Note that the use of the phrase *target* alien invasive species refers to the fact that there may be no attempts to eradicate certain alien species (for example agouti). The spatial relationship between the planned reserve areas is represented diagrammatically as follows:



Galliwasp reserve design

Table 1 . Vision, aim and objectives: their justifications and indicators.

<i>Vision (over 20 years)</i>	<i>Description and justification</i>	<i>Indicators</i>
<p>Montserrat supports a secure, self-sustaining population of wild Montserrat galliwasp, co-existing with people, and nationally and globally valued</p>	<p>'Security' refers to addressing the extremely high risk of extinction of the Montserrat galliwasp's global population, which is currently restricted to a very small area. 'Self-sustaining' refers to the wild (<i>in situ</i>) population and implies <i>ex situ</i> intervention, or other intensive ongoing management, would no longer be required. 'Co-existence with people' recognises that in Montserrat this species can necessarily only exist in close proximity to people or in areas also used by people. 'Nationally and globally valued' means that the Montserrat galliwasp is of some recognised benefit to people</p>	<p>The Montserrat galliwasp is downlisted to Endangered. This could be achieved by a galliwasp population of:</p> <ul style="list-style-type: none"> • of more than one site and • of more than 50 mature individuals and • not declining in range or numbers <p>'Self-sustaining' means no ongoing ex situ management for galliwasp conducted over a five-year period. This would mean that we are not having to continue to head-start, translocate etc.</p> <p>Human access to areas in which galliwasp occurs is managed for their conservation.</p> <p>The species is included in promotional or cultural materials for Montserrat and is a reason for scientists or tourists to visit Mont-</p>
<i>Aim (over 5 years)</i>	<i>Description and justification</i>	<i>Indicators</i>
<p>Increase the size of the Montserrat galliwasp's global range and establish an <i>ex situ</i> breeding programme</p>	<p><i>In situ</i> refers to Montserrat galliwasp living in the wild; <i>ex situ</i> refers to a proposed population of Montserrat galliwasp, bred and/or reared in captivity at a site in Montserrat. The <i>ex situ</i> population can only contribute to a sustained increase in the <i>in situ</i> population if threats in the known range are first reduced (and kept reduced), and only with the ongoing support of the people of Montserrat through awareness raising and sensitization to the plight of the species.</p>	<p>At least three clutches of Montserrat galliwasp produced and/or reared (to 1 year-old) in captivity in Montserrat.</p> <p>At least three clutches of Montserrat galliwasp released into the known range at Woodlands.</p> <p>Invasive alien vertebrate species are confirmed absent within the perimeter of a predator-proof fence encompassing a significant proportion of the known Montserrat galliwasp range at Woodlands.</p> <p>If fencing is not feasible, introduced predator numbers are substantially reduced in number and maintained at a low level in an area designated for intensive predator control</p> <p style="text-align: right;"><i>Cont....</i></p>

<i>Aim (over 5 years)</i>	<i>Description and justification</i>	<i>Indicators</i>
		<p>Populations of other herptile species, and (if possible to measure) Montserrat galliwasp, increase within the area in which invasive alien vertebrate species are controlled.</p> <p>Measurable changes in human behaviour among residents and users of the Woodlands site, specifically reduced numbers of free-ranging domestic cats and dogs and any built development is built to galliwasp friendly guidelines.</p>
<i>Objectives (5 years)</i>	<i>Description and justification</i>	<i>Indicators</i>
<p>0. The Montserrat galliwasp SAP is successfully coordinated by a Montserratian team and resources are obtained to carry out the projects in the plan.</p>	<p>A team of Montserratian professionals will co-ordinate the projects and activities outlined below and monitor the achievement of SAP milestones.</p> <p>A Species Interest Group (SIG) will act as an advisory body.</p> <p>Several of the objectives will require significant financial and human resources, and therefore obtaining these resources will be a major challenge that needs addressing.</p>	<p>A named group of Montserratian professionals has salaried time assigned to the role of SAP coordinators.</p> <p>A SIG is formed from relevant technical advisors and regularly corresponds by email to advise on priority activities outlined in the SAP.</p>
<p>1. National and international awareness of the value and status of the Montserrat galliwasp and its habitat, is raised sufficiently to ensure support for, and participation in, vital conservation activities.</p>	<p>All the actions identified in this plan, but especially the <i>in situ</i> actions (i.e. in and around the known Montserrat galliwasp range at Woodlands), will need the support of the people of Montserrat.</p> <p>Significant resources for the ambitious activities described in this plan will need to be obtained from international conservation donors, and to achieve this, awareness raising will be necessary.</p> <p>It is critical that people are not only aware of the plight of the Montserrat galliwasp but also sensitive to it to the point that they modify their behaviour in a way that reduces believed negative impacts on this species. These impacts are primarily from residential development and associated activities (land clearance) and domestic pets that can act as predators (cats and dogs)</p>	<p>The proportion of people in Montserrat that are aware the Montserrat galliwasp is a threatened endemic, and aware of the threats it faces, increases.</p> <p>Land clearance (tree and boulder removal) in plots not developed immediately afterwards, decreases.</p> <p>Land clearance (tree and boulder removal) in existing (inhabited) residential plots is reduced.</p> <p>The number of unrestrained domestic dogs within the Woodlands area decreases.</p> <p style="text-align: right;">Cont....</p>

<i>Objectives (5 years)</i>	<i>Description and justification</i>	<i>Indicators</i>
		<p>The number of domestic cats outdoors at night in the Woodlands area decreases during the lifetime of this plan.</p> <p>A community based organization (CBO), located in the Woodlands area, is established and facilitated to assist in monitoring and managing the Woodlands area.</p> <p><i>(Optionally)</i> The number of domestic cats in the Woodlands area that are spayed increases during the lifetime of this plan.</p> <p><i>(Optionally)</i> The number of domestic cats in the Woodlands area does not increase during the lifetime of this plan.</p> <p>Possibly the 'during the lifetime..' bit can be omitted, since it is an indicator of a plan objective, it is kind of self-evident that it is time-bound in this way.</p>
<p>2. The Forest Reserve, plus additional land outside the Forest Reserve, is managed – through acquisition and/or agreement – by a community based organization (CBO) facilitated by DOE.</p>	<p>Based on our current knowledge of the Montserrat galliwasp, site-based conservation – with the sole site (at least initially) being in the Woodlands area – appears to be the priority strategy. The galliwasp is known to occupy an area that includes</p> <ul style="list-style-type: none"> • a small part of the Centre Hills Forest Reserve that is not actively managed for galliwasps at present; • Crown Land, not actively managed for conservation at present; • private land sub-divided into plots designated for residential development. <p>Management of (iii) will require voluntary agreement (codes of practice) with private landowners and/ or acquisition of parcels of private land by/for GOM to allow effective management. A Woodlands CBO will play a key role in this (see Objective 2).</p>	<p>A Management Plan for the galliwasp reserve is implemented by the end of this plan.</p>

Objectives (5 years)	Description and justification	Indicators
<p>3. The impact of invasive alien species on Montserrat galliwasp is reduced by establishing a fenced reserve free of target species.</p>	<p>Target invasive alien species are kept clear from an area encompassing the majority of the currently-known Montserrat galliwasp range by eradication, and establishing and maintaining a predator-proof fence to prevent re-invasion.</p> <p>Invasive alien species and residential development pressures have been identified as the main putative threats facing the Montserrat galliwasp. These two threats are linked via domestic pets (predators).</p> <p>A managed area kept clear of target alien species will provide a site in which to reintroduce captive bred and/or reared galliwasp in order to increase the <i>in situ</i> population size.</p> <p>Impacts of this action on species of conservation concern (proxies for the Montserrat galliwasp) will be monitored against baselines established before fencing and eradication.</p> <p>Clearly, achieving Obj. 2 is a necessary condition for this Objective.</p>	<p>A scoping report on the feasibility of funding, building and maintaining a predator-proof fence is completed.</p> <p>If feasible:</p> <p>A reserve containing a predator-proofed fenced area is built.</p> <p>Monitoring indicates that the predator-proof fenced area is free of rats, goats, pigs, fowl, cats and cane toads.</p> <p>If not feasible:</p> <p>A programme of predator control is operational; bait-take and trap returns are being monitored. Bait-take and trap returns are held at consistently low levels (relative to the baiting and trapping effort deployed).</p>
<p>4. A captive-breeding programme, with trained staff, is established in Montserrat with the aim of releasing galliwasp into the wild in Woodlands and/or a second site.</p>	<p>An <i>ex situ</i> (but in Montserrat) programme of breeding and/or rearing ('headstarting') Montserrat galliwasp will allow us to increase the size of the population <i>in situ</i> by restocking the known range.</p> <p>In the longer-term (beyond the lifetime of this plan) the aim is to conduct galliwasp reintroductions in additional areas on Montserrat and thereby increasing the species' range.</p> <p>This Objective carries high risks (of further depleting the <i>in situ</i> population and/or of not capturing enough genetic diversity in the <i>ex situ</i> population). However, the SAP workshop determined that the risks of <i>not</i> meeting this Objective (i.e. extinction of the galliwasp) were higher.</p> <p>This Objective is only worthwhile if Obj. 3 is achieved. It is not an end in itself. It is not intended to produce a 'safety net' population, rather to restock the <i>in situ</i> population.</p>	<p>A minimum of one pair of galliwasp are managed <i>ex situ</i> at a Montserratian site at some point during the lifetime of the plan.</p> <p>Montserratian staff are responsible for the day-to-day running of the <i>ex situ</i> facility.</p>

<i>Objectives (5 years)</i>	<i>Description and justification</i>	<i>Indicators</i>
<p>5. DOE declares a Montserrat galliwasp reserve in the Woodlands area, under the CEMA act.</p>	<p>CEMA is in final draft. It makes the Montserrat galliwasp a protected species (which, under current Montserrat legislation it is not) and allows for the declaration of reserves of various types, with at least two types having potential to be used to secure the galliwasp site for conservation.</p> <p>CEMA also allows for regulations to be created to enforce reserve management prescriptions.</p> <p>It may also be possible to create a regulation under existing planning law to reduce (but not eliminate) instances of land clearance where this is done solely as a means of minimal compliance with planning permission.</p>	<p>A galliwasp reserve is declared.</p> <p>Regulations are developed and in place in accordance with the needs of the management plan (Obj. 2).</p>
<p>6. Research and a monitoring scheme underpin management decisions and allows success to be monitored.</p>	<p>A weakness in this plan is the current inability to directly monitor impacts of the proposed actions on the Montserrat galliwasp. This will be partly addressed by monitoring other, proxy species (under Obj. 3). However, this Objective will seek primarily to identify methodologies that will allow us to monitor impacts on the galliwasp directly.</p> <p>An additional site for future (beyond the lifetime of this plan) reintroductions will also be identified under this Objective.</p> <p>An analysis of genetic diversity in the Montserrat galliwasp population will allow optimal management of the <i>ex situ</i> population and of future (beyond the lifetime of this plan) reintroductions to additional areas.</p>	<p>A galliwasp monitoring scheme established and maintained within the Montserrat Biodiversity Database by the end of the plan.</p> <p>At least one scientific paper on galliwasp conservation and/or ecology published by the end of the plan.</p> <p>A second reintroduction site identified.</p> <p>An assessment of genetic variation in the galliwasp population completed.</p>

3.2. Projects and activities

Framework Objective 1 (awareness raising and sensitisation, particularly for users of the Woodlands area) is seen as a necessary condition for Objectives 2 and 3 (identifying, demarcating and predator-proof-fencing an area encompassing at least a large part of the known Montserrat galliwasp range) to succeed. Objective 4 (breeding and/or rearing Montserrat galliwasp in captivity) is only justified if Objectives 2 and 3 are achieved. Objective 5 (enacting legislation for declaring a reserve) is necessary for establishing the legal framework for Objective 2 (identifying and demarcating a galliwasp reserve). A number of monitoring activities will be needed to ensure Objectives 2 and 3 are achieving their targets; in addition, other research activities (Objective 6) will inform management actions to conserve the Montserrat galliwasp *in situ* and *ex situ*. Objective 0 is an overarching set of project management and resourcing activities to ensure the remaining Objectives (1-6) are completed.

The **Projects** below unpack the finer details of the objectives. Completion of all the projects listed for an objective should mean that the objective will be achieved. A project is a broad concept of what needs to be done and includes a set of activities. Projects or groups of related projects are shown under headings highlighted in yellow, with project activities detailed under each heading.

Note that the activities under section 3.4 in the following table (reducing abundance of target invasive alien species) can be adapted to cover ongoing predator control if, following scoping, establishment of a predator-proof fence is assessed as being not feasible.

Priority indicates the importance (Critical - High - Moderate - Low) of the project activities to the achievement of the overall goal and vision of the Plan.

Agencies responsible for leading each action are listed (see Acronyms).

Costs are estimated as overall cost during the lifetime of the Plan, in thousands of US Dollars, except where followed by p.a., which indicates costs per annum.

Timescale indicates the period of time (in quarters) during which an activity will be conducted (e.g. Q3 2011 - Q3 2011). A few activities will need to be ongoing, continuing beyond the lifetime of this 5 year plan.

Objectively verifiable **Indicators** which demonstrate that the project has been successfully car-

ried out are listed.

Risks and Opportunities that might affect the execution of the project are presented.

The **Project timetable** summarizes the information in the Timescale column on a single chart to give an overview of the projects plan. A few activities planned to be still ongoing at the end of the 5 year plan (i.e. at the end of Q3 2016) are indicated. Only major project activities are shown here, not the detailed sub-activities unpacked by the projects table.

Table 2. Projects and activities

Obj.	Project and Activities	Priority	Agencies responsible	Cost (US\$ k)	Timescale	Indicators	Risks and opportunities
0	Coordination and resourcing of SAP						
0.1	Establish a galliwasp SAP coordinating team	Critical	DOE	0-1 p.a.	Q4 2011	SAP team meets quarterly (and has salaried time available to do this) to coordinate implementation of SAP. SAP meets its indicator targets during their timescales.	SAP aspirations fall under DOE's remit Momentum from workshop Lack of cooperation from stakeholders
0.1.1	Identify team members						
0.1.2	Incorporate the role into their work programmes						
0.1.3	Agree the team's objectives						
0.2	Establish a galliwasp SAP steering/advisory committee	Critical	DOE, Durrell	0-1	Q3 2011	Committee members identified An average of one email exchange between members of the committee and the coordinating team per month	Plenty of expertise Committee isn't used
0.3	Appoint a Montserrat SAPs Manager to promote SAP implementation. This is seen as a keystone action in the implementation of this (and other) SAP	Critical	Durrell, Kew, RSPB, DOE	>100	Q3 2011 – Q3 2012	A Montserrat-based Manager is in this post	Funders may see post as unsustainable
0.31	Obtain funding to employ SAP manager to manage the implementation of multiple SAPs in Montserrat	Critical	Durrell, Kew, RSPB, DOE	> 100	Q3 2011 – Q3 2012	Funding applications successful	Natural follow-on to current SAP project Funders may see post as unsustainable
0.32	Determine job description and employment arrangements, and recruit SAP manager	Critical	Durrell, Kew, RSPB, DOE	1-10	Q1 2012	Person recruited with successful track record of getting proposals funded	Likely to be non-Montserratian

0.4	SAP manager and co-ordinating team source funds for plan implementation	Critical	DOE, Durrell	0-1 p.a.	Q3 2011 – Q3 2014	At least two funding proposals submitted to international donors.	SAPs give clear justification for projects
0.4.1	Submit project proposals to funders						
1	Raise awareness of and sensitivity to galliwasp						
1.1	Preliminary awareness raising and sensitisation	High	DOE	1-10	Q3 2011 – Q1 2012	?	?
1.1.1	Focus groups with Woodlands residents and landowners	High	DOE	0-1	Q3 2011	At least one focus group meeting involving at least 5 local stakeholders	Lack of interest restricts participation
1.1.2	Information gathering on people's knowledge / attitudes / behaviour	Moderate	DOE	0-1	Q4 2011 – Q1 2012	Questionnaire/ interview results received from >100 Montserratians, and >10 people resident in the Woodlands area	Time-consuming to execute this sort of survey This type of survey largely already completed by the Centre Hills Project – needs re-analysing.
1.1.3	Radio and TV programmes with DOA/DOE	Moderate	DOA, DOE	0-1	Q3 2011 – Q1 2012	Galliwasp and the SAP project covered in at least one radio broadcast and one television broadcast.	?
1.1.4	Galliwasp display at Montserrat agricultural exhibition	Moderate	DOE	0-1	Q3 2011	Display presented.	DOE have existing materials Exhibition popular
1.2	Pride campaign (to instill Montserratian pride in the galliwasp). This may be via (a) a RARE course or (b) separate activities	High	DOE, Durrell	>50 (?)	Q3 2012 – Q4 2013	Pride campaign completed.	?
1.2 a	A DOE or PPU staff member completes the RARE course	High	DOE, Durrell	>50 (?)	Q4 2012 – Q4 2013	RARE course completed.	The RARE course is competitive to be accepted on to.

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1.2.1 a	Identify application procedures for RARE	High	Durrell	0-1	Q3 2011	Application form and guidelines obtained	?
1.2.1 b	Review (and if necessary gather more) information on peoples' knowledge, attitudes, behaviour	Moderate	DOE	0-1	Q4 2011 – Q1 2012	Report by education officer	?
1.2.2 b	Identify target groups (e.g. primary, secondary schools)	High	DOE	0-1	Q1 2012	Report by education officer	
1.2.3 b	Develop a pride campaign strategy	High	DOE	0-1	Q2 2011	Strategic plan	Proven strategy in Montserrat and elsewhere
1.2.4 b	Produce radio/TV jingles (calypso)	High	DOE	0-1	Q2 2011	Jingles broadcast at least 50 times	Montserrat may be saturated with awareness raising
1.2.5 b	Deploy a galliwasp mascot for Montserrat	Moderate	DOE	1-10	Q2 2011 – Q1 2012	Mascot appears at at least 4 public events	
1.2.6 b	Produce educational posters for airport and other target areas	Moderate	DOE	1-10	Q2 2012	Posters on display in at least five major public locations including airport arrivals.	Could be combined with other SAP species
1.2.7 b	Develop educational materials for visitors (including DOE and Centre Hills websites)	Moderate	DOE	1-10	Q2 2012	Brochures in tourist outlets; material on DOE website	Could be combined with other SAP species
1.3	Raise awareness of fenced galliwasp reserve	Critical	DOE	1-10	Q4 2013 – Q1 2015	Increased proportion of Montserratians know about need for fenced reserve	?
1.3.1	Install signage at the fenced reserve (interpretation)	Critical	DOE, reserve manager (see 2.6.1)	0-1	Q2 2015	At least two interpretation signs in place in or around the Galliwasp reserve.	Signs need to be robust
1.4	Develop guided tours by forest rangers, including hiking, galliwasp fence and captive facility tours	High	DOE, reserve manager (see 2.6.1)	0-1 (profit making)	Q2 2015 onwards	At least 10 guided tours of at least 6 people each conducted in the galliwasp reserve and captive facility per year.	Is dependent on Montserrat's tourist industry sourcing tourists

1.4.1	Establish a mechanism for collecting visitor contributions	High	DOE	0-1	Q2 2015 – Q1 2016	A fee includes a contribution to the new Environmental Fund	Could help fund galliwasp management Environmental fund may not be operational
1.5	Develop guidelines for sensitive land use (e.g. gardening, construction) in Woodlands (Note: this is a repeat of Obj.2.2.2)	Critical	DOE, Durrell, RSPB	0-1	Q1 2013	At least 50 copies of a colour leaflet distributed to residences in Woodlands.	Potential for considerable local pride in having a 'neighbourhood endemic'
1.6	Develop guidelines, training and support (e.g. bait stations) for residents and public health officials on the safe, responsible deployment of poisons	Critical	DOE	1-10	Q1 2012 – Q3 2012	Number of ad hoc and home-made poisoning incidents reduced by 75%	Many Woodlands residents are already unhappy about these ad hoc incidents
1.6.1	Monitor incidents of ad hoc and home-made poisoning						
2	Establish and manage a galliwasp reserve						
2.1.	Demarcate (GIS) galliwasp reserve, including demarcation of core area (to be fenced)	Critical	DOE, PPU, Legal Dept	10-50	Q1 2012 – Q3 2014	GIS demarcation of galliwasp reserve contained within national GIS GIS demarcation of core area	Biodiversity data incorporated into national GIS by supportive staff
2.1.1	Produce a cadastral map (GIS) for Woodlands area	High	PPU, DOE	0-1	Q1 2012	Cadastral map produced and held in the PPU GIS unit.	Digitization already completed
2.1.2	Maintain and update cadastral map (through site visits) to monitor development pressure	High	DOE	0-1	Q1 2012 onwards	Six monthly annotated paper copies of cadastral map submitted by DOE to PPU GIS unit.	Two DOE staff live in Woodlands and can easily update map by site visits
2.2	Seek signed agreements on sensitive land use (see Obj. 1.5) with Woodlands residents and land-owners	Critical	DOE	0-1	Q2 2012 – Q1 2013	At least five signed commitments to 'galliwasp-friendly living' from Woodland residences.	Private land ownership and government interference are sensitive issues in the West Indies

								Potential for high sense of pride in endemic local species
2.2.1	Identify activities that likely impact on galliwasp conservation (e.g. pesticide use, tree-felling, use of machinery, boulder removal, use of fire, restraining pets (esp cats at night), de-sexing pets)	Critical	DOE, Durrell, RSPB	0-1	Q3 2012	0-1	Document reporting landowner activities that are believed to increase/reduce risk to galliwasp is written.	Putative impacts largely identified in this SAP Establishing actual impacts directly (with no way of monitoring galliwasps) difficult
2.2.2	Develop guidelines for sensitive land use (e.g. gardening, construction) in Woodlands (Note: this is a repeat of Obj. 1.5)	Critical	DOE, Durrell, RSPB	0-1	Q3 2012	At least 50 copies of a colour leaflet distributed to residences and farmers in Woodlands.	Potential for considerable local pride in having a 'neighbourhood endemic'	
2.2.3	Encourage fencing-in of domestic dogs in yards	Critical	DOE	0-1	Q4 2011	Number of fenced yards in and around Woodlands increases by 50%	Fencing seen as lowering value of property (makes neighbourhood look less safe) If prestige depends on galliwasp, fencing is consistent with this	
2.2.4	Subsidize yard fencing Deploy signage/interpretation on use of fencing, value of area	High	DOE	1-10	Q1 2012		Residents / landowners may resist restrictions on their activities Woodlands is already an upmarket, covenant-bound area, so residents may be sympathetic	
2.2.5	Hold face-to-face meetings with residents/landowners, through CBO	High	DOE	0-1	Q3 2012 - Q4 2012	At least 10 local householders/landowners involved in face-to-face meetings with SAP team		
2.2.6	Promote and obtain signed agreements	Critical	DOE	0-1	Q3 2012 - Q1 2013	At least five signed commitments to 'galliwasp-friendly living' from Woodland residences.	This approach to conservation has not been attempted previously in Montserrat.	

2.3	Acquire land parcels for GOM to manage as part of galliwasp reserve	High	DOE	>100	Q2 2013 – Q2 2014	At least 2 land parcels acquired by or for GOM for the galliwasp reserve.	Land-owners may be unwilling to sell. If sufficient agreements are obtained, acquisition may not be needed Landowners may want alternative land of equal market value
2.4	Produce a management plan for the galliwasp reserve (to include management of the fenced area – see Obj. 3.)	Critical	DOE, Durrell, RSPB, Kew	1-10	Q3 2014- Q4 2014	Management Plan produced and distributed	?
2.4.1	Participatory workshop produces management plan	Critical	DOE	1-10	Q3 2014	Plan from workshop distribution	Montserrat is 'workshop-saturated'
2.5	DOE adopts and implements Galliwasp Reserve Management Plan (a large proportion of the actions contained therein would be contained in this SAP)	Critical	DOE	50-100	Adoption by Q3 2014 Mgmt Q3 2014 ff	See 2.6.1-2.6.2	?
2.5.1	Reserve manager appointed	Critical	DOE	50-100 (?)	Q3 2014	Contract signed	Could be an existing DOE staff if salaried time allocated
2.5.2	Reserve manager reports against Management Plan targets and indicators	Critical	DOE	0-1	Continuous from Q3 2014	Management Plan progress reports distributed	?
2.6	Establish and maintain CBO in Woodlands which is incentivised to support site-based galliwasp conservation (facilitated by DOE)	High	DOE	1-10	Q1 2012 onwards	CBO established with at least five named members	(See 2.7.1-2.7.4)
2.6.1	Identify DOE staff member to be the contact person for CBO	High	DOE	0-1	Q1 2012	DOE staff member identified	DOE have many other commitments
2.6.2	Appointed DOE staff member holds face-to-face meetings with potential members	High	DOE	0-1	Q2 2012 – Q3 2012	DOE staff meets with CBO rep at least once every 2 months	DOE has many other commitments

2.6.3	DOE contact develops activities, products to incentivise and motivate CBO members	High	DOE	0-1	Q3 2012 – Q1 2013	(Products, activities)	Governor may be persuaded to hold soirees for CBO
2.6.4	Familiarise CBO with land use agreements (Obj. 2.2) and galli-wasp reserve management plan (Obj. 2.5)	High	DOE	0-1	Q1 2013 and Q4 2014	At least one meeting held between CBO and DOE contact point, with at least six participants.	?
3	Establish an area free of target invasive alien species in the galliwasp reserve						
3.1	Scoping to assess feasibility of a fenced area and surrounding buffer in the Woodlands galli-wasp reserve	Critical	DOE, RSPB, consultant (New Zealand)	10-50 (?)	Q2 2013 – Q1 2015	Detailed report on costs and difficulties of fencing, compared to the efficacy /recurrent costs of ongoing alien species control (?)	Fence turns out to be less cost-effective than ongoing alien species control Fence is prohibitively expensive Logistical, legal and/or physical constraints make fence non-feasible
3.1.1	Obtain expert advice on how to buy or build; specify design	Critical	DOE, RSPB, consultant	1-10 (?)	Q2 2013	Feasibility & Planning report into fencing options, written by an expert consultant, is published.	Predator fencing expertise is largely confined to New Zealand.
3.1.2	Complete an environmental appraisal	High	DOE	1-10	Q1 2014 – Q2 2014	Environmental appraisal report published.	Fence may prove to have unacceptable impacts
3.1.3	Get PPU approval to build the fence	Critical	DOE, PPU	0-1	Q2 2014 – Q3 2014	Written approval for fence obtained from PPU.	?
3.1.4	Define the range of the galli-wasp (desk-based job) using knowledge available at the time	High	Durrell	0-1	Q2 2014	National GIS contains a shapefile indicating the inferred boundaries of the galliwasp range	Uncertainty over known range. Survey methods may improve (Obj 6.2)

3.1.5	Determine resistance of fencing materials to acidic volcanic ash in Woodlands	Critical	SAP manager	0-1	Q2 2013 – Q3 2014	Feasibility & Planning report into fencing options contains a relevant section	<p>This is a novel problem that fence manufacturers may not have encountered.</p> <p>RSPB has good contacts with predator-fencing companies, and other projects that involve fencing</p> <p>RSPB has good contacts with predator-fencing companies, and other projects that involve fencing</p> <p>Cost per unit area declines sharply as area fenced increases, thus the most cost-effective fences are the most expensive in absolute terms.</p> <p>Possibility of the facility generating some money through e.g. admission fee or similar</p> <p>Constraints (or extra costs) resulting from physical factors (slope, boulders, streams) greatly reduce or alter the area that can be fenced</p> <p>Good cadastral data exists in GIS</p>
3.1.6	Cost the fencing and maintenance for 10-25 years to decide on affordability	Critical	SAP manager, consultant	0-1	Q2 2013	Feasibility & Planning report into fencing options contains a relevant section	
3.1.7	Determine the constraints on where the fence can be sited	Critical	SAP manager	0-1	Q3 2013 – Q1 2014	Feasibility & Planning report into fencing options contains a relevant section on physical and legal constraints	
3.1.8	Use GIS to plot the boundary to be fenced using the constraints from 3.1.4	High	SAP manager, PPU	0-1	Q3 2014	National GIS contains a shapefile indicating the area to be fenced	

3.1.9	Produce business plan for fence to generate income	High	DOE, SAP manager	0-1	Q4 2014 - Q1 2015	Business plan completed	?
3.2	Build the fence and establish vegetation break	Critical	DOE, SAP manager	>100	Q4 2014 - Q1 2015	Fence built	Limited availability of labour on Montserrat Difficulty of accessing appropriate materials
3.2.4	Recruit team to build the fence and agree contracts and payment schedule	Critical	DOE, reserve manager	>50 (?)	Q3 2014 - Q4 2014	Contracts for fence-building contractors signed	Will need overseas assistance with construction
3.3	Eradicate target invasive alien species from within the fenced area	Critical	DOE, reserve manager	10-50 (?)	Q2 2015 - Q3 2015	Intensive monitoring produces no detections of target species within the fence except for short-term incursions (<2 months)	?
3.3.1	Eradicate rats by trapping and/or poisoning (note: poisoning has the disadvantage of not revealing non-target species mortality)	Critical	DOE, reserve manager	1-10	Q2 2015 - Q3 2015	Intensive monitoring produces no detections within the fence after six months of eradication actions (except for subsequent incursions, see below)	Standard methods may have to be modified to minimise galliwasp bycatch risk. Live-trapping could be an alternative
3.3.2	Eradicate feral cats by live-trapping or poisoning	Critical	DOE, reserve manager	1-10	Q2 2015 - Q3 2015	Intensive monitoring produces no detections within the fence after six months of eradication actions (except for subsequent incursions, see below)	Could tag / 'microchip' domestic cats to avoid accidental killing and track repeat incursions
3.3.3	Remove feral fowl by trapping (long-term eradication may be impossible if fowl can fly over fence)	Critical	DOE, reserve manager	1-10	Q2 2015 - Q3 2015	Intensive monitoring produces a reduced number of post-control fowl detections within the fence after six months of eradication actions	Fowl are easy to trap in Montserrat

3.3.4	Eradicate cane toads	Critical	DOE, reserve manager	1-10	Q2 2015 – Q3 2015	Intensive monitoring produces no defecations within the fence after six months of eradication actions (except for subsequent incursions, see below)	Methods not well established and may involve some risk of bycatch
3.3.5	Determine impacts of invasive species' from dietary studies during eradications 2.3.1-2.3.3	High	Durrell, reserve manager	1-10	Q2 2015 – Q3 2015	Report or scientific paper on target species' diets published.	May be some reluctance to harvest stomachs A fridge / freezer will be needed
3.3.6	Monitor for invasive species presence to ensure fenced area is not re-invaded	Critical	DOE, reserve manager	0-1	Ongoing post-Q3 2015	National biodiversity database contains monitoring data collected at least every quarter.	Some methods (e.g. rat tunnels) well-established in Montserrat
3.4	Substantially reduce abundance of target invasive alien species in buffer zone	High ?	DOE, reserve manager	10-50 p.a. (?)	Ongoing post-Q3 2015	Acceptable levels of target species in area established from baseline and cat numbers kept at or below that level.	Effort needed may be prohibitively expensive
3.4.1	Control rats by trapping and/or poisoning.	High ?	DOE, reserve manager	1-10 p.a. (?)	Ongoing post-Q3 2015	Rat tracking tunnel index averages 20% at most.	Large edge to area ratio necessitates major control effort Poor understanding of relationship between abundance and impact. Need to avoid non-target mortality may make this more expensive than normal

3.4.2	Control feral cats with live-traps	High ?	DOE, reserve manager	0-1 p.a. (?)	Ongoing post-Q3 2015	Acceptable levels of cats in area established from baseline and cat numbers kept at or below that level.	No understanding of relationship between abundance and impact (we do not know targets needed) Tag / 'microchip' domestic cats to avoid accidental killing and track repeat incursions
3.4.3	Control feral fowl with live-traps	High ?	DOE, reserve manager	0-1 p.a. (?)	Ongoing post-Q3 2015	Feral fowl abundance reduced by at least 75% of baseline.	No understanding of relationship between abundance and impact. Fowl easy to trap
3.4.4	CBO harvests exotic fruits in buffer area	High ?	DOE, reserve manager	0-1 p.a. (?)	Ongoing post-Q3 2015	Quantity of windfall fruit in the buffer zone drops by at least 50% of baseline	People rarely walk off trail in the forest, so harvest may be spatially limited. Relies on difficult voluntary work Harvested food has value
3.5	Monitor impacts of eradication and control efforts: in each case (3.5.1-3.5.5) establishing a pre-eradication baseline to monitor against	Critical	Durrell, Kew, RSPB reserve manager	10-50	Q3 2014 and Q3 2015 onwards	Impacts (changes) are evident in improved status of species of conservation concern	?
3.5.1	Monitor vegetation changes	High	DOE, reserve manager, Kew	1-10	Q3 2014 and Q3 2015 onwards	Report/scientific paper published within 5 years of fence establishment	Centre Hills Biodiversity Assessment established protocols
3.5.2	Monitor changes in insect biomass / diversity / indicator taxa	Critical	DOE, reserve manager, ???	1-10	Q3 2014 and Q3 2015 onwards	Report/scientific paper published within 5 years of fence establishment	Centre Hills Biodiversity Assessment established protocols

3.5.3	Monitor changes in non-galliwasp herpetofauna abundance	Critical	DOE, reserve manager, Durrell	1-10	Q3 2014 and Q3 2015 onwards	Report/scientific paper published within 5 years of fence establishment	Centre Hills Biodiversity Assessment established protocols
3.5.4	Monitor galliwasp population (proportion of area occupied)	High	DOE, reserve manager, Durrell	1-10	Q3 2014 and Q3 2015 onwards	Report/scientific paper published within 5 years of fence establishment	No established method of monitoring galliwasp
3.5.5	Monitor bird responses	Critical	DOE, reserve manager, RSPB	1-10	Q3 2014 and Q3 2015 onwards	Report/scientific paper published within 5 years of fence establishment	RSPB have established protocols
3.6	Monitor fence integrity and eradicate target invasive alien species after any incursions	Critical	reserve manager	?	Ongoing post Q2 2015	Monthly report submitted to Director of Environment by reserve manager relates outcome of regular fence checks	?
3.6.1	Develop a fence maintenance plan to include prescriptions for purchase and shipping or local construction of material, costs, responsible persons, and source of funds.	Critical	Reserve manager	0-1	Q2 2013	Plan published before the fence is built	?
3.6.2	Identify and train a team on standby to rapidly repair fence	Critical	DOE, reserve manager	0-1 ?	Q1 2015	Team trained during fence build	May be hard to identify team?
3.6.3	Damage to fence that is sufficient to cause a loss of integrity is repaired within 2 weeks of detection.	Critical	DOE, reserve manager	1-10 ?	Ongoing post Q2 2015	Monthly monitoring and maintenance report submitted to Director of Environment by reserve manager relates outcome of fence damage events.	Cost assumes not catastrophe like a major hurricane.
3.6.4	Invasive alien vertebrates are eradicated within two months of any detected incursion	Critical	DOE, reserve manager	10-50 (?) (contin-gency)	Ongoing post Q2 2015	Intensive monitoring indicates ongoing zero detection of alien vertebrates by two months after an incursion	?

4 Establish a captive galliwasp breeding and/or rearing programme in Montserrat							
4.1	DOE staff trained in galliwasp captive husbandry	Critical	DOE, Durrell	1-10	Q2 2012 – Q3 2012	6 persons trained	Easy training programme due the ease of keeping this group of reptiles in captivity DOE staff leave the post
4.1.1	DOE staff trained in Jersey (Durrell) using model species from Haiti	High	DOE, Durrell	1-10	Q2 2012 – Q3 2012	2 persons trained (Need to quantify time needed in Jersey)	Full time dedicated staff in Jersey for training and support DOE staff leave the post
4.1.2	DOE staff trained in Montserrat using model species from Haiti	Critical	DOE, Durrell	1-10	Q2 2012 – Q3 2012	6 persons trained (Need to quantify time needed in Jersey)	Large number of specimens, sexes and size classes to learn from (reduction of training period) DOE staff leave the post
4.2.	Montserrat Veterinary (and 'backup' vet in Antigua) trained in captive management	High	Durrell, DOE	1-10	Q3 2012	1 person trained in Montserrat, at least one outside the island	Montserrat vet unable to commit time to wildlife medicine Durrell have full time vet available to offer remote support (via Skype etc)
4.3	Identify site and build and equip captive facilities in Montserrat	Critical	DOE, Durrell	10-50	Q3 2012 – Q4 2012	Facilities built and equipped	Facilities can be relatively cheap (modified port-a-cabin)
4.3.1	Identify DOE staff or recruit people to manage captive facilities (15 person-hours/ week) x 5 years	Critical	DOE	1-50	Q3 2012	People recruited and/or established staff have the requisite time commitment written into their work programmes.	DOE will need multiple staff to cover holidays, week-ends, sick leave It may be possible to recruit local volunteer support

4.3.2	Secure funds to run the facilities x 5 years	Critical	Durrell, DOE	1-10	Q3 2012	Funding agreements comprise sufficient funds to match pre-determined budget.	Zoos may be interested in partnering
4.4	Search Woodlands for founders of the ex situ programme in Montserrat (8 h/week) x 5 years	Critical	DOE, reserve manager, SAP manager	10-50	Q4 2012 ongoing	At least 1 male plus 1 female taken into captivity	Galliwasp are very difficult to find Pitfalls can provide an additional search method once rats eradicated Removal of animals from the wild population may increase its extinction risk still further
4.4.1	Trial use of pitfall traps to catch galliwasp inside fenced area	Critical	DOE, reserve manager, SAP manager	10-50	Q4 2015 ongoing	At least 1,000 pitfall trap-nights completed in the first year after target invasive species eradicated.	Pitfalls hitherto untested; may be the missing knack May need a method to exclude larger crabs and other predators from pitfalls
4.4.2	Captured galliwasp taken into captivity and successfully breeding	Critical	DOE, reserve manager, (Durrell?)	1-10 p.a. (?)	Q4 2012 ongoing	Zero deaths of captured individuals over one year after capture. at least one successful breeding attempt	Sufficient galliwasp for a viable ex situ programme may not be captured Unknown response of Montserrat galliwasp to captive conditions Experience with analogue species is encouraging
4.4.3	Health screening for captives	Moderate	Durrell	1-10	Q4 2012 ongoing	All captive individuals subject to full health screening within 1 month of capture	Hands-on experience for trained vets?

4.4.4	If sufficient galliwasp are caught or bred, establish a second ex situ colony outside Montserrat as a safety net (at Durrell, Jersey)	Moderate	DOE, Durrell	1-10	Indeterminate (after 2009)	Second colony maintains alive at least 3 males and 3 females for >1 year, and achieves at least one successful breeding attempt	Sufficient galliwasp for a viable ex situ programme may not be captured Galliwasp can be prolific species
4.5	Develop a reintroduction plan	Critical	Durrell, DOE	0-1	Q2 2012	Plan endorsed by the IUCN	Sufficient galliwasp for a viable ex situ programme may not be captured
5	CEMA is enacted and a Montserrat galliwasp reserve declared						
5.1	Finalise CEMA legislation	Critical	DOE	0-1	Q3 2011	CEMA final draft agreed	?
5.2	Submit CEMA to ExCo and then LegCo	Critical	DOE	0-1	Q4 2011	Draft submitted	ExCo may have higher priorities
5.3	Complete regulation to create galliwasp reserve	Critical	Legal Department, DOE	0-1	Q4 2013 - Q2 2014	Regulation passed by legislature	ExCo may have higher priorities
5.3.1	Create a regulation under CEMA to specify rules of reserve use, to include: <ul style="list-style-type: none"> no dogs; walkers stay on the trail; no fires; no use of heavy equipment 	High (?)	Legal Department, DOE	0-1 ?	Q4 2013 - Q2 2012	Regulation contains specification of rules	This is unlikely to be applicable to any reserve areas on private land
5.4	Change planning regulation that allows clearance without construction to meet planning permission requirements (make a condition of planning approval)	High	PPU, DOE, Legal?	0-1	Q2 2012 - Q3 2012	Planning approval protocol changed	Does not cover clearance for land speculation (only for development)

5.5	When buying a plot of land in Woodlands, purchasers receive information with the deed (from real estate agent) advising them of galliwasp issues and encouraging them to seek advice from DOE on submitting a planning application	High	PPU, DOE	0-1	Q1 2012 – Q3 2013	Estate agents agree to bundle advice with deeds	Planned online access to cadastral GIS may facilitate this Some real estate agents are based outside Montserrat
6 Research and monitoring support decision-making for galliwasp management							
6.1	Extend Biodiversity Database to capture data relevant to galliwasp management	High	DOE, Alan Mills Consulting	1-10	Q3 2012 – Q3 2012	Biodiversity database contains modules for invasive species, herpetofauna, plant, and bird monitoring Biodiversity database contains modules for invasive species control and eradication data Biodiversity database contains modules for site management and pressure data	The foundation for much of this database structure is being created under the current SAP project
6.1.1	DOE staff trained in database use and data analysis	High	Alan Mills Consulting, DOE	1-10	Q3 2012	DOE produces annual report on biodiversity monitoring, based on outputs from the Biodiversity Database	Database management capacity is limited in MALHE
6.2	Improve detection of galliwasp surveys	High	DOE, Durrell		Q1 2012 onwards	Galliwasp detection rate per unit effort increases by to a level where a substantial number of detections are made on a survey.	No currently known method for improving detection. Fenced reserve would give the opportunity for pitfall trapping.
6.2.1	Design viewing platforms for sit-and-wait searches	Moderate	DOE	1-10	Q1 2012 – Q4 2012	Viewing platform(s) deployed for >100 platform-evenings	Method only surveys a small area

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6.2.2	Trial use of pitfall traps to catch galliwasp inside fenced area Note: repeat of Obj. 4.4.1)	Critical	DOE, reserve manager, SAP manager	10-50	Q4 2015 onwards	At least 2,000 pitfall trap-nights completed in the first year after target invasive species eradicated.	Pitfalls hitherto untested; may be the missing knack May need a method to exclude larger crabs from pitfalls
6.2.3	Continue use of endoscope for burrow / crevice searches	Moderate	DOE	1-10	Q1 2012 - Q4 2012	Endoscope deployed for >100 team-evenings	No detections from 6 months of surveys in 2007-08
6.2.4	Visual searches at different times of day	Moderate	DOE	1-10	Q1 2012 - Q4 2012	> 100 site visits completed	Surveys in 2007-08 restricted to start or end of day
6.2.5	Camera trapping at known galliwasp sites at Woodlands	High	DOE	0-1	Q1 2012 - Q4 2012	>400 camera-nights at >2 sites at Woodlands recorded and analysed	Some video cameras and recorders available from Oriole project
6.2.6	Investigate potential for using underground imaging technology	Moderate	Durrell	0-1	Q4 2012	Report on potential of technology distributed	May be prohibitively expensive and/or inappropriate
6.3	Complete habitat analysis of 2008 survey (to select future search areas)	High	Durrell	0-1	Q1 2012 - Q4 2012	Report, based on robust statistics, distributed	Low galliwasp detectability will increase uncertainty in findings
6.4	Survey of potential future area for translocation / reintroduction Identify areas with similar attributes to Woodlands site for possible future (post-Woodlands) reintroductions (also identified under Obj. 4)	Moderate	DOE, reserve manager, Durrell, PPU	1-10	Q1 2016 onwards	Detailed information on environmental features, legal issues and invasive species abundance collated in database for at least one area of >5 ha	Limited understanding of galliwasp ecology make it difficult to determine the key variables <i>a priori</i>

6.5	Complete desk-based research on existing (including historical) knowledge of <i>Diploglossinae</i>	Moderate	Durrell, RSPB	1-10	Q3 2013 – Q4 2013	Report/scientific paper published	Substantial amount completed in producing this SAP. Potentially lots of UK-based historical sources of info (House of Commons, British Museum, British Library, Natural History Museum of Nottingham, IOZ)
6.6	Analyse genetic variation in galliwasp population using all available samples	High	Durrell	10-50	Q4 2014 – Q3 2015	Appropriate genetic data obtained on all galliwasp hitherto obtained and captured in the future	Sufficient samples may not be available for analyses Captive galliwasp can provide samples
6.7	Investigate potential effectiveness of artificial refugia for increasing galliwasp survival and/or detection probability	Critical	Durrell	1-10	Q2 2012 – Q4 2012	At least 2 new designs deployed at Woodlands by the end of Y2.	May increase chances of galliwasp survival outside of (or instead of) fenced area

Project plan for Montserrat galliwasp

Key to objectives:

Manage	Raise awareness	Declare reserve	Fence, eradicate	Captive breed	Enact legislation	Research
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Projects (years divided into quarters; 1 = January-March, 2 = April-June, 3 = July-September, 4 = October-December):

Project	2011			2012			2013			2014			2015			2016			
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
0.1 Establish galliwasp SAP coordinating team																			
0.2 Establish steering/advisory committee																			
0.3 Appoint Montserrat SAPs Manager																			
0.4 SAP manager and sourcing funding																			
1.1 Preliminary awareness raising																			
1.2 Pride campaign																			
1.3 Raise awareness of fenced reserve																			
1.4 Develop guided tours																			
1.5 Develop guidelines for sensitive land use																			
2.1 Demarcate galliwasp reserve																			
2.2 Signed agreements on sensitive land use																			
2.3 Acquire land parcels for GOM to manage																			
2.4 Produce management plan for reserve																			
2.5 DOE adopts, implements management plan																			
2.6 Establish and maintain CBO in Woodlands																			
3.1 Scoping to establish a fenced area																			
3.2 Build the fence																			
3.3 Eradicate target alien species and monitor																			

Project	2011			2012			2013			2014			2015			2016					
	3	4		1	2	3	4		1	2	3	4		1	2	3	4	1	2	...	
3.4 Control target alien species inside buffer																					
3.5 Monitor impacts of eradications and control																					
3.6 Monitor fence integrity, eradicate incursions																					
4.1 Montserrat staff trained in captive husbandry																					
4.2 Montserrat / Antigua vets trained																					
4.3 Build, equip captive facilities in Montserrat																					
4.4 Search Woodlands for founder galliwasps																					
4.5 Develop reintroduction plan																					
5.1 Finalise CEMA legislation																					
5.2 Submit CEMA to ExCo and then LegCo																					
5.3 Regulation to create galliwasp reserve																					
5.4 New planning approval protocol (clearance)																					
5.5 Info pack bundled with deeds on land sale																					
6.1 Extend Biodiversity Database																					
6.2 Improve detection of galliwasps on surveys																					
6.3 Complete habitat analysis of 2008 survey																					
6.4 Survey potential future reintroduction area																					
6.5 Desk-based research on galliwasps																					
6.6 Analyse genetic variation in galliwasps																					

4 Monitoring and evaluation plan

Indicators for each project are identified in Table 2 to measure progress. A mid-term review will be held two years into plan implementation to see if the plan is on target. A keystone action in this plan is the recruitment of a salaried SAP Manager to manage both this and other Montserrat SAPs in liaison with individual SAP coordinators or coordinating teams. A key role of this SAP Manager will be to raise funds for the implementation of these plans. A workshop will be held towards the end of the five years to develop the next plan.

The M & E plan is the means by which progress towards achieving the objectives and aim of the action plan are determined. The M & E plan is to be prepared by adding two columns to the Projects Table, one for recording the completion date of projects/activities and another for inserting additional remarks. The SAP coordinator fills in the information over time. The completed Project Table provides easily accessible information on conservation progress for the species.

References

Note: a number of these references were not available for compiling this plan. Where these are referred to in the body text, they are cited as x (date) cited in y (date), where y is a reference that was consulted directly. Some references that were not consulted directly are also listed in Annex 5 for completeness and are marked in that table with an asterisk; these may contain additional information that could be used to expand upon the table in that Annex. Henderson & Powell (2009), however, provide a very comprehensive and up to date review of all of the West Indian *Celestus* and *Diploglossus* species and so the table in Annex 5 is unlikely to have any significant gaps in what has been reported for those 26 species.

- Arnaud, G., Rodriguez, A., Ortega-Rubio, A. & Alvarez-Cardenas, S. 1993. Predation by cats on the unique endemic lizard of Socorro Island (*Urosaurus auriculatus*), Revilagigedo, Mexico. *Ohio J. Sci.* 93: 101-104
- Arshad, M. I., Zakaria, M., Sajap, A. S. & Ismail, A. 2000. Food and feeding habits of red junglefowl. *Pakistan Journal of Biological Sciences*, 3: 1024-1026
- Atkinson, I. A. E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. In Moors, P. J. (ed.) *Conservation of Island Birds*. ICBP Technical Publication No.3: 35•81.
- Atkinson, I. A. E. (2001) Introduced mammals and models for restoration. *Biological Conservation*, 99, 81-96.
- Atkinson, I. A. E. & Atkinson, T. J. 2000. Land vertebrates as invasive species on island served by the South Pacific Regional Environment Programme. In: *Invasive Species in the Pacific: A Technical Review and Draft Regional Strategy*. South Pacific Regional Environment Programme, Samoa: 19-84
- Avila-Pires, T. C. S. 1995. Lizards of Brazilian Amazonia (Reptilia: Squamata). *Zool. Verh., Leiden* 299: 1-706
- Barbour, T. 1909. Some new South American cold-blooded vertebrates. *Proc. New England zool. Club* 4: 47-5
- Barbour, T. 1919. Herpetological notes *Proceedings of the New England Zoological Club* 7: 7-13
- Barbour, T. & Shreve, B. 1937. *Novitates Cubanae*. *Bull. Mus. comp. Zool. Harvard* 80: 377-387
- Barbour, T. & Ramsden, C. T. 1919. The herpetology of Cuba. *Mem. Mus. Comp. Zool., Harvard Coll.* 47: 69-213.
- Bauer, A. M.; Günther, R. & Klipfel, M. 1995. The herpetological contributions of Wilhelm C. H. Peters (1815-1883). *SSAR Facsimile Reprints in Herpetology*, 714 pp.
- Böhme, W. & Fischer E. 1998. Verification of species identity and geographic origin of an extinct lizard (Reptilia: Anguidae: *Celestus occiduus*) based on stomach contents, with comments on other undiscovered large lizards. *Cryptozoology* 13: 23-37
- Boulenger, G. A. 1885. *Catalogue of the lizards in the British Museum (Natural History)*. Vol. 2, Second edition. London, xiii+497 pp.
- Boulenger, G.A. 1898. Third report on additions to the lizard collection in the Natural History Museum. *Proc. Zool. Soc. London* 1898: 912-923.
- Breuil, M. 2002. *Histoire naturelle des amphibiens et reptiles terrestres de l'archipel Guade-*

- loupéen. Publications Scientifiques du Muséum National d'Histoire Naturelle, Paris
- Brock, E. M. & Howard, W. E. 1962. Control methods for snakes. Proceedings of the 1st Vertebrate Pest Conference: 18-31 University of Nebraska - Lincoln
- Buley, K. R. 2001. Montserrat mountain chicken population and habitat assessment and a preliminary assessment of the other herpetofauna of Montserrat August & September 2001. Unpublished report to Durrell Wildlife Conservation Trust.
- Burns, K. K., Cunningham, C. A., Dupuis, R. A., Trask, M. N., Tulloch, J. S., Powell, R., Parmelee, J. S., Jr., Kopecky, K. L. & Jolley, M. L. 1992. Lizards of the Cayos Siete Hermanos, Dominican Republic, Hispaniola. Bulletin of the Chicago Herpetological Society, 27: 225-232.
- Burton, 1711 (or 1728). The English Empire In America: Or A View Of The Dominions Of The Crown Of England In The West Indies. A. Bettesworth, and J. Batley, London
- Campbell, J. A. 2007. *Celestus ingridae*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- Campbell J. A. & Camarillo R. J. L. 1994. A new lizard of the genus *Diploglossus* (Anguillidae: Diploglossinae) from Mexico, with a review of the Mexican and northern Central American species. *Herpetologica* 50 (2): 193-209
- Campbell, K. J. and Donlan, C. J. 2005. A review of feral goat eradication on islands, *Conservation Biology*, vol. 19: 1362-74.
- Campos, C. B., Esteves, C. F., Ferraz, K. M. P. M. B., Crawshaw, P. G. & Verdade, L. M. 2007. Diet of free-ranging cats and dogs in a suburban and rural environment, southeastern Brazil. *Journal of Zoology*, 273: 14-20
- Canseco-Márquez, L., Campbell, J. A., Ponce-Campos, P., Muñoz-Alonso, A. & García Aguayo, A. 2007. *Celestus enneagrammus*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010
- Cassidy, F. G. & Le Page, R. B. 1980. Dictionary of Jamaican English. 2nd Edn. Cambridge University Press.
- Cochran, D.M. 1927. A new genus of anguillid lizards from Haiti. *Proc. Biol. Soc. Washington* 40: 91-92.
- Cochran, D.M. 1939. Diagnoses of three new lizards and a frog from the Dominican Republic. *Proc. New England Zool. Club* 18: 13.
- Cochran, D.M. 1941. The herpetology of Hispaniola. *Bull. US Natl. Mus.* 177: vii + 398 pp.
- Cocteau, J.-T. 1838. in J.-T. Cocteau & Bibron, G. 1838-1843, *Reptiles*, p. (5), 1-142. in R. de la Sagra. 1838. *Historia Física, Política y Natural de la Isla de Cuba*. Arthus Bertrand, Paris.
- Coleman, R. M. 1997. Geographic Distribution. *Diploglossus monotropis* *Herpetological Review* 28 (4): 210
- Collias, N. E. & Collias, E. C. 1967. A field study of the red jungle fowl in North-Central India. *Condor*, 69: 360-386
- Collias, N. E. & Saichuae, P. 1967. Ecology of the red jungle fowl in Thailand and Malaya with reference to the origin of domestication. *Nat. Hist. Bull. Siam. Soc.*, 22: 189-209
- Cooper, W. E., Jr. & Bradley, K. A. 2009. Prey chemical discrimination by a diploglossine lizard, the giant Hispaniolan galliwasp (*Celestus warreni*). *Amphibia-Reptilia*, 30: 135-140.
- Cope, E. D. 1861. Descriptions of reptiles from tropical America and Asia. *Proc. Acad. Nat. Sci. Philadelphia* 1860: 368-374
- Cope, E. D. 1862. On the genera *Panolopus*, *Centropyx*, *Aristelliger* and *Sphaerodactylus*. *Proc. Acad. Nat. Sci. Philadelphia* 13 (1861): 494-500.
- Cope, E. D. 1868. An examination of the Reptilia and Batrachia obtained by the Orton Expedition to Ecuador and the Upper Amazon, with notes on other species. *Proc. Acad. Nat. Sci. Philadelphia* 20: 96-140
- Cope, E. D. 1894. Third addition to a knowledge of the batrachia and reptilia of Costa Rica.

- Proc. Acad. Nat. Sci. Philadelphia 1894: 194-206
- Corry, E., Martin, M., Martin, J., Fenton, C., Daly, J., Young, R. P. & Morton, M. N. In prep. A survey of the Montserrat galliwasp and its habitat
- Cousens, P. N. 1956. Notes on the Jamaican and Cayman Island lizards of the genus *Celestus Breviora* (56): 1-6
- Dalsgaard, B., Hilton, G., Gray, G., Aymer, L., Boat-swain, J., Daley, J., Fenton, C., Martin, J., Martin, L., Murrain, P., Arendt, W., Gibbons, D. & Olesen, J. 2007. Impacts of a volcanic eruption on the forest bird community of Montserrat, Lesser Antilles. *Ibis*, 149: 298-312.
- Daltry, J.C. 1999. Unpublished report to Montserrat Forestry and Environment Division on 1995 survey of reptiles and amphibians on Montserrat. Fauna and Flora International.
- Daudin, F. M. 1802. Histoire naturelle, générale et particulière des Reptiles. T.4. F. Dufart imp., Paris, 1-397 + pls.
- Day, M. 1996. *Diploglossus montisserrati*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- De Barros, M. F. & Avari, R. 2010. Bribas. Zoo Animals of Sao Paulo. Translated from Portuguese to English by Google Translate. Downloaded from <http://www.zoologico.sp.gov.br/animaisdozoo/umvovomuitosacudido.htm> on 29th April 2010
- De Magalhaes, J. P. & Costa, J. 2009. A database of vertebrate longevity records and their relation to other life-history traits. *Journal of Evolutionary Biology* 22:1770-1774.
- Du Terte, J.-B. 1667. Histoire générale des Antilles habituées par le Français. T.1. contenant tout ce qui s'est passé dans l'établissement des colonies françaises. T.2. contenant l'histoire naturelle. Thomas Jolly, Paris
- Duméril, A. M. C. & Bibron, G. 1839. *Erpétologie Générale ou Histoire Naturelle Complète des Reptiles*. Vol.5. Roret/Fain et Thunot, Paris, 871 pp.
- Dunn, E. R. 1939. Zoological results of the George Vanderbilt South Pacific expedition of 1937, Part III: The lizards of Malpelo Island, Columbia. *Notulae Naturae of the Academy of Natural Sciences of Philadelphia*, 4: 1-3.
- Franz, R. & Cordier, D. 1996. Herpetofaunas of the National Parks of Haiti. Unpubl., USAID/Haiti
- Garman, S. 1887. On West Indian Geckonidae and Anguide. *Bull. Essex Inst.* 19: 17-24.
- Garman, S. 1888. Reptiles and batrachians from the Caymans and from the Bahamas. Collected by Prof. C. J. Maynard for the Museum of Comparative Zoology at Cambridge, Mass. *Bull. Essex Inst.* 20: 1-13 (sometimes cited as pp. 101-113)
- Gibson, R. 1996a. *Celestus duquesneyi*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- Gibson, R. 1996b. *Celestus fowleri*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- Gibson, R. 1996c. *Celestus microblepharis*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- Global Invasive Species Database. 2010. IUCN Species Survival Commission's Invasive Species Specialist Group. Accessed on 28 April 2010 at <http://www.issg.org/database/welcome/>
- Goetz, M. 2008 Hispaniolan galliwasp *Celestus warreni* husbandry guidelines. Unpubl., Durrell Wildlife Conservation Trust, Jersey, Great Britain. (Appended to this publication as Annex 6).
- Gosse, P. H. 1850. Natural history: reptiles. Society for Promoting Christian Knowledge, London.
- Grant, C. 1940. The herpetology of Jamaica II. The reptiles. *Bull. Inst. Jamaica., Sci. Ser.* 1: 61-148.
- Grant, C. 1951. The specific characters of the *Celesti*, with description of anew species of *Celestus* (Sauria: Anguidae). *Copeia* 1951: 67-69.

- Gray, G., Bunting, R., Roy, S., Massei, G., Millett, J. & O'Garro, M. 2010. Montserrat Centre Hills Feral Livestock Action Plan (Draft). Royal Society for the Protection of Birds and Montserrat Department of Environment.
- Gray, J. E. 1831. A synopsis of the species of Class Reptilia. In: Griffith, E & E. Pidgeon: The animal kingdom arranged in conformity with its organisation by the Baron Cuvier with additional descriptions of all the species hither named, and of many before noticed (Vol. 9). Whittaker, Treacher and Co., London: 481 + 110 pp.
- Gray, J. E. 1852. Description of Sauresia, a new genus of Scincidae from St. Domingo. *Ann. Mag. Nat. Hist.* 10:281-282
- Greene, H. W., Sigala Rodríguez, J. J. S. & Powell, B. J. 2006. Parental Behavior in Anguid Lizards. *South American Journal of Herpetology*. 1 (1): 9-19.
- Greer, A. E. 1967 Notes on the Mode of Reproduction in Anguid Lizards. *Herpetologica*, 23: 94-99
- Guthrie, J. E. 1932. Snakes versus birds; birds versus snakes. *The Wilson Bulletin*, 44: 88-113
- Hallermann, J. & Böhme, W. 2002. On giant anguids from the West Indies with special reference to *Celestus warreni* (Schwartz, 1970) and its relatives from Hispaniola (Reptilia: Squamata: Anguidae). *Mitt. Hamb. Zool. Mus. Inst.* 99: 169-178
- Hedges, S. B. 2010. Caribherp: database of West Indian amphibians and reptiles (<http://evo.bio.psu.edu/caribherp/>). Pennsylvania State University, University Park, Pennsylvania. Accessed 08 April 2010.
- Henderson R. W. 1988. *Diploglossus anelpistus* Schwartz, Graham and Duval. *Catalogue of American Amphibians and Reptiles* No.424.
- Henderson, R. W. & Powell, R. 2009. Natural history of West Indian reptiles and amphibians. University Press of Florida.
- Hidalgo H 1982. Rediscovery of the anguid lizard *Diploglossus atitlanensis* (Smith). *Transactions of the Kansas Academy of Science* 85 (1): 34-38
- Incháustegui, M., S. J., Schwartz, A. & Hendersen, R. W. 1985. Hispaniolan giant *Diploglossus* (Sauria: Anguidae): description of a new species and notes on the ecology of *D. warreni*. *Amphibia-Reptilia*, 6: 195-201.
- IUCN. 1994. IUCN Red List Categories. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland.
- IUCN. 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- Ivie, M. A., Marske, K. A., Foley, I. A., Guerrero, K. A. & Ivie, L. L. 2008. Invertebrates of the Centre Hills and Montserrat, with an emphasis on beetles. In: Young, R. P. (ed.) A biodiversity assessment of the Centre Hills, Montserrat. Durrell Conservation Science Report 1. Durrell Wildlife Conservation Trust, Jersey, Channel Islands.
- JVCI (J. Craig Venter Institute) 2010 Reptiles database: Family Anguidae. Downloaded from <http://www.icvi.org/reptiles/families/anguidae.php> on 07 April 2010
- Kiester, R. 1975. Notes on the natural history of *Diploglossus millepunctatus*. Pp. 39-43 in J. Graham, editor. *The Biological Investigation of Malpelo Island, Colombia*. Smithsonian Contributions to Zoology, No.176.
- Köhler, G. 2000. Reptilien und Amphibien Mittelamerikas, Bd 1: Krokodile, Schildkröten, Echsen. Herpeton Verlag, Offenbach, 158 pp.
- Kuhl, H. 1820. Beiträge zur Zoologie und vergleichenden Anatomie. Hermannsche Buchhandlung, Frankfurt, 152 pp.
- Lawler, H. E. & Norris, C. 1979. Breeding the Haitian Giant galliwasp, *Diploglossus warreni* (Sauria: Anguidae) at the Knoxville Zoological Park. *Third Annual Symposium on Captive Propagation and Husbandry*: 73-79.
- Lee, J. & Calderón Mandujano, R. 2007. *Celestus rozellae*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- Liner, E. A. 1994. Scientific and common names for the Amphibians and Reptiles of Mexico in English and Spanish. *Herpetol. Circ.* No.

23: 1-113, SSAR

28 April 2010

- Liner, E. A. 2007. A checklist of the amphibians and reptiles of Mexico. Louisiana State University Occasional Papers of the Museum of Natural Science 80: 1-60
- Lopez Luna, M.A. & Canseco-Márquez, L. 2007. *Celestus legnotus*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.
- López-Victoria, M. & Werding, B. 2008. Ecology of the endemic land crab *Johngarthia malpilensis* (Decapoda: Brachyura: Gecarcinidae), a poorly known species from the tropical Eastern Pacific. Pacific Science 62:483-493
- Lotzkat, S., Stadler, L., Carrizo, A., Hertz, A. & Kohler, G. 2010 Notes on the easternmost population of *Diploglossus bilobatus* (Squamata: Anguidae) in Veraguas, Panama. Salamandra 46: 59-62
- Lynn, W.G., and Grant, C. (1940): The Herpetology of Jamaica. Bulletin of the Institute of Jamaica, Science Series 1: 1-148.
- Mackenzie, D.I., Nichols, J.D., Royle, J.A., Pollock, K.H., Bailey, L.L. & Hines, J.E. (2006) Occupancy Estimation and Modelling. Elsevier Academic Press, London, UK.
- Mansat, A. 2007. Montserrat modelled vegetation map (draft). Royal Botanic Gardens, Kew
- Marske, K. A. 2004. Effects of volcanic ash on the insect food of the Montserrat Oriole *Icterus oberi* Lawrence 1880. Master's thesis, Montana State University, Bozeman, US. X + 178 pp.
- McCranie, J. R. & Wilson, L. D. 1996. A new arboreal lizard of the genus *Celestus* (Squamata: Anguidae) from northern Honduras. Revista De Biología Tropical 44: 259-264
- McGinnity, D. 2002. The conservation initiative for giant galliwasp at Nashville Zoo: A preliminary account. *International Zoo News* 49: 396-403.
- McGinnity, D. & Powell, R. 2004a. *Celestus anelpistus*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on
- McGinnity, D. & Powell, R. 2004b. *Celestus warreni*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 29 April 2010.
- Montserrat Centre Hills Project (2006). Newsletter January 2006. Montserrat. Available online at: http://www.malhe.gov.ms/centrehills/docs/centre_hills_project_newsletter_june_06.pdf
- Montserrat Volcano Observatory 2010. Accessed on 29 April 2010 at <http://www.montserratvolcanoobservatory.info/>
- Moreno, J. A. (ed) 1991. Status y distribución de los reptiles y anfibios de la region de Puerto Rico. Publicación Científica Miscelánea No. 1. San Juan: Departamento de Recursos Naturales de Puerto Rico.
- Myers, C.W. 1973. Anguid lizards of the genus *Diploglossus* in Panamá, with the description of a new species. American Museum Novitates (2523): 1-20
- Nogales, M. & Medina, F. M. 2009 Trophic ecology of feral cats (*Felis silvestris f. catus*) in the main environments of an oceanic archipelago (Canary Islands): An updated approach. *Mammalian Biology*, 74: 171-183
- O'Shaughnessy, A. W. E. 1874. Description of a new species of lizard of the genus *Celestus*. *Ann. Mag. nat. Hist.* (4) 13: 257-258
- Ogrodowczyk, A., Murrain, P., Martin L. & Young, R. P. 2006. Recent observations of the Montserrat galliwasp, *Diploglossus montisserrati*. *Herpetological Bulletin* 98: 9-11
- Parker, H. W. 1924. (*Diploglossus tenuifasciatus*) *Ann. Mag. nat. Hist.* (9) 13: 586
- Peracca, M. G. 1890. Descrizione di una nuova specie del gen. *Diploglossus* Wieg. *Bollettino dei Musei di Zoologia ed Anatomia Comparata della R. Università di Torino* 5 (77): 1-5
- Phillips, R. B., Winchell, C. S & Schmidt, R. H. 2007. Dietary overlap of an alien and native carinivore on San Clemente Island, California. *Journal of Mammalogy*, 88: 173-180

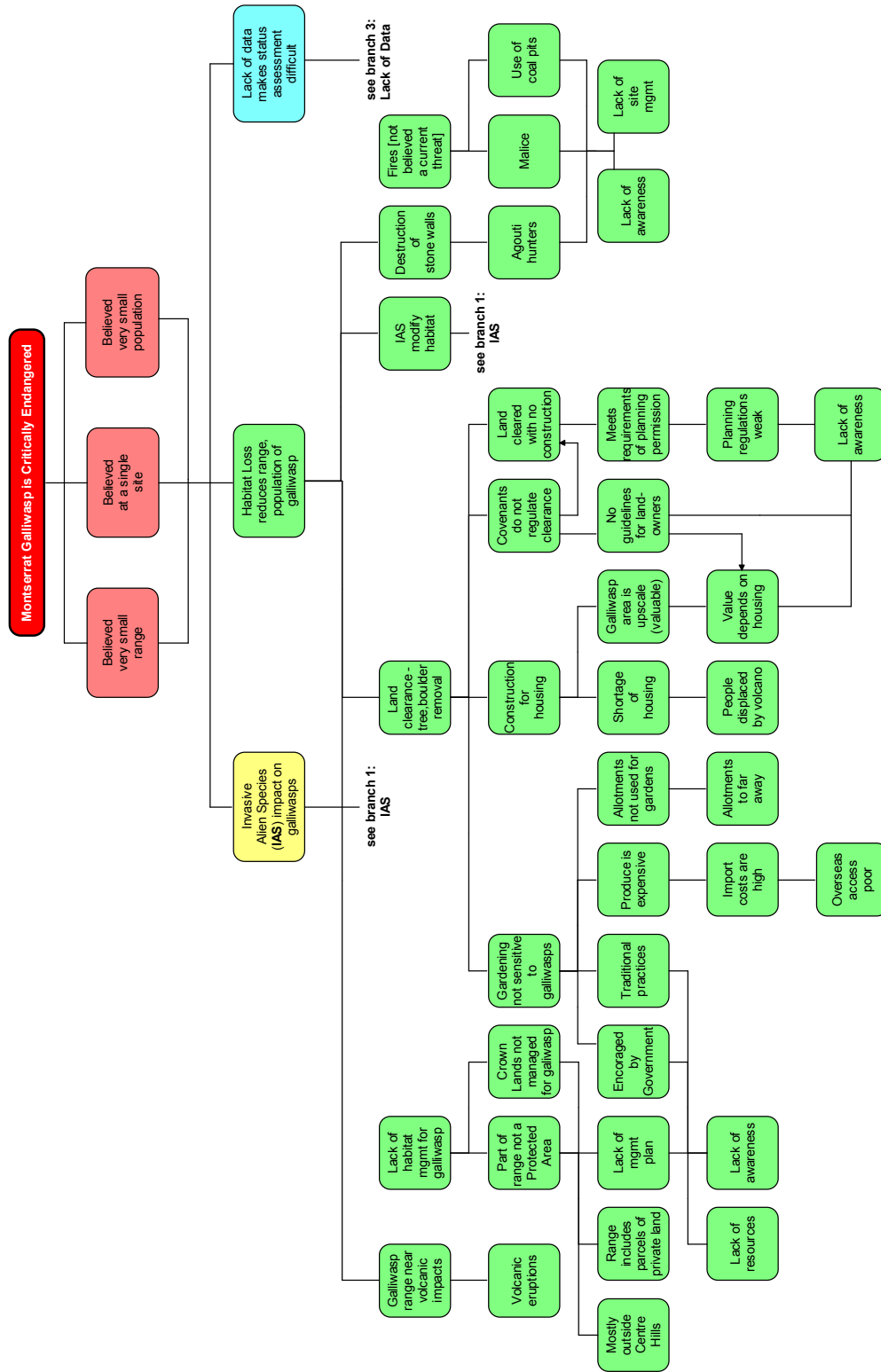
- Pienkowski, MW (2005). The UK Overseas Territories: rich in biodiversity, poor in resources and a UK responsibility. Oral Presentation to the British Ecological Society Annual Conference, University of Hertford, September 2005. Abstract at <http://www.britishecologicalsociety.org/articles/meetings/current/annualmeeting2005/session/?session=84>
- Powell, R. 1999a. Herpetology of Navassa Island, Caribbean Journal of Science, 35:1-13
- Powell, R. 1999b. *Celestus badius*. Catalogue of American Amphibians and Reptiles, 694: 1-2.
- Powell, R. & Hendersen, R. W. 2005. Conservation status of Lesser Antillean reptiles. Iguana, 12: 63-77
- Powell, R., Henderson, R. W. Adler, K & Dundee, H. A. 1996. An annotated checklist of West Indian amphibians and reptiles. In R. Powell and R. W. Henderson (eds.), Contributions to West Indian Herpetology: A Tribute to Albert Schwartz, p.51-93. Society for the Study of Amphibians and Reptiles, Ithaca (New York). Contributions to Herpetology, volume 12.
- Powell, R., Ottenwalder, J. A., Inchaustegui, S. J., Hendersen, R. W. & Glor, R. E. 2000 Amphibians and reptiles of the Dominican Republic: species of special concern. Oryx, 34: 118-128.
- Rochefort, C. D. 1658. Histoire naturelle et morale des Antilles de l'Amerique. Histoire générale des Antilles habituées par le Français. T.1. Histoire naturelle, 1-236. T.2. Histoire morale, 264-527 + 13 pp. Arnould Liers, Rotterdam.
- Savage, J. M. 2002. The Amphibians and Reptiles of Costa Rica. University of Chicago Press.
- Savage, J. M. & Lips, K. R. 1993 A review of the status and biogeography of the lizard genera *Celestus* and *Diploglossus* (Squamata: Anguidae), with a description of two new species from Costa Rica. Revista de Biología Tropical 42(3): 817-842
- Savage, JM; Lips, KR; Ibanez D 2008. A new species of *Celestus* from west-central Panama, with consideration of the status of the genera of the Anguidae: Diploglossinae (Squamata). Revista de Biología Tropical 56 (2): 845-859
- Schmidt, K. P. 1933. New reptiles and amphibians from Honduras. Field Mus. Nat. Hist. Zool. Ser. 20: 15-22.
- Schwartz, A. 1970. A new species of large *Diploglossus* (Sauria: Anguidae) from Hispaniola. Proc. Biol. Soc. Washington 82: 777-787.
- Schwartz, A. 1971. A new species of bromellad-inhabiting galliwasp (Sauria: Anguidae) from Jamaica. Breviora 371:1-10.
- Schwartz, A. & Henderson, R. W. 1991. Amphibians and Reptiles of the West Indies. University of Florida Press, Gainesville, 720 pp.
- Schwartz, A. & Inchaustegui, S.I.. 1976. A new species of *Diploglossus* (Reptilia, Lacertilia, Anguidae) from Hispaniola. Journal of Herpetology, 10: 241-246.
- Schwartz, A. 1964. *Diploglossus costatus* Cope (Sauria: Anguidae) and its relatives in Hispaniola. Reading Publ. Museum and Art Gallery Sci. Publ. 13: 1-57
- Schwartz, A. & Henderson, R. W. 1985. A guide to the identification of the amphibians and reptiles of the West Indies exclusive of Hispaniola. Milwaukee Public Mus., 16
- Schwartz, A., Graham, E. D., Jr., & Duval, J. J. 1979. A new species of *Diploglossus* (Sauria: Anguidae) from Hispaniola. Proc. Biol. Soc. Washington 92: 1-9.
- Shaw, G. 1802. General Zoology or Systematic Natural History. Vol. III. Part I. Amphibia. G. Kearsley, London.
- Slevin, J. R. 1928. Description of a new species of lizard from Malpelo Island. Proc. Cal. Acad. Sci. 26 (21): 681-684
- Smith, H. 1942. Mexican herpetological miscellany. Proc. US. Natl. Mus. 92 (3153): 349-395
- Smith, H. M. & Taylor, E. H. 1950. An annotated checklist and key to the reptiles of Mexico exclusive of the snakes. Bull. US Natl. Mus. 199: 1-253
- Stejneger, L. 1904 Herpetology of Porto Rico. Report of the United States National Museum for the year 1902: 551-724

- Stevens, M. and G. Waldmann. 2001. Animal Biodiversity of the Lesser Antillean Island of Montserrat (British West Indies): An Annotated Checklist of Terrestrial and Freshwater Animals. Archiv Zool. Publ., vol. 6. Martina Galunder-Verlag, Nümbrecht, Germany.
- Taylor, E. H. 1956. A review of the lizards of Costa Rica. Univ. Kansas Sci. Bull. 38 (part 1): 3-322
- Thomas, R. 1971. A new species of *Diploglossus* (Sauria: Anguidae) from Hispaniola. Occas. Pap. Mus., Zool. Louisiana State Univ.
- Thomas, R. & Gaa Kessler, A. 1996. Non-anoline reptiles. Pp. 347-362, In: The Food Web of a Tropical Rain Forest. Ed. Reagan, D. P. & Waide, R. B. Univ. Chicago Press, Chicago.
- Thomas, R. & Hedges, S. B. 1989. A new *Celestus* (Sauria: Anguidae) from the Chaîne de la Selle of Haiti. Copeia 1989 (4): 886-891
- Thomas, R. & Hedges, S. B. 1998. A new anguid lizard (*Diploglossus*) from Cuba. Copeia 1998: 97-103
- Towns, T. R., Atkinson, I. A. E. and Daugherty, C. H. 2006. Have the harmful effects of introduced rats on islands been exaggerated? Biological Invasions 8: 863-891
- Townsend, J. H., Hughes, S. M., Hines, J. J., Carter, D. J. & Sandoval, G. 2005. Notes on a juvenile *Celestus montanus* Schmidt, 1933, a rare lizard from Parque Nacional El Cusuco, Honduras. Herpetozoa 18 (1-2):67-68.
- Underwood G. 1959. A new Jamaican galliwasp (Sauria, Anguidae). Breviora 102: 1-13
- Underwood, G. 1964. An anguid lizard from the Leeward Islands. Breviora 200:1-10
- Varnham, K. J. 2007. Invasive rats on tropical islands: Their history, ecology, impacts and eradication. Unpublished report to the Royal Society for the Protection of Birds. RSPB, The Lodge, Sandy, Beds, UK.
- Villa J. D. & Occhipinti N. A. 1988. *Diploglossus montisilvestris* Myers. Catalogue of American Amphibians and Reptiles No. 444 1988: 1
- Villa, J. D. & Wilson L. D. 1988. *Celestus bivittatus* (Boulenger). Catalogue of American Amphibians and Reptiles No. 423 1988: 1-2
- Vitt, L. J. 1985. On the biology of the little known anguid lizard, *Diploglossus lessonae*, in northeast Brazil. Papeis Avulsos De Zoologia (Sao Paulo) 36 (7): 69-76
- Vitt, L. J. 1992a. Mimicry of millipedes and centipedes by elongate terrestrial vertebrates. Research and Exploration, 8:76-95
- Vitt, L. J. 1992b. Diversity of reproductive strategies among Brazilian lizards and snakes: the significance of lineage and adaptation. Pp 135- in: Hamlett, W. C. (Ed) Reproductive biology of South American vertebrates. Springer Verlag
- Werler, J. E. & Campbell, J. A. 2004. New Lizard Of The Genus *Diploglossus* (Anguidae: Diploglossinae) From The Tuxtlan Faunal Region, Veracruz, Mexico. The Southwestern Naturalist 49 (3):327-333
- White, L. R. & Powell, R. 1996. *Celestus agasepoides*. Catalogue of American Amphibians and Reptiles, 627: 1-2.
- Willock, R. & Williams, C. 2006. General public survey of Montserrat residents' attitudes to the value of the Centre Hills. Unpubl report to Centre Hills Project, Montserrat National Trust, Montserrat.
- Wilson, B. S. & Vogel, P. 2000. A survey of the herpetofauna of the Hellshire Hills, Jamaica, including the rediscovery of the Blue-tailed galliwasp (*Celestus duquesneyi* Grant). Caribbean Journal of Science, 36: 244-249.
- Wilson, L. D. & McCranie, J. R. 2002. Update on the list of reptiles known from Honduras. Herpetological Review 33:90-94
- Wilson, L. D. & McCranie, J. R. 2003. The conservation status of the herpetofauna of Honduras. Amphibian and Reptile Conservation 3: 6-33
- Wilson, L. D., Porras, L., & McCranie, J. R. 1986. Distributional and taxonomic comments on some members of the Honduran herpetofauna. Milwaukee Publ. Mus. Contr. Biol. & Geol. No. 66, 8 pp.
- World Conservation Monitoring Centre 1996. *Ce-*

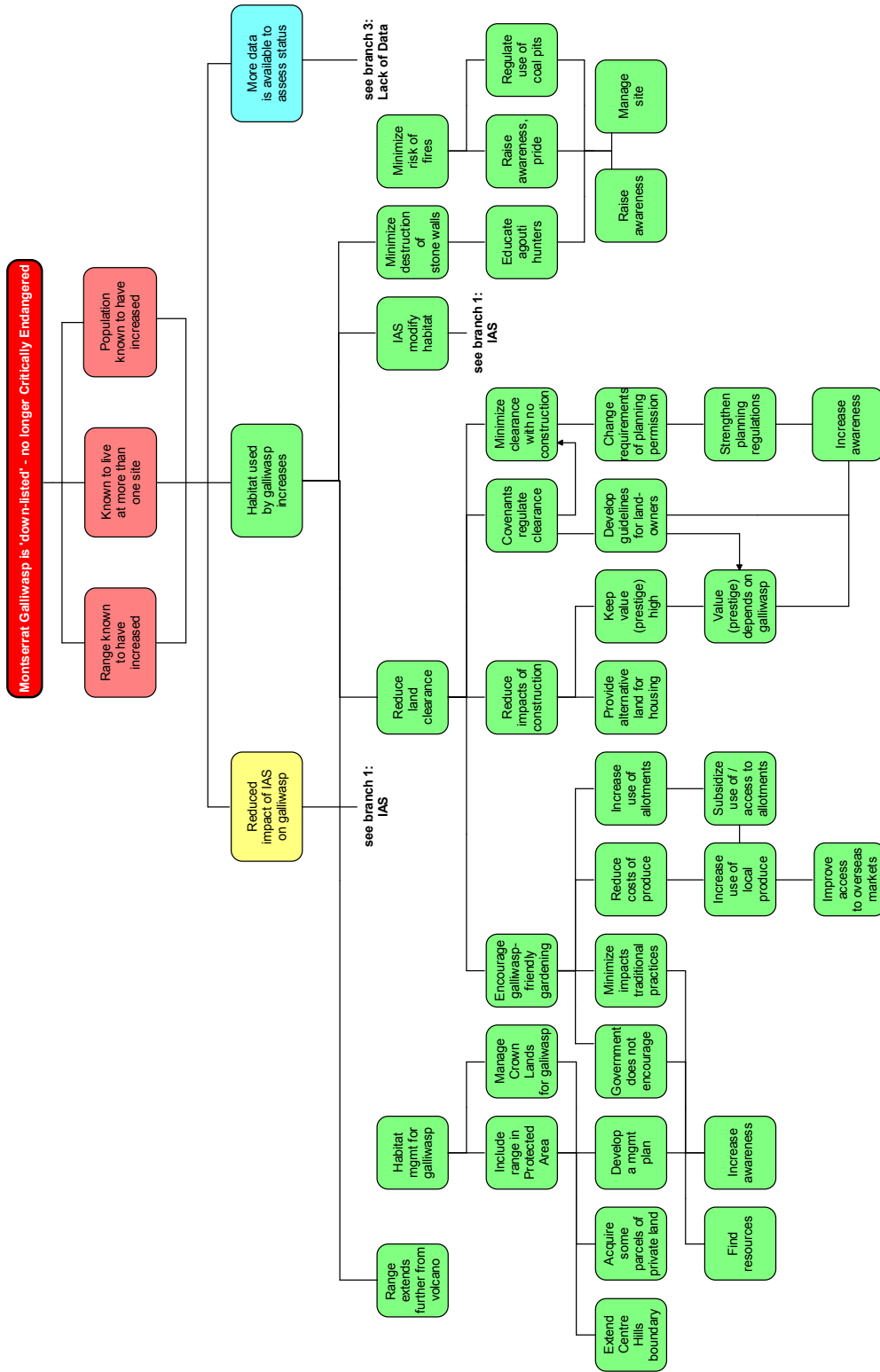
Iestus occiduus. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1. <www.iucnredlist.org>. Downloaded on 28 April 2010.

Young, R. P. (ed.) (2008). A biodiversity assessment of the Centre Hills, Montserrat. Durrell Conservation Science Report 1. Durrell Wildlife Conservation Trust, Jersey, Channel Islands.

Annex 1: Problem Tree for Montserrat galliwasp SAP (continued)



Annex 2: Solution Tree for Montserrat galliwasp SAP (continued)



Annex 3. Stakeholder analysis

The likely impact of each stakeholder and whether the impact is positive or negative (+ or -) is given, as is the intensity of this impact (scored from 1, low impact, to 4, high impact), whether or not a representative of that stakeholder attended the SAP workshop, and the likely actions of the stakeholder in relation to the Plan. (Note: the intensity of impact is scored differently to the way it is in the Montserrat mountain chicken SAP.) The workshop also identified certain stakeholders of especial importance to the success of this plan but who were unable to attend and whose input was sought via a focus group after the SAP workshop; these are shown in bold type.

Who	Im- pact	Intensity	At- tended	Likely actions
International stakeholders				
Overseas Territories Environment Programme OTEP	+	4		Funding
Darwin Initiative	+	4		Funding
Department for International Development (DFID)	+	4		Funding
Organization of Eastern Caribbean States OECS	+	3		Funding and technical assistance
Durrell Wildlife Conservation Trust (Durrell)	+	4	P	Lead on OTEP SAP project; long-term involvement in conservation on Montserrat; captive breeding
Royal Society for the Protection of Birds (RSPB)	+	4	P	CHP; long-term involvement in conservation on Montserrat
Royal Botanical Gardens, Kew (RBG-K)	+	3		Long-term involvement in conservation on Montserrat
Conservation International (CI)	+	3	P	Funding
International zoos (e.g. Nashville, EAZA)	+	2		Funding
World Conservation Union (IUCN)	+	2		Advisory
US trusts and foundations (not specified)	+	?		Funding
Convention on Biological Diversity (CBD)	+	2		International convention with (British) governmental obligations to produce Biodiversity Strategy and Action Plans
World Wildlife Fund (WWF)	+	1		Funding
Montserrat Government Agencies				
Government of Montserrat GOM	+/-	4	P	Can effect legislative change; unsustainable land use

Who	Im- pact	Intensity	At- tended	Likely actions
Montserrat Government Agencies				
Department of Environment DOE (MALHE)	+	4	P	Lead agency for terrestrial conservation on Montserrat; species management; protected area management; SAP coordination
Physical Planning Unit PPU (MALHE)	+	3	P	Regulate land use for development and protected areas; monitoring of land use
Department of Agriculture DOA (MALHE)	+	2	P	Land use
Legal Department	+	2	P	Drafting legislation (CEMA)
ExCo/LegCo	+	4		Approve and enact legislation (CEMA)
Police / Cadets / Defence Force	-	2		At present not enforcing wildlife laws (i.e. negative impact)
Montserrat Water Authority (MUL)	+/-	1		Site management; water abstraction from Duberry Est spring
Emergency Department	+	2		Monitoring risk factors
Environmental Health	+/-	2		Enforcement of environmental (including pest control / poisoning) regulations
Civil society in Montserrat				
Landowners (estate owners, home owners/residents, real estate agents)	+/-	4	(focus group)	Land use (including clearance, construction)
Montserrat National Trust MNT	+	1	P	Lead conservation NGO on Montserrat
Forest users (not including tourists)	-	4 (?)	P	Habitat loss and/or degradation
Farmers / harvesters	-	2		Habitat loss and/or degradation
Charcoal burners	-	2		Habitat loss and/or degradation
Hunters	+/-	3		Remove alien predators; cause habitat disturbance
Tourists (local and overseas)	+	2		Revenue, awareness
Tour guides	+	2		Awareness, wardening
Hikers (local and overseas)	-	2		Degrade habitat

Annex 4. Factors affecting action plan implementation

Factor	Impact
Cultural attitudes	
Financial investment in conservation may be seen as taking money away from human development	-
Some people value their pets (cats and dogs) above wildlife	-
National pride in a uniquely Montserratian species	+
Existing residents in the Woodlands area may not want further development	+
Many Montserratians have never seen the Montserrat galliwasp	-
Economic value	
Montserrat galliwasp can potentially bring in tourist revenue (e.g. visiting fenced reserve, <i>ex situ</i> facility)	+
Montserrat galliwasp are unlikely to be seen by tourists in the wild	-
High pressure for house building on Montserrat this is economic not cultural	-
Overseas researchers bring some money into Montserrat's economy	+
Centre Hills provide a vital role in watershed protection	+
Centre Hills provide vital environmental services	+
Administrative / political set-up	
The Montserrat galliwasp SAP is a part of DOE's workplan; DOE staff motivated and experienced	+
Good communications and coordination between GOM agencies	+
Biodiversity conservation depends on only a few persons	-
There is no warden for the Montserrat galliwasp site at Woodlands	-
Woodlands is an upmarket, easily accessed area – with the potential for recruiting volunteer wardens	+
New legislation (CEMA) will give more protection to Montserrat galliwasp	+
Most of the known Montserrat galliwasp range is outside of existing protected area boundaries	-
The Centre Hills protected area boundary is very near the Montserrat galliwasp range	+
Most of the known Montserrat galliwasp range is on private land, sub-divided for residential development	-
Most of the known Montserrat galliwasp range is on Crown Land	+

Administrative / political set-up		
This Crown Land has no management plan for conservation		-
The plan may be of low interest to politicians		-
Species biology		
Very little is known of the Montserrat galliwasp's biology and conservation status		-
The Montserrat galliwasp is very difficult to detect and monitor, making it difficult to assess the impacts of management actions		-
Analogue species seem to be fairly robust to <i>ex situ</i> conditions		+
The Montserrat galliwasp is predicted to be vulnerable to invasive alien species and habitat loss, both of which are affecting the species' known range		-
Juvenile Montserrat galliwasp are likely more prone to these threats		-
The Montserrat galliwasp is only known from a very small area		-
Analogue species suggest reproductive maturity is only reached after 2-3 years		-
The species is not very charismatic - difficult to raise public enthusiasm		-
It has proved possible to raise the public profile of and pride in other un-charismatic species		+
Montserrat galliwasp co-occur with other species of conservation priority (e.g. mountain chicken, Montserrat oriole)		+
Montserrat galliwasp's semi-fossorial (burrowing) habitats may make them relatively susceptible to mortality as bycatch in some invasive alien species control methods (e.g. poison bait stations)		-
Resources for SAP implementation		
The Montserrat galliwasp is Critically Endangered and so may be a priority for funders		+
The Montserrat galliwasp's lack of wide public appeal may make funders less inclined to support its conservation		-
The SAP and the Centre Hills Management Plan can assist in fund raising		+
Predator-proof fencing is very expensive		-
Control of invasive alien species is expensive		-
Acquiring private land parcels will be expensive		-
A feral livestock action plan has now been developed		+
Demarcating a new protected area to include the known Montserrat galliwasp range will be expensive		-
A number of agencies have a track record of supporting conservation on Montserrat (e.g. DFID, OTEP, EU, Darwin Initiative, etc)		+

Annex 5 Biology of galliwasps (genera *Celestus* and *Diploglossus*)

The following table uses the classification in Savage, Lips & Ibanez 2008 (Table 2) – which is largely consistent with Henderson & Powell 2009, Hedges 2010 and JCVI 2010 – but with the following exceptions:

- *C. agasepsoides* and *C. haetiana* (Henderson & Powell 2009, Hedges 2010) are not classified here as *Sauresia agasepsoides* and *S. haetiana* (the genus *Sauresia* is treated as separate but nested with *Diploglossus* by Savage, Lips & Ibanez 2008).
- *C. maculatus* and *C. molesworthi* are treated here as separate species (following Henderson & Powell 2009 and Hedges 2010), and not as subspecies of *C. cruscus* (as, for example, by JCVI 2010). (Savage, Lips & Ibanez 2008 also do not recognize these species but do not mention subspecies).

Following Savage, Lips & Ibanez 2008, three species listed by JCVI 2010 are not included in this table; they are:

- *Diploglossus microcephalus* Hallowell 1856 Small-headed Galliwasp (Mexico)
- *Diploglossus microlepis* Gray 1831 Small-lipped Galliwasp (unknown locality)
- *Diploglossus owenii* Duméril & Bibron 1839 (Mexico, Guatemala)

All are listed by JCVI as of “unclear status”; none are listed on multiple other herpetological check-

lists (e.g. Liner 1994, 2007); and none appear to have any references to them beyond the 19th Century.

SVL = maximum reported snout-vent length, for males in all cases except *C. duquesneyi*, *C. fowleri*, *C. macrotus*, *C. microblepharis*, *C. montanus*

“Long-armed” refers to species with arms longer than the snout-ear distance; “short-armed” species have arms equal or shorter than this. “Members of the long-arm group live in stone-walls, cliffs, heaps of coconut husks or similar dry habitats. Members of the short-arm group live beneath objects or among dead leaves and escape by wriggling” (Grant 1951, referring to (*C. duquesneyi*, *C. hewardi*, *C. occiduus* (long-armed); *C. maculatus*, *C. cruscus*, *C. molesworthi* and *D. pleii* (short-armed)).

West Indian species are shown with their Latin names in **bold** type.

* indicates references that were not available to consult directly in compiling this table; these may contain additional information that can be used to expand upon this table. Henderson & Powell (2009), however, provide a very comprehensive and up to date review of all of the West Indian species and so the following table is unlikely to have any significant gaps in what has been reported for those 26 species.

NOTE: for reasons of space, some fields in the following table are consolidated into single columns (Habitat and Elevation; Behaviour plus Reproduction plus SVL). For ease of sorting and filtering, a Microsoft Excel spreadsheet version of this table with these fields as separate columns is also available.

SPECIES ACTION PLAN FOR THE MONTSERRAT GALLIWASP

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus adercus</i> 2008	Panama	Not assessed	—	Tropical premontane forest 850m	Possibly arboreal — 146mm	—	Collected from roof thatching, suggesting arboreality. Species name means unexpected; southern-most known member of this genus	Savage et al 2008
<i>Celestus agasepsoides</i> 1971 Serpentine Four-toed Galliwasp	Hispaniola (Dominican Republic) Single island endemic	Not assessed	—	Xeric woodland and open areas, under rocks / debris 0-460m	Semi-fossorial to fossorial — 71mm	Beetles (inc larvae, pupae); crickets, roaches, flies, ants, centipedes	4 digits on each limb Classified as <i>Sauresia agasepsoides</i> by Savage et al 2008	Henderson & Powell 2009 Schwartz & Henderson 1991 (as <i>Diploglossus agasepsoides</i>) Thomas 1971 * White & Powell 1996 *
<i>Celestus anelpipistus</i> 1979 Giant Hispaniolan galliwasp; Attagracia Giant Galliwasp	Hispaniola (Dominican Republic) Single island endemic	CR A2c; B1ab (i,ii,iii) + 2ab (i,ii,iii); C2a (i,ii) ver 3.1 (2001)	Habitat loss	Mesic broadleaf forest, creeks; amongst tree roots —	Nocturnal Live-bearing; 2 ♀♀ gave birth to 42 young (Jul-Aug) 285mm	—	Illustrations: see Schwartz, Graham & Duval 1979; Henderson 1988	Hallermann & Böhme 2002 * Henderson 1988 * Henderson & Powell 2009 McGinnity & Powell 2004a Powell et al 1996 * Schwartz, & Henderson 1991 Schwartz, et al 1979 *
<i>Celestus ariflanensis</i> 1950	Mexico, Guatemala, Nicaragua, El Salvador	Not assessed	—	Lower montane wet (cloud) forest 700-1,650m	Arboreal; diurnal — 113m	—	Basks on tree trunks	Campbell & Camarillo 1994 Hidalgo 1982 * Savage et al 2008 Smith & Taylor 1950 Not listed for Nicaragua or Mexico by Köhler 2000

SPECIES ACTION PLAN FOR THE MONTSERRAT GALLIWASP

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus badlus</i> 1868 Navassa Galliwasp	Navassa Island Single island endemic	Not assessed (abundant on Navassa, 5.2 km ²)	—	Grassy areas, near former human habitation; rock faces —	Diurnal. Terrestrial (in leaf-litter) gravid females Apr; juveniles Jul-Aug 104mm	Earth-worms; presumably takes leaf litter invertebrates opportunistically	"Swims" through leaf litter, surfacing to scan surroundings	Cope 1868 Henderson & Powell 2009 Powell 1999a, 1999b Schwartz 1964 *
<i>Celestus barbouri</i> 1940 Limestone Forest Galliwasp	Jamaica Single island endemic	Not assessed	—	Mesic, cultivated; in coconut trash in dry scrub forest >600m	— — 106mm	—	Illustration: JCVI 2010	Cousens 1956 Grant 1940 * Henderson & Powell 2009 Schwartz & Henderson 1991
<i>Celestus bivittatus</i> 1895	Guatemala, Honduras, El Salvador, Nicaragua	Not assessed	A "medium vulnerability" species - primarily because restricted to 2 ecological formations	Pine forest; dry pine-oak forest 990-1,980m	Terrestrial, foraging in leaf litter hiding under logs, rocks Clutch 10; born Mar 103mm	—	Not listed for El Salvador by Köhler 2000. Apparently not listed by Peters & Donoso-Barros 1970	Boulenger 1895 * Campbell & Camarillo 1994 Köhler 2000 * Villa & Wilson 1988 * Wilson & McCranie 2003

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus costatus</i> 1862 Hispaniolan Smooth Galliwasp	Hispaniola, Ile de la Tortue, Ile-a- Vache, Isla Saona, Isla Catalina, Haïti, Do- minican Republic Single island endemic (Inc. off- shore islets)	Not as- sessed	—	Mesic, xeric. Most abundant in broad- leaf forest, inc. coffee and ca- cao plan- tation. Also in pine forests and disturbed areas (pasture, gardens) 0-2,300m	Terrestrial, occasionally arboreal. Diurnal. Live-bearing; clutch 3-9 127mm	Omnivo- rous (inc roaches, melon, dwarf gecko)	Actively forages in leaf litter in "an <i>Armeiva</i> -like fashion" between 0900 and 1130. Occasionally found on tree trunks, bromeliads <6m off ground. Long-armed Longevity in captiv- ity over 12 years Illustrations: see Fischer 1886 (as <i>Dip- loglossus ohlenadorffii</i>); Cochran, 1941 (as <i>C. badius</i> not as <i>C. co- status</i>). JCVI 2010	Barbour 1919 * Boulenger 1885 *, 1888 * Cochran 1941 Cope 1862, 1868 * Franz & Cordier 1986 Greer 1967 Henderson & Powell 2009 Schwartz 1964 *, 1971 Schwartz & Henderson 1991 Thomas & Hedges 1989
<i>Celestus cruscus</i> 1887 Garman's Galli- wasp; Jamaican Galliwasp	Jamaica Single island endemic	Not as- sessed	—	Largely mesic, also xeric (scrub) 0-1,220m	— Live-bearing; clutch 1-5 90mm	Includes insects	Found under coco- nut husks, in a termi- narium, rock piles, &C Short-armed Illustrations: see Schwartz & Hender- son 1985; JCVI 2010	Cousens 1956 Garman 1887 * Schwartz & Henderson 1985
<i>Celestus curtissi</i> 1951 Hispaniolan Khaki Galliwasp	Hispaniola, Ile de la Tortue, Ile de la Gonave, Isla Cata- lina, Isla Saona, Haïti, Dominican Republic Single island endemic (Inc. off- shore is.)	Not as- sessed	—	Xeric, un- der sur- face de- bris, rock piles 0-550m	— Live-bearing; clutch 2-5 86mm	—	For illustrations see Grant 1951; Schwartz 1964; JCVI 2010	Grant 1951 Henderson & Powell 2009 Schwartz 1964 * Schwartz & Henderson 1991

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus cyanochloris</i> 1894	Costa Rica	Not assessed (Rare)	—	Moist and wet forest 1,200-1,550m	Terrestrial; diurnal —	—	Occasionally climbs into low bushes	Cope 1894 * Köhler 2000 * Savage 2002 Taylor 1956 *
<i>Celestus darlingtoni</i> 1939 Darlington's Galliwasp; Hispaniolan Striped Galliwasp	Hispaniola (Dominican Republic) Single island endemic	Not assessed	—	Mesic 1,600-2,500m	Terrestrial. Lethargic on cold mornings Clutch 2 85mm	—	Found in moist situations (often at edge of bogs); pine forest, sawdust piles, under rocks, bark Illustrations: see Cochran 1941, JCVI 2010	Cochran 1939 *, 1941 Henderson & Powell 2009 Schwartz & Henderson 1991
<i>Celestus cluquesneyi</i> 1940 Blue-tailed Galliwasp	Jamaica Single island endemic	DD ver 2.3 (1994) (Rare; probably should be CR)	Introduced predators; habitat loss; persecution	Dry forest leaf litter 160m	— 111mm (♀)	—	Long-armed. Not collected since 1930 until 1997 when rediscovered	Grant 1940 * Henderson & Powell 2009 Schwartz & Henderson 1991 Wilson & Vogel 2000
<i>Celestus enneagrammus</i> 1860 Huasteca Lesser Galliwasp	Mexico (coastal areas of Oaxaca, Veracruz, Puebla)	LC ver 3.1 (2001) (locally common in suitable habitat)	Not thought to be facing any major threats	Cloud forest, pine, oak pastures 1,000-1,830m	Mostly terrestrial Live-bearing 89mm	—	—	Boulenger 1885 * Campbell & Camarillo 1994 Canseco-Márquez et al 2007 Cope 1861 * Werler & Campbell 2004

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus fowleri</i> 1971 Fowler's Galliwasp; Bromeliad Galliwasp	Jamaica Single island endemic	DD ver 2.3 (1994) (Restricted; habitat fragmentation)	—	Mesic, deciduous forest; bromeliads 160m	Arboreal — 105mm (♀)	—	Found in bromeliads to at least 2.5m off ground Long-armed Classified as <i>Sauresia fowleri</i> by Savage, Lips & Ibanez 2008	Henderson & Powell 2009 Schwartz 1971 Schwartz & Henderson 1991
<i>Celestus haefianus</i> 1927 Earless Galliwasp	Hispaniola (Haiti) Single island endemic	Not assessed (Habitat under threat)	—	Mesic, upland broadleaf forest; sometimes drier pine forest 790-2,690m	Terrestrial Live-bearing; clutch 3-8. Gravid females Mar-Aug 98mm	Beetles (adult, larval); roaches, flies, ants, hymenoptera, spiders, centipedes, snails, earth-worms	Under logs, rocks, surface debris. 4 digits on each limb Illustrations: see Cochran 1941; Schwartz 1965; JCVI 2010	Cochran 1927 * Cochran 1941 * Greer 1967 Henderson & Powell 2009 Powell et al 1996
<i>Celestus hewardi</i> 1845 Heward's Galliwasp; Red-spotted Galliwasp	Jamaica Single island endemic	Not assessed	—	Mesic, rocky talus, edge of doline pasture 0-915m	Diurnal — 132mm	Stomachs contained "flat slug-like animals known locally as 'cow's tongues'"	Basks shortly after sunrise but only with head protruding, runs across walls later in day Long-armed	Bauer et al 1995 * Boulenger 1885 * Cousens 1956 Grant 1940 * Henderson & Powell 2009
<i>Celestus hylatus</i> 1994	Costa Rica	Not assessed	—	Lowland wet and moist forest; in leaf litter, fallen trees 40-360m	Diurnal, terrestrial — 107mm	—	" Might be arboreal and possibly active at night" Short-armed	Köhler 2000 * Savage 2002 Savage & Lips 1993 *

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus Ingridae</i> 2004 Campbell's Galliwasp	Mexico (Veracruz)	DD ver 3.1 (2001)	—	Mesic 1,200m	Arboreal and terrestrial — 105mm	—	Most found under loose bark; some on tree trunks 1-2m off ground Long-armed Illustrations: see Werler & Campbell 2004	Campbell 2007 Werler & Campbell 2004
<i>Celestus legnotus</i> 1994 Campbell's Galliwasp	Mexico (Puebla)	LC ver 3.1 (2001)	No significant threats	Mesic, forest, pastures 1,210-1,715m	Terrestrial Live-bearing 113mm	—	Reported in highly disturbed habitat (pasture; formerly temperate broadleaf forest), actively foraging in grass.	Campbell & Camarillo 1994 Lopez Luna & Canseco-Márquez 2007
<i>Celestus macrotus</i> 1989 Thomas' Galliwasp; La Selle Galliwasp	Hispaniola (Haiti) Single island endemic	Not assessed	—	Mesic (moist, mossy), high elevation pine forest, limestone rocks 2,020m	— 60mm (♀)	—	Long-armed Illustrations: see Thomas & Hedges 1989	Henderson & Powell 2009 Schwartz & Henderson 1991 Thomas & Hedges 1989
<i>Celestus maculatus</i> 1888 Cayman Galliwasp	Little Cayman, Cayman Brac Single island endemic	Not assessed	—	Littoral(?); in leaf litter and stone piles; near abandoned houses 0m	Disappeared into holes in coral rock Clutch 3 92mm	Includes insects	Short-armed JCVI (2010) considers <i>C. maculatus</i> and subspecies of <i>C. cruscus</i> . Henderson & Powell 2009 treat it as a full species, as here.	Garman 1888 * Grant 1940 * Henderson & Powell 2009
<i>Celestus marcano</i> 1976 Marcano's Galliwasp; Pico Duarte Galliwasp	Hispaniola (Dominican Republic) Single island endemic	Not assessed	—	Mesic, montane river valleys 1,500-1,800m	Extremely lethargic on cold (0 °C) mornings — 78mm	—	Long-armed Found in locally dry soil (but near creeks) with large number of rocks Illustrations: see Schwartz & Inchaustegui 1976	Henderson & Powell 2009 Schwartz & Inchaustegui 1976 Schwartz & Henderson 1991

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Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus microblepharis</i> 1959 Small-eyed Galliwasp	Jamaica Single island endemic	DD ver 2,3 (1994) "Lack of info suggests rarity or possible extinction"	—	coastal scrub, backing onto limestone scrub forest; in conut trash 0m	— 87mm (♀)	—	Illustrations: see Underwood 1959	Henderson & Powell 2009 Schwartz & Henderson 1991 Underwood 1959 *
<i>Celestus molesworthi</i> 1940 Porifland Coast Galliwasp	Jamaica Single island endemic	Not assessed	—	Mesic; under conut husks, rubbish —	— 85mm	—	Short-armed JCVI (2010) considers <i>C. maculatus</i> and subspecies of <i>C. cruciatus</i> ; Henderson & Powell 2009 treat it as a full species, as here.	Grant 1940 * Henderson & Powell 2009
<i>Celestus montanus</i> 1933 Mountain Lesser Galliwasp	Honduras	Not assessed	—	Premontane wet forest 915-1,350m	Terrestrial or arboreal? Gravid Apr 80mm (♀)	—	Long-armed Type collected in roof thatch (suggesting arboreality); juvenile caught active on the ground (near rocky stream)	Campbell & Camarillo 1994 Grant 1940 * Schmidt 1933 Townsend et al 2005 Wilson et al 1986 *
<i>Celestus occidatus</i> 1802 Jamaican Giant Galliwasp. Sinking Galliwasp	Jamaica Single island endemic	EX ver 2,3 (1994)	Extinction possibly attributable to introduced predators such as mongoose	Woody and marshy areas —	— 305mm	Fish, fruit	Last recorded in 1840 Long-armed	Böhme & Fischer 1998 Boulenger 1885 * Henderson & Powell 2009 McGinnity 2002 Schwartz 1970 * Shaw 1802
<i>Celestus orobius</i> 1994	Costa Rica	Not assessed	—	Lower montane rainforest 1,500-2,000m	Terrestrial — 83mm	—	6-8 individuals found on the ground in a small, rocky clearing Short-armed Illustrations: see Savage, Lips & Ibanez 2008	Köhler 2000 * Savage 2002 Savage & Lips 1993 * Savage et al 2008

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus rozellae</i> 1942 Rozella's Lesser Galliwasp	S Mexico (Yucatan), Guatemala, Belize, Honduras	NT Ver 3.1 (2001) (rare)	Habitat loss	Moist lowland forest 0-1,350m	Diurnal, mostly arboreal Live-bearing; clutch 5-8 102mm	—	Found at considerable height in palm trees Illustrations: see Campbell & Camarillo 1994	Campbell & Camarillo 1994 Köhler 2000* Smith 1942* Werler & Campbell 2004 Has been reported for Honduras (JCVI 2010). Not listed for Honduras by Köhler 2000 or by Wilson & McCranie 2002
<i>Celestus scansorius</i> 1996	Honduras	Not assessed (Rare)	—	Lower montane wet 1,550-1,590m	Arboreal —	—	—	Köhler 2000* McCranie & Wilson 1996* Wilson & McCranie 2003
<i>Celestus sepsoides</i> 1852 Hispaniolan Four-toed Galliwasp	Hispaniola (Haiti, Dominican Republic) Single island endemic	Not assessed	—	Mesic. Broadleaf forest, under rocks, logs, trash; 0-790m (possibly to 950m)	Terrestrial Live-bearing; clutch 1-2 78mm	—	Also found in abandoned gardens. Never encountered in the open Short-armed 4 digits on each limb Illustrations: see Boulenger 1885; Cochran 1941	Boulenger 1885* Cochran 1941 Gray 1852 Henderson & Powell 2009 Schwartz & Henderson 1991
<i>Celestus stenurus</i> 1862 Cape's Galliwasp; Hispaniolan Keel Galliwasp	Hispaniola (Haiti, Dominican Republic), Ile-a-Vache, Ile Grande Cayemite, Ile a Cabrit Single island endemic (inc. off-shore islets)	Not assessed	—	Mesic; also moist shaded conditions in otherwise xeric. Under rocks, surface debris 0-1,220m	Terrestrial Live-bearing; clutch 5-6. Births May-Jun 172mm	—	Particularly abundant in piles of rocks along stream channel with dense fern Long-armed Illustrations: see Boulenger 1885 (as <i>Diploglossus striatus</i>); Cochran 1941 (as <i>C. costatus</i>); Grant 1951 (as <i>C. castatus</i>); JCVI 2010	Boulenger 1885* Cochran 1941 Cope 1862 Franz & Cordier 1986 Henderson & Powell 2009 Schwartz & Henderson 1991

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Celestus warreni</i> 1970 Giant Hispaniolan galliwasp	Hispaniola (Haiti), Ile de la Tortue Single island endemic (Inc. off-shore islets)	CR A2ac; B1ab (i,ii,iii,iv) +2ab (i,ii,iii,iv) ver 3.1 (2001)	Habitat loss; Introduced predators; persecution	Mesic, Lowland broadleaf forest; banana groves; also dry forest rocky areas 0-500m?	Crepuscular. Terrestrial (presumed burrowing) Live-bearing; clutch 8-34 (correlates with SVL). Mature at 3-4 years. Gravid Aug. Lifespan (captivity) 10 years, probably longer 279mm	Millipedes, centipedes, slugs, whip scorpions, spiders, tarantulas, earwigs, bugs, beetles (adult, larval), <i>Anolis</i> , galliwasp (<i>C. celestus</i>)	Powell & Henderson (2003) synonymized <i>C. carraui</i> with <i>C. warreni</i> . Illustrations: see Henderson & Schwartz 1984; JVI 2010 Hallermann & Böhme 2002 suggest relegating several species of <i>Celestus</i> to subspecies of <i>C. warreni</i> ; in particular <i>C. carraui</i> (as here) and <i>C. anelpistus</i>	Hallermann & Böhme 2002 * Henderson 1988 * Henderson & Powell 2009 McGinnity pers. comm. McGinnity 2002 McGinnity & Powell 2004 Powell et al 2000 Schwartz 1970 * Schwartz & Henderson 1991
<i>Diploglossus bifobatus</i> 1874 O'Shaughnessy's Galliwasp	Costa Rica, Panama, Nicaragua	Not assessed	—	Lowland moist and wet forest; premontane wet forest and rainforest. In leaf litter 0- >1,000m	Terrestrial; semi-fossorial; diurnal Egg-laying 6-15 eggs 92mm	—	Females apparently brood eggs Observability possibly related to rainfall (more seen in Panama just before onset of rainy season) Illustrations: see Myers 1973; Lotzkat et al 2010	Myers 1973 O'Shaughnessy 1874 * Savage 2002 Lotzkat et al 2010
<i>Diploglossus delasagra</i> 1838 Cuban Galliwasp; Cuban Pale-necked Galliwasp; Celestus de la Sagra	Cuba, Isla de la Juventud Single island endemic	Not assessed	—	Mesic, broadleaf forest; under surface objects (rocks, logs, boards) —	Terrestrial (fossorial) Egg-laying 2-6 eggs 121mm	—	Occasionally uncovered during ploughing Males or females may guard eggs Short-armed For illustrations see Barbour & Ramsden 1919; Barbour & Shreve 1937; Brongersma 1946	Barbour & Ramsden 1919 Barbour & Shreve 1937 Cocteau 1938 * Henderson & Powell 2009 Schwartz & Henderson 1991

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Diploglossus fasciatus</i> 1831 Banded Galliwasp	Brazil, Bolivia, Peru	Not assessed	—	—	—	—	Likely to show parental care of newborns Illustrations: see Savage, Lips & Ibanez 2008	Avila-Pires 1995 * Barbour 1909 * Gray 1831 * Greene et al 2006 Savage et al 2008
<i>Diploglossus garridoi</i> 1998 Cuban galliwasp; Cuban Small-eared Galliwasp	Cuba Single island endemic	Not assessed	—	Mesic; open area surrounded by mixed broad-leaf / pine forest; near stream 1,110m	Terrestrial? Gravid Jun (♀ contained 4 shelled eggs) 103mm (♀)	—	Underneath cut vegetation Short-armed Illustrations: Thomas & Hedges 1998	Thomas & Hedges 1998
<i>Diploglossus lessonae</i> 1890 Brazilian Galliwasp; Briba	Brazil	Not assessed	—	Semi-arid, lowland forest, savannah and dry forest —	Terrestrial? Egg-laying; clutch 5-7 155mm	spiders, scorpions, scorpions, beetle larvae, earthworms	Illustrations: see Vift 1992a; JCVI 2010	de Barros & Avari 2010 Parker 1924 * Peracca 1890 * Vift 1985 *, 1992 a, b
<i>Diploglossus millepunctatus</i> 1874 Dotted Galliwasp	Malpelo Island (Colombia) Single island endemic	Not assessed (Common and ubiquitous but restricted to single island ca. 1.2km ²)	—	Xeric; bare rock and sparse vegetation (algae, mosses, lichens; some patches of grass) 0-376m	Terrestrial; diurnal. Gravid Mar 250mm	Invertebrates (insects and crabs); fish regurgitated by boobies; dead boobies	Regurgitated fish is an important part of diet; breeding may be time to coincide with boobie breeding. Usually stay close to retreats in rock crevices. Long-armed Bask mid-morning; otherwise in crevices	Kiester 1975 O'Shaughnessy 1874 * Slevin 1928

Name year described	Range	Status	Threats	Habitat Elevation	Behaviour Reproduction SVL (mm)	Diet	Comments	References and notes
<i>Diploglossus monotropis</i> 1820 Rose-sided galliwasp; scorpion coral; madre de culebra; madre (de) coral (mother of coral snakes)	Nicaragua, Costa Rica, Panama, Colombia, Ecuador	Not assessed (Considered rare)	—	Humid Atlantic lowlands. Edges of rainforest; cacao plantation, thick secondary growth 0-1,000m	Terrestrial, diurnal. Under logs, leaf litter Egg-laying: clutch 4-7. Mature at 3 years(?) Life span (captivity) 12.3Y 215mm	—	Known locally as escorpion coral (coral snake scorpion) because of mistaken belief in venomous stinging in the tail.	Coleman 1997 * Kuhl 1820 * McGinnity pers. comm. Myers 1973 Savage 2002 Villa & Occhipinti 1988 *
<i>Diploglossus montisivestris</i> 1973	Panama	Not assessed	—	Cloud forest, pine, oak, pastures 1,440m	Arboreal? — 100mm	—	Caught on tree trunk (< 1m off ground); this plus long claws suggest arboreality. Illustrations: see Myers 1973	Myers 1973 * Villa & Occhipinti 1988 *
<i>Diploglossus montisserati</i> 1964 Montserrat Galliwasp	Montserrat Single island endemic	CR B1+2c ver 2.3 (1994)	Introduced predators; habitat availability?	Mesic; broadleaf forest near streams; under rocks, tree roots 183m	Terrestrial (fossorial), crepuscular, — 180mm	—	Speculation that it feeds on crayfish For illustrations see Underwood 1964; Ogradowczyk et al 2006	Buley 2001 Henderson & Powell 2009 Ogradowczyk, Murrain, Martin & Young 2006 Schwartz & Henderson 1991 Underwood 1964
<i>Diploglossus nigropunctatus</i> 1937 Cuban Pale-necked Galliwasp	Cuba Single island endemic	Not assessed	—	Field near edge of woods; under rotten wood —	Terrestrial (fossorial): associated with ants (nests) Egg-laying: clutch 4-5 121mm	—	Males and females may brood eggs Elevated to full species status by Thomas & Hedges 1998 Illustrations: see Thomas & Hedges 1998	Barbour & Shreve 1937 Henderson & Powell 2009 Schwartz & Henderson 1991 Thomas & Hedges 1998
<i>Diploglossus pleii</i> 1839 Puerto Rican Galliwasp; Culebra de Cuatro Patas	Puerto Rico, Single island endemic	Not assessed ("Stable")	—	Mesic, under surface objects; ravines, banana trash; sugarcane fields 50-670m	Terrestrial (semi-fossorial); in lower layers of deep leaf litter) Live-bearing: 2-4 embryos 125mm	Millipedes, beetles, earwigs, slugs, termites, spiders, centipedes	May be a millipede eating specialist Short-armed Illustrations: see Stejneger 1904; Schmidt 1928; Rivero 1978. Terra typica: Martini-que (in error)	Duméril & Bibron 1839 * Henderson & Powell 2009 Schwartz & Henderson 1991 Stejneger 1904 Thomas & Goa Kessler 1996

Annex 6. Hispaniolan galliwasp *Celestus warreni* husbandry guidelines

Matthias Goetz
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Fig. 1: Adult male *C. warreni* (MG).

Introduction

Giant galliwasp are diploglossine anguid lizards restricted to the Neotropics. They are live-bearing skink-like lizards, and reach maximum snout vent lengths greater than 200 mm. They are rarely seen, as they are nocturnal and semi-fossorial. Four species in the genus *Celestus*, collectively known as West Indian giant galliwasp, occur or occurred on Jamaica and Hispaniola. *Celestus occiduus* is endemic to Jamaica, *Celestus warreni* is restricted to Haiti and *Celestus anelpistus* and *Celestus carraui* are only found in the Dominican Republic. The last two species are now believed to be subspecies of *C. warreni* (Hallermann & Böhme 2002); *C. carraui* might be a synonym to *C. warreni* (Powell and Henderson 2003).

Distribution

The range of *C. warreni* is limited to a now mostly deforested area of northern Haiti, where it occurs up to moderate elevations.

Habitat

C. warreni, like other galliwasp, occupies semi-dry to moist woodlands where it lives primarily in the leaf-litter and top-soil layers, or under stones and fallen trees. They are occasionally seen basking on patches of open ground.

Conservation Status and Threats

C. warreni is listed as Critically Endangered on the IUCN Red List. Although the generation length is not known with any certainty, an 80% reduction in total population size over the last twenty years seems reasonable, and this results in a Critically Endangered listing. Also, the extent of occurrence is less than 100 km² and the area of occupancy is smaller than 10 km². There is continuing decline in the extent of occurrence, area of occupancy, suitable habitat and number of locations, and the remaining habitat is severely fragmented (McGinnity & Powell 2004).

Captive Management

Sexing Individuals

Males usually are larger and have wider heads than females, but this only becomes clear when large individuals of similar age are compared. Otherwise, young males could be mistaken for females.

In general, only mature individuals can be sexed reliably, via repeated ultrasound scans to observe the cycling of ovaries versus the constant size of testes.

A less certain/effective alternative is to carefully observe two adult individuals introduced into the same enclosure over a couple of days. Two males will definitely fight or chase each other, whereas two females or a pair will not interact much outside the breeding season. Great care has to be taken to separate fighting individuals before they damage each other.

Housing

At Durrell, adults are kept either in pairs or individually in enclosures approximately about 150 x 50 cm in size (Fig. 2). Juveniles and immature individuals are kept in small groups in appropriately-sized enclosures such as plastic storage containers (Figs. 3 and 4). Adult males must not be kept together due to their aggressiveness.

Although this species is not known as a good climber, in order to prevent adults escaping, enclosures need to have at least 30cm clearance above the substrate

The substrate needs to be deep enough for digging/burrowing; about 15-20 cm deep for adults, but approximately 5 cm deep will suffice for hatchlings. This can be any type of topsoil or compost, which can be used on its own or mixed with small bark chips; even a mix of large chunk ver-

miculite, coconut fibres and moss has been used successfully. Basic requirements for the substrate are that it holds humidity well, does not give off and/or break down quickly to dust and is easy for the galliwasp to dig in. There should be plenty of hides on the surface of the substrate, such as palm fronds, pieces of bark or plastic half-rounds. A layer of leaf litter was provided initially in order to mimic natural habitat, however, this proved to be a hindrance because cleaning the substrate of faecal matter and food was nearly impossible and the animals were rarely seen to monitor their physical condition. A small water dish needs to be provided permanently.



Fig. 2: Enclosure for adults. Note the newspaper used to maintain substrate humidity at one end of the enclosure (MG).



Fig. 3: Enclosures for two to three sub-adults (MG).



Fig. 4: Rearing pens for hatchlings and juveniles (MG).

Temperature, Humidity and Lighting

Ambient room temperature during the warm and wet summer period should be about 26-28°C during the day and around 23-24°C at night. In the cooler and drier winter, this can be reduced to be about 24-26°C during the day and around 21°C at night. Even in summer, temperatures should resemble those found on the substrate of shaded tropical woodland.

For basking, hot-spots with temperatures up to 35-40°C need to be provided all year round at one end of the enclosure. Here, the substrate can dry out partially during the day. At the other end, a layer of newspapers, a sheet of plastic or a piece of bark provides a cooler area where the substrate underneath stays constantly humid (Fig. 2). This creates a gradient of temperature and humidity over the length of the enclosure, allowing the animals to choose their preferred position / location.

Humidity is provided by spraying the substrate each evening. During the drier and cooler winter months, only a light spray is provided to ensure the covered area stays humid. During the wet summer months, the whole enclosure is sprayed more heavily, and the substrate is only allowed to dry out slightly around the basking area.

In adult enclosures, lighting is provided by daylight strip lights and a basking spot. As for most reptiles, it is important to provide this species with UV-A

and UV-B radiation. For this purpose, self ballasted Mercury vapour bulbs are used. The intensity of the UV-B radiation should be regularly measured by a UV reader (Solarmeter 6.2) and should ideally lie between 100 and 300 μ W/m². We recommend the brands MegaRay and T-Rex which come in 100W and 160W).

Smaller, relatively low enclosures for rearing hatchlings might be fitted with UV fluorescent strip-lights. We recommend a combination of a ZooMed 2.0 (which has a better light colour index but hardly any UV-B output) with, depending on distance to the ground, a ZooMed 5.0 or 10.0 (for UV-B radiation). The intensity of the radiation, especially in higher enclosures, can be greatly increased by using a reflector. If UV radiation in smaller enclosures is provided by these strip lights, a normal incandescent spotlight can then be used to create a basking area.

Diet in captivity

Nashville Zoo experimented with different diets after several cases of metabolic bone disease, and the diet at Durrell was adapted from the one developed by Nashville Zoo.

30 parts frozen turkey breast, 10 parts frozen rat pups, one part cuttlefish bone (all parts by weight) and some Nutrobal (vitamin and mineral supplement) are put through a mincer and thoroughly mixed. This paste can be frozen, e.g. in ice-cube trays, and stored for several months in the freezer. Defrosted chunks (approximately the size of the animal's head) are offered to the animals in the evening on small plastic trays.

Adult individuals get fed every 3-5 days, hatchlings and small juveniles every second day. Occasionally, the animals will be fed insects, insect larvae or snails instead of the mix.

Reproduction in Captivity

Breeding Seasonality

Pairs can be introduced in the breeding season which, in the wild, generally lasts from February until April. At Durrell, copulations were observed in March, juveniles were then born in August.

Mating and Gravid Females

Due to the secretive lifestyle and the shyness of the species, not much is known about courtship and mating. During the matings observed at Durrell, the male held the female by her neck and the back of the head (Fig. 5). This was observed repeatedly on several consecutive days. If the fe-

male is gravid, it will become noticeably larger over the next months. The male should be removed at this stage at the latest. This is to allow the female the rest and all the food it needs, and also to prevent the male from preying on the newborns. However, it is not known whether females prey on their young or for how long after giving birth they might be inhibited from doing so, nor whether males would actually prey on "their" offspring.

Raising Juveniles

At Durrell, clutches to date consisted of between 19 and 22 individuals, and newborns measured 46-49mm in SVL and weighed 1.4 - 1.8g. As soon as offspring are seen in the female's enclosure, they should be caught up and transferred to rearing enclosures. At Durrell, plastic tanks (PalPens) measuring 25 x 45 cm are used to rear groups of up to five juveniles for the first four months. Then, once the juveniles have reached approximately 6cm SVL, they need to be transferred to larger enclosures. This is to ensure that the growth rates of subordinate animals are not suppressed. Juveniles need to be checked at least bi-weekly and should periodically be re-sorted into tanks according to size to prevent a strong hierarchy from forming, where smaller individuals could be outcompeted for food by bigger, dominant siblings.

The first food taken is usually insects, mainly crickets of appropriate size dusted with Nutrobal; the pre-fabricated mix can be introduced over the next weeks and should be taken without any problems.



Fig 5: *C. warreni* mating (GG).

Veterinary aspects

Blood sampling

Blood samples can be drawn from the tail vein. Care has to be taken when doing this, as this spe-

cies (like all anguids) will shed its tail if too much pressure is applied. The risk can be lowered greatly if the whole animal is wrapped in a sheet of rubber foam and held firmly in the hand, applying pressure uniformly.

Marking

We marked *C. warreni* with PIT-tags. Due to the osteoderms anguids possess, the best location for transponders seems to be the flanks rather than e.g. the dorsal tail base.

Ultrasound scanning

As mentioned above, we used ultrasound scanning to determine the sex of individuals. If an adult/mature individual is scanned about once per month for three to four months, the cycling of the ovaries in females can be reliably observed as opposed to males testes which don't change in size.

The images are not as clear as would be expected from reptiles of that size as the osteoderms cover all of the body, forming a dense bony layer. This also makes follow-up examinations of gravid females difficult as well and structures/details of fetuses are very hard if not impossible to detect, even when scanning under water. Even the use of a high-resolution 3D ultrasound scanner did not provide any clearer images through the osteoderms.

X-ray

Much clearer images of gravid females and fetuses can be obtained by x-raying. Bony structures, especially the skulls of late fetuses can be clearly seen.

Bibliography

Hallermann, J. & W. Böhme (2002): On giant anguids from the West Indies with special reference to *Celestus warreni* (Schwartz, 1970) and its relatives from Hispaniola (Reptilia: Squamata: Anguinae). Mitt. Hamb. Zool. Mus. Inst. 99: 169-178.

Powell, R. & Henderson, R.W. (2003): The taxonomic and conservation status of Giant Hispaniolan *Celestus* (Anguinae). Carib. J. Sci. 39.

McGinnity, D. & Powell, R. (2004): *Celestus warreni*. In: IUCN 2007. 2007 IUCN Red List of Threat-

ened Species. <www.iucnredlist.org>. Download 29. January 2008.

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Photography

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