# Best Practice Guidelines for the

# Montserrat Tarantula (*Cyrtopholis femoralis*)

**Authors:** Gerardo Garcia, Tamas Papp, Stuart Longhorn, Tom Jameson, Amber Flewitt and Heather Prince.

**Terrestrial Invertebrate TAG Chairs:** Mark Bushell

**Published:** 2021

**TITAG Chair:**
Mark Bushell, Bristol Zoo Gardens, Clifton, Bristol, BS8 3HA.

**TITAG Vice-Chairs:**
Tamás Papp, Chester Zoo, Moston Rd, Upton, Chester CH2 1EU. t.papp@chesterzoo.org. Vítek Lukáš, Zoo Praha, U Trojského zámku 3/120, 171 00 Praha 7, Czechia.

## EAZA Best Practice Guidelines disclaimer



The information contained in these EAZA Best Practice Guidelines has been obtained from numerous sources believed to be reliable. EAZA and the EAZA Terrestrial Invertebrate TAG make a diligent effort to provide a complete and accurate representation of the data in its reports, publications, and services. However, EAZA does not guarantee the accuracy, adequacy, or completeness of any information. EAZA disclaims all liability for errors or omissions that may exist and shall not be liable for any incidental, consequential, or other damages (whether resulting from negligence or otherwise) including, without limitation, exemplary damages or lost profits arising out of or in connection with the use of this publication.

Because the technical information provided in the EAZA Best Practice Guidelines can easily be misread or misinterpreted unless properly analyzed, EAZA strongly recommends that users of this information consult with the editors in all matters related to data analysis and interpretation.

## EAZA preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the "Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria". These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country. Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

**Citation:** Garcia, G., Papp, T., Longhorn, S., Jameson, T.J.M., Prince, H., Flewitt, A. & Prince, H., 2020. Best Practice Guidelines for Montserrat Tarantula (*Cyrtopholis femoralis*). European Association of Zoos and Aquaria, Amsterdam, The Netherlands.

**Cover Photo:** G. Garcia

## Summary

The information in these Best Practice Guidelines has come from a variety of sources including an extensive literature review, the experience of the authors, as well as direct observations of *Cyrtopholis femoralis* in captivity and the wild. Much of the information on veterinary considerations for tarantula spiders (i.e. theraphosids) in general relevant to *C. femoralis* comes from Pellett et al (2015).

Captive breeding of *Cyrtopholis femoralis* is essential for facilitating research on this understudied species of tarantula. As an endemic of Montserrat *C. femoralis* is vulnerable to extinction as a result of natural disasters and introduced species (see section 1.5.4). Further research is required to assess the taxonomic status and distribution of this species to plan appropriate conservation actions. As such, the captive population of *C. femoralis* may represent an important insurance population and potential founder stock for future reintroductions into the wild. Similarly, the captive population is a useful resource for conservation research, data from which can be used to inform in-situ conservation efforts.

*Cyrtopholis femoralis* is chronically understudied (see section 2.8). As such, these Best Practice Guidelines represent by far the most comprehensive assessment of all aspects of the species biology and the starting point for any further research and conservation planning concerning the species.

*Cyrtopholis femoralis* has proven to be very receptive to captive management, breeding and growing successfully in captivity. *C. femoralis* thrives in captive conditions without overly complex or expensive husbandry requirements. As such, *C. femoralis* appears to be an ideal candidate for ex-situ captive breeding.


## Key husbandry points

1. *Cyrtopholis femoralis* can be maintained in simple plastic tanks with no additional furnishings besides a water bowl. The most important component of the enclosure is a suitable substrate that allows a burrow to be constructed. Coir or a coir sand mix are recommended as this substrate holds its shape well, allowing a naturally shaped burrow to build easily, either in part or completely by the spider, as well as having suitable features for drainage, absorption, pH, etc… Substrate must be deep enough to allow a burrow to be built, an absolute minimum of 15cm, preferably deeper.
2. *Cyrtopholis femoralis* should be kept in individual enclosures, specimens only being mixed for mating when males begin to show courtship behaviour.
3. Like other tarantula spiders (aka theraphosids), *Cyrtopholis femoralis* have a long gestation period (8 months) and are slow growing (maturity reached in 5-6 years). After hatching, spiderlings must be separated into individual specialist enclosures. Specimens must be moved to progressively larger enclosures as they grow.

# Contents

# Section 1: Biology and field data

## Biology

## 1.1 Taxonomy:

**Order:** Araneae

**Family:** Theraphosidae Thorell, 1869

**Genus:** *Cyrtopholis* Simon, 1892

**Species:** *Cyrtopholis femoralis* Pocock, 1903

**Common names**:

Montserrat Tarantula

**Subspecies:**

No subspecies or synonyms are known for this species (e.g. after Petrunkevitch, 1911, World Spider Catalog (2020)).

## 1.2 Morphology

*Cyrtopholis* is a fairly small tarantula spider compared to some notable relatives in the same family Theraphosidae (aka theraphosids), with female adults only measuring up to around 40 mm in total body length (Rosa et al., 2013). Integument varies from deep chestnut to greyish-black colour on the body and leg or palp femora, with lighter leg joints, and a pale brown to grey on the lower limb segments, pedipalps and chelicerae. Mature males can be lighter brown or chestnut colour, while females or larger juveniles may be darker. Different colour morphs may represent distinct population or undescribed species, further taxonomic work is needed (see section 2.8). The body and legs are covered with longer setae, which were originally described as “yellowish-brown hairs, with long pale bristles on the abdomen” (Pocock, 1903, p. 96) (Fig. 1).

Further details of the morphology of *Cyrtopholis femoralis*, and indeed any members of the genus are either entirely lacking or desperately in need of updated (or more complete) descriptions (see section 2.8). An incomplete description of only the adult male of *C. femoralis* is provided by Pocock (1903), such as: For eyes with “anterior line of the eyes are slightly procurved, laterals a little larger than medias, medians barely a radius apart” and for legs, with “femur of the third leg is considerably more relatively thickened”, “the tarsal scopulae of the third and fourth legs are divided by a narrow band of bristles” and “protarsus of the first leg is straight, not arcuate“ (p.96-97).


Figure 1. *Cyrtopholis femoralis* encountered on Montserrat. (A) Adult male. (B) Well-grown on juvenile (C) Young juvenile.  (G. Garcia).

## 1.3 Physiology

Nothing has been published on the physiology of *Cyrtopholis femoralis.* All observation of *C. femoralis* suggest that the species is an obligate burrowing terrestrial tarantula, with no distinct or unusual physiological features.

Like all tarantulas *Cyrtopholis femoralis* detect prey and conspecifics by the means of sensory hairs that detect vibrations transmitted via the ground (trichobothria) (Cleton et al.,2015). As a defence mechanism, in addition to a capability to bite, *C. femoralis* also possess urticating bristles on the dorsal side of the abdomen. When threatened the rear pair of legs are used to shear off the bristles, creating an airborne cloud of bristles that can have an irritating effect on the potential aggressor (Cleton et al., 2015). Seven different urticating bristle morphologies are known in various tarantulas (see Kaderka et al., 2019), the form(s) present in *C. femoralis* has yet to be identified, but given the condition of likely close allies, type I is expected, and possibly type III. It remains unclear what direct effect these defensive bristles may have on various natural and introduced predators or parasites. Similarly, the effect of any defensive bite on other such species is unknown.

## 1.4 Longevity

No long-term studies of *Cyrtopholis femoralis* have been carried out, and as such, no individuals have been followed for their whole lives from birth to a natural death. The only adult Individuals in captivity were established in Chester Zoo from wild caught individuals between 08/07/2013 and 14/07/2013, age at capture of these individuals is unknown. Following the successful hatching of *C. femoralis* specimens at Chester Zoo on 07/07/2016, individuals are being monitored to establish the first records of life history for this species. Based on experience with other terrestrial tarantulas of similar sizes and ecology *C. femoralis* is expected to grow by a series of moults, typically several times a year when young, and less frequently with age, to an expected annually or even biannually in mature females. Both sexes are expected to take 5-6 years to reach sexual maturity, with males surviving 1-1.5 years once maturity is reached (up to first adult moult), and females surviving for 5-6 years after reaching maturity (T. Papp, pers. obs.), or perhaps longer.

# Field data

## 1.5 Conservation status/Zoogeography/Ecology

### 1.5.1 Distribution

*Cyrtopholis femoralis* is endemic to Montserrat in the Lesser Antilles of the Caribbean (Fig. 2), which totals just 102 km$^2$. and is potentially the only theraphosid on the island. The same species is thought to be historically widespread and abundant across all of Montserrat (Rosa et al., 2013), although large sections of its former range are expected to have been recently lost (See section 1.5.4). No formal studies of *C. femoralis* have taken place. An assessment of species distribution should be a priority for any research program initiated for the species (see section 2.8).

It is possible that *Cyrtopholis femoralis* may be made up of at least two distinct species occupying distinct habitat and altitudinal zones across Montserrat (S. Longhorn, pers. obs.). Investigating the presence of potential cryptic species of *C. femoralis* is a priority for this species (see section 2.8).

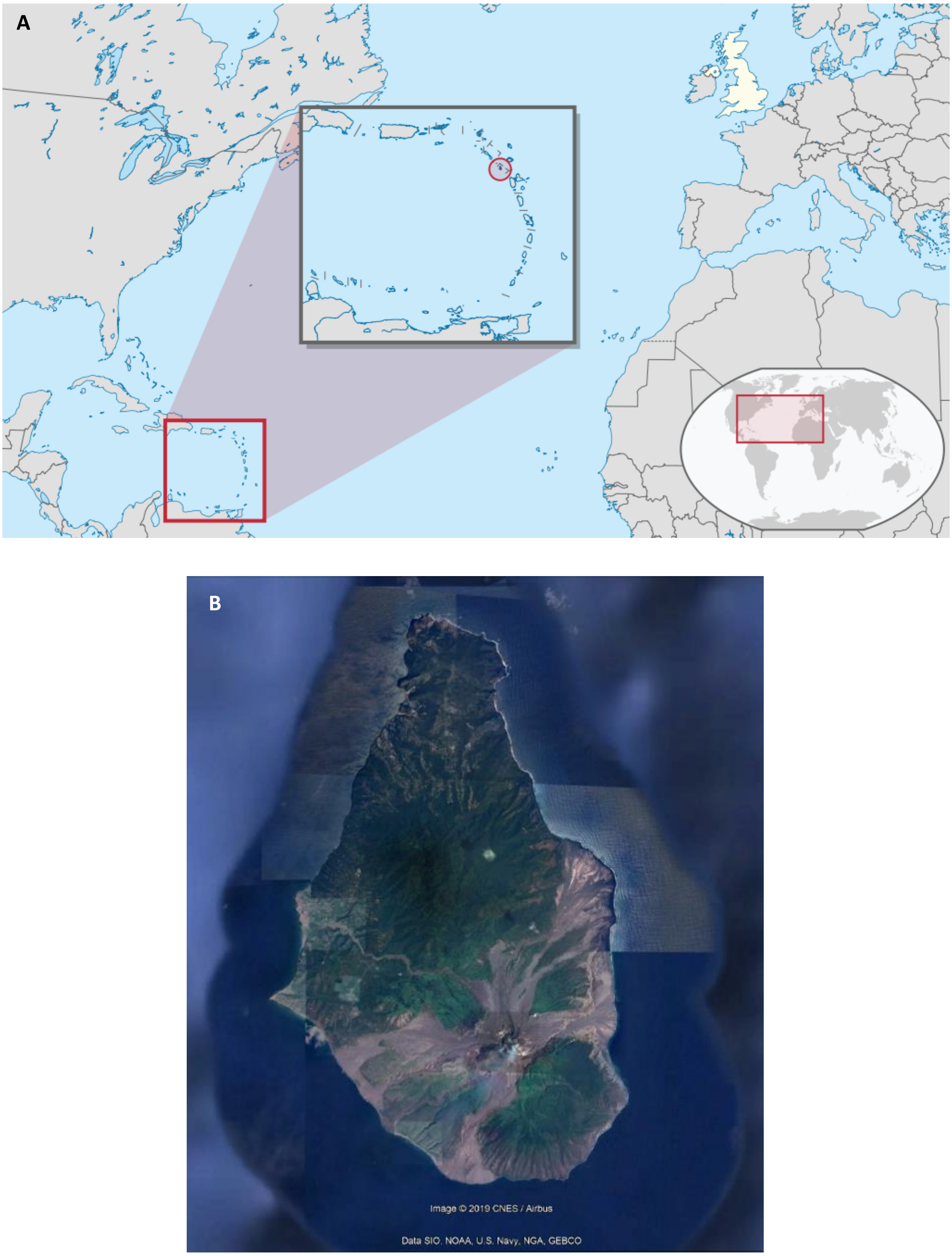


Figure 2. The island of Montserrat: (A) Relative location of Montserrat on the map of the world (Wikicommons); (B) Satellite view of Montserrat (Google Earth).

### 1.5.2 Habitat

*Cyrtopholis femoralis* is widespread and abundant across Montserrat (Rosa et al., 2013), inhabiting both areas of natural vegetation and highly disturbed land such as urban gardens and agricultural land (Fig. 3) (G. Garcia, pers. obs.). As an obligate burrowing species, the main habitat prerequisite can be expected to be suitable substrate for the construction of terrestrial burrows. Males may be found away from burrows, as these wander large distances in search of females, and as such these individuals may also transiently inhabit less suitable areas (G. Garcia, pers. obs.). No formal studies of *C. femoralis* habitat preferences have taken place, such studies will be necessary to develop a conservation assessment of this species (see section 2.8).


Figure 3. *Cyrtopholis femoralis* habitat in Montserrat: (A) Primary forest in Central Hills National Park (G. Garcia); (B) arid hills altered by grazing of feral goats (G. Garcia); (C) banana plantation (G. Garcia); (D) gardens in residential areas (Montserrat Botanical Gardens, magicmontsserat.blogspot.com).

### 1.5.3 Population

*Cyrtopholis femoralis* has been anecdotally reported to be abundant and widespread across Montserrat (G. Garcia, pers. obs.; Rosa et al., 2013). No formal studies of *C. femoralis* population demographics have taken place, such studies will be necessary to develop a conservation assessment of this species (see section 2.8).

It has been suggested that *Cyrtopholis femoralis* may exhibit some level of coloniality (G. Garcia, pers. obs.). Observations of *C. femoralis* in the wild have found that up to 100 burrows can often be found in close association with one another (entrances <30cm apart) (Fig. 4). To date, recorded aggregations of burrows have only ever been found to contain juvenile individuals (G. Garcia, pers. obs.), suggesting that members of the same brood, or a series of broods may form natural colonies. In such a case, aggregations may be due to limited dispersal of recently hatched young around their maternal source (where the founder female(s) may no longer be present). It also indicates that younger individuals, although also solitary, may be more tolerant of closer physical association than adults. It can be speculated that older individuals have a comparably larger area of influence around their burrow, for example expanding their zone of prey capture as body size increases (alongside expansion of the burrow). Here, intra-specific predation may also be a key factor in the development of colonies, with larger individuals increasingly preying on smaller conspecifics nearby. Several outside factors may also lead to attrition in the number of surviving individuals from a given brood, and/or in a given colony, such as predators and parasites, as well as climatic factors such a drought.

Figure 4. Multiple *Cyrtopholis femoralis* burrows (arrows) beneath a small plantation of bananas in Montserrat Botanical Gardens (G. Garcia).

### 1.5.4 Threats to wild population

**Volcanic activity:**

The Soufrière Hills Volcano, located in the south of the island, began its first historic eruption for 350 years on 18 July 1995 with a series of steam and gas explosions. Lava extrusion later commenced in November 1995. Following a series of short-term evacuations, a state of emergency was declared in April 1996. The capital Plymouth was abandoned along with all other communities located in the southern two-thirds of the island. In June 1997, a small dome collapse generated widespread pyroclastic flows to the north of the dome that killed 19 people in the village of Streatham. Pyroclastic flows from the same event also reached the W.H. Bramble airport to the NE of the dome, resulting in its permanent closure (Kokelaar, 2002).

Between 1995 and 2010 there were five phases of volcanic activity lasting up to 3 years separated by periods of little or no activity of up to 2 years. Activity during these phases has included the repeated growth and collapse of a lava dome and associated pyroclastic flows, more than 100 large volcanic explosions and frequent ash falls, some of which affected areas in the Centre Hills and even some parts on the north of the island. The last activity occurred in February 2010, when a major dome collapse impacted 11 $km^2$ to the north and northeast of the volcano, including the Farm River Valley and Fairy Walk in the Central Hills. Pyroclastic flow deposits also added 1 $km^2$ of new land to the eastern coastline between Trant's Bay and Spanish Point (Cole et al., 2010; Stinton et al., 2014a; Stinton, et al., 2014b). Since the collapse in 2010, there has been no evidence of further dome growth and volcanic activity appears to remain at a minimal level. However, an assessment issued in 2012 by the UK Scientific Advisory Committee on Montserrat Volcanic Activity, indicated that the balance of probability is that the volcanic activity is paused, as it has done on previous occasions since the start of the crisis, rather than ceased; whereby the continuing venting of gases indicates a high probability that there will be renewed lava extrusion in the medium future. At present, nearly 60% of Montserrat's land area is within the exclusion zone (Scientific advisory Committee on Montserrat Volcanic activity, 2018).

There is little data on habitat loss or habitat regeneration of the areas affected by the volcano since 1995. There was substantial defoliation after major ash falls, but this was followed by a rapid recovery (within weeks to a few months), and there was also some acid rain and ash damage during periods of chronic ash fall (C. Fenton pers. comms.). Research indicates large but ephemeral effects of ash fall on canopy insects, with some suggestion that ground-dwelling insects were more seriously impacted (Marske et al., 2007) but recovery again appeared to be rapid. The assessment of Marke et al. (2007) however used sampling sites in the Central Hills, which in general were not as severely impacted as other more southerly parts of the island, much of which was devastated on one or more occasions, as outlined above. Also, their study did not focus on litter-dwelling or subterranean burrowing species such as *Cyrtopholis femoralis,* where potentially any build up of ash deposits may have led to substantial losses, through blocking of burrows, lack of food sources etc. In the short-term the negative affects of the repeated volcanic activity to our focal species in more severely affected areas are likely to have been similarly devastating to much of their population as known for many other better studied fauna. For various species, even with good recovery in some peripheral areas, there were consequent longer-term knock-on effects on some vertebrate consumers. Pederson et al. (2012) documented dramatic decreases in bat populations and increases in several sublethal pathologies associated with accumulation of ash. Equally, Dalsgaard et al. (2007) showed that most bird populations in the Centre Hills were negatively affected by ongoing volcanic events in the short term with notable declines in terrestrially foraging bird species, but these were not strongly impacted in long term with good recovery, and they did not discuss any notable knock-on effects. However, organism such as bats, birds, and the winged insects often found in the canopy are unlikely to be surrogates for understanding the impact of volcanism on terrestrial burrowing spiders. As well as difference in body size, lifestyle, etc., there is also likely a conspicuous difference in dispersal abilities. Winged individuals of many of the aforementioned groups may be able to flee from rapidly changing environmental conditions, but also have a greater ability to recolonize areas later, even if initially that is only patchy residual habitat. Overall, it seems highly likely that the complete loss of large swathes of habitat in the south of Montserrat resulted in the regional extirpation of *C. femoralis* in these areas, but direct data on both losses as well as both shorter- and longer-term impacts of more ephemeral volcanic events (ash falls) in peripheral areas do not exist.

**Invasive species:**

Several species of invasive alien mammal occur on Montserrat, including rats (two species), chickens, pigs, goats, domestic cats, dogs, cows, and donkeys. Rats are among the most damaging invasive species to many components of native fauna, where the multiple impacts of rats (*Rattus norvegicus* and *R. rattus*) on island ecosystems have been described in many publications (Atkinson 1985; Atkinson & Atkinson 2000; Towns et al. 2006; Global Invasive Species Database, 2018). As abundant, opportunist omnivores, rats predate many native invertebrates and smaller vertebrates, and have driven declines and extinctions of numerous species through processes such as competition, predation and modifying habitats. Among invertebrate communities, larger terrestrial species such as *Cyrtopholis femoralis* are plausibly among the most seriously impacted by invasive rodent predation, potentially leading to populations being suppressed by several order of magnitude compared to natural levels (St Clair et al., 2011). That said on Montserrat, the negative effect of rats on *Cyrtopholis femoralis* may not be as extreme as found with some other large terrestrial invertebrates on other islands. This is because in addition to both a defensive bite and presence of urticating hairs (see section 1.3), our focal theraphosids are typically found in obligate burrows, which likely offer them notable protection. Furthermore, it is believed that some species on tropical islands where land crabs are native tend to suffer fewer impacts from the introduction of rats, because land crabs are ecologically rather similar predators to rats (Atkinson, 1985).

European settlers brought brown rats (*Rattus norvegicus*) and black rats (*Rattus rattus*) to Montserrat. Black rats reached the Caribbean as early as the beginning of the seventeenth century, with brown rats perhaps two centuries later (Varnham, 2010). Both species of rats are currently very abundant in Montserrat's Central Hills forests. Snap-trapping data indicates that, in the forest, black rats are somewhat more abundant than brown rats, although both are present throughout. In general, in the Central Hills, black rats are more abundant at higher altitudes, and are more arboreal, than brown rats. Both species' population levels at this site appear to be linked to the local abundance of large fruit trees and clearings (Young, 2007). Rats, probably mainly brown rats, are also abundant in the settled lowland areas of Montserrat. Although as said above, burrows may offer protection for many individuals of *Cyrtopholis femoralis* from direct predation by both species of rats, this does not apply to the recently hatched dispersing young, nor adult males (See section 1.8), where any negative affect of predation by rats in particular should be studied, as well as general aspects about competition for shared prey resources, notably other terrestrial invertebrates. Equally, introduced chickens, also likely present since the earliest European settlers, may to the same degree negatively affect populations of *Cyrtopholis femoralis* through these same routes, again in particular through direct predation of exposed individual spiders (most notably dispersing young or adult males as for rats) as well as indirect competition for some prey resources.

Since the late nineties, feral pigs (*Sus scrofa*) have spread rapidly through Montserrat's Central Hills forest following the release of domestic pigs from farms evacuated in the wake of the volcanic crisis. The main source of invasion is thought to have been from the Harris area to the southeast of the Central Hills (J. Daley pers. comms.), and consequently the invasion has spread progressively from the southeast of the hills. Pigs were first noted as a substantial presence in the Central Hills forests during 2001 (Buley, 2001) and there is no evidence of a feral pig population in Montserrat prior to the volcanic crisis. In the following years they spread rapidly through most of the forest, but substantial control efforts by local forest rangers in 2004, together with a project led by the RSPB from 2009 to 2013, has led the population of feral pigs in the Central Hills to be greatly reduced. As invasives, pigs can have a major impact on some island tropical forests. Like rats, they are opportunistic omnivores, and can cause declines and extinctions in other terrestrial fauna through predation (Cruz et al., 2005). There is little specific scientific information regarding their effects on terrestrial invertebrates. In some island forests, especially Hawaii, feral pigs have had profound impacts on the vegetation structure of the forest itself, through soil-rooting. As such they may greatly disrupt females and juveniles of *Cyrtopholis femoralis* by digging up burrows, and consuming any they expose. Feral pigs also consume seedlings of vegetation which may expose remaining burrows to excessive heat in the day though increased sunlight, as well as alter the local prey abundances by affecting vegetation changes, and through spreading propagules of invasive plants (Global Invasive Species Database, 2018), such as guava (*Psidium guajava*) which may conversely provide excess shade, etc.

In Montserrat, goats (*Capra hircus*) and cattle (*Bos taurus*) are also encountered in the Central Hills forests. As with pigs, cattle were released to fend for themselves when people were evacuated from the south of the island in 1995 and their population has grown significantly over time (S. Mendes pers. comms.). Goats meanwhile have had free roaming populations for years prior to 1995 (S. Mendes pers. comms.). When introduced to islands, these two species can affect forest structure and native plant communities through their grazing and browsing, with knock-on effects for native animals(Atkinson & Atkinson, 2000; Campbell & Donlan, 2005; Desender et al., 1998; Global Invasive Species Database, 2018), specifically for *Cyrtopholis femoralis* as outlined above for feral pigs.

There is almost certainly a feral cat (*Felis catus*) population in Montserrat, although this has not been confirmed by formal study, and anecdotal information rarely distinguishes between detections of wandering domestic cats and true feral animals. The distribution, population density and ecology of the feral population is not known. Feral cats are devastating invasive species on many islands, through predation. Mammals and birds are most commonly affected (Global Invasive Species Database, 2018). In some circumstances, feral cat predation on introduced rats may be beneficial to native island ecosystems by reducing rat impacts (Courchamp et al., 2003). Little research has been done to investigate the impact of feral cats on terrestrial invertebrates such as *Cyrtopholis femoralis,* It is plausible that any cats on the island act as both a direct predator, possibly most important to negatively affect survival of exposed 'wandering' males of *Cyrtopholis femoralis,*, but also conversely cats may also act as a helpful control against other potential predators, birds, rats etc.

The agouti (*Dasyprocta antillensis*) was probably introduced by early human settlers' as a food source at some time before the arrival of Europeans, and is now widespread through forested areas of Montserrat (Young, 2007). Agoutis, like the more recently introduced red-footed tortoises (*Geochelone carbonia*) are not thought to impact native wildlife significantly and are not considered invasive.

The common green iguana (*Iguana iguana*) has been introduced to or has otherwise invaded almost all the Lesser Antillean islands in the last decade and is highly invasive (e.g. Falcón et al., 2013; Haakonsson, 2016; Vuillaume et al., 2015). Montserrat also harbors a native genetically distinct iguana, but which is not readily distinguishable from the invasive, common green iguana of American mainland decent (Stephen et al., 2013). A stark green iguana population increase has been reported from Montserrat in 2017 (S. Mendes, pers. comms.), suggesting an invasion of the non-native common green iguana, which possesses a much higher reproductive potential than any native island forms. Invasive green iguanas are known to be able to alter habitats drastically and catastrophically through overgrazing of seedlings, shrubs and trees (Haakonsson 2016; F. Burton, pers. comms.; M. Goetz, pers. comms.) Therefore, various Iguana and other such large lizards, like several mammals are likely able to affect overall vegetation structures and food sources of *Cyrtopholis femoralis*, but also equally juvenile Iguana may also act as direct predators to exposed individuals of the focal spider, particularly dispersing young.

Cane toads (*Rhinella marina*) have been introduced to Montserrat and are now widespread and common throughout the island. In the Central Hills forests, they appear to be highly clustered around watercourses, rather than dispersed throughout. 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 (Global Invasive Species Database, 2018). As such, the cane toad is potentially an important predator of *Cyrtopholis femoralis*.

The possible effect of other potential non-vertebrate introduced predators or parasites is unknown, but in particular effects of scorpions or parasitic wasps should be considered for their influence.

**Built development:**

Human development can result in the loss and degradation of *Cyrtopholis femoralis* habitat, the introduction of invasive alien predators (cats and dogs) and possibly chemical contaminants. Again, at present, there are no data to indicate whether such impacts are occurring on Montserrat although the boundary of the Central Hills Reserve seems likely to be an area of high sensitivity in this regard. Substantial movement of the human populace on the island occurred in response to the volcanic activity, with increased development of many coastal regions towards the habitable northern part of the islands, which has likely destroyed or at least altered much previous habitat in this zone. Montserrat's national GIS (housed at the Physical Planning Unit, PPU) may be able to provide a mechanism for monitoring such pressures, both from the recent past and in the future.

### 1.5.5 Conservation status

*Cyrtopholis femoralis* has not been assessed by the IUCN and is not subject to protection my any specific national or international law. Gathering data to inform IUCN assessment should be made a priority in all research on *C. femoralis* following a taxonomic review of the species (see section 2.8). Recently, several Mexican and Central American tarantulas with similar ecology to *Cyrtopholis femoralis* have been formally assessed, three of which were placed into the Endangered category (Fukushima et al. 2019). Notably, each of these three had either a slightly or dramatically greater Area of Occupancy (AOO, with 2688, 2248 and 264 KM² for *Brachypelma schroederi*, *B. baumgarteni* and *B. boehmei* respectively) than possible for *Cyrtopholis femoralis* - even if occupied the entire island of Montserrat (at total island size is only 102 km²). Given the pronounced natural and human driven pressures on populations of *Cyrtopholis femoralis* (see section 1.5.4), many of which also influenced the aforementioned assessments, but also notably the additional pronounced effects of volcanism affecting about 60% of the island, we may anticipate *Cyrtopholis femoralis* may equally fall into at least the Endangered category, or even be considered Critically Endangered.

## 1.6 Diet and feeding behaviour

Like other theraphosids, *Cyrtopholis femoralis* likely feeds on a variety of invertebrates and also (although we expect less often) small vertebrates (Fig. 5). No formal studies have been carried out to assess the diet of the species in the wild and no published observations of predatory behaviour exist. Observations of *C. femoralis* in the wild suggest that the species is very shy and rarely ventures far beyond the burrow entrance (with the exception of males in the breeding season – see section 1.8.5). As such, *C. femoralis* is assumed to exhibit very passive "sit-and-wait" hunting behaviour, opportunistically catching prey items that wander close to the burrow entrance (G. Garcia, per. obs.).

As in other terrestrial tarantulas *Cyrtopholis* femoralis is assumed to respond to vibration in the ground/ the web surrounding the entrance to the burrow as prey approaches, moving to the burrow entrance. Once the prey is within range (*i.e.* within a few centimetres), the tarantula leaps forward with raised forelegs, pedipalps, chelicerae, and fangs, sinking fangs into the prey, injecting venom and digestive enzymes. Once killed prey is held in the pedipalps and fangs whilst eaten.

Figure 5. *Cyrtopholis femoralis* eating a introduced house gecko (likely *Hemidactylus mabouia)* on Montserrat (G. Garcia).

## 1.7 Reproduction

Reproduction in *Cyrtopholis femoralis* is typical for a theraphosid (T. Papp, pers. obs.). Reproduction begins with complex courtship behaviour (see section 1.8.5) leading to insemination of the female. Successful insemination is followed by egg laying within an egg sac.

### 1.7.1 Developmental stages to sexual maturity

No long-term studies of *Cyrtopholis femoralis* life history have yet been completed; however, such investigation is currently underway within the captive population at Chester Zoo (see section 1.4). Following successful mating of a pair on 02/11/2015 spiderlings were found in the tank of the mother 8 months later (07/07/2016). Based on experience with other terrestrial tarantulas, eggs can be expected to be laid around 10 weeks after mating, development in the egg stage taking 6-10 weeks. Remaining within the egg sac, larva hatch and remain immobile for a further 2-3 weeks. At the end of the larval stage the first shed occurs, individuals emerging as juveniles. After this first shed stage, the mother opens the egg sac, allowing 'spiderlings' to escape the maternal burrow (T. Papp, pers. obs.). This latter stage are capable of dispersal and self-sufficiency. There is no need for parental care, although the young may stay within the confines of the maternal burrow for several days or even weeks in the wild.

Once hatched, spiderlings will replace their exterior cuticle (i.e. shed their skin) at regular intervals, typically every few months until they reach approximately 15 mm total body length. Afterwards, they moulting intervals prolonged until maturity is reached after 5-6 years. Spiderlings have a leg span of 6-7 mm upon hatching, 12-15mm after the first year, and around 25mm after the second year (T. Papp, pers. obs.).

### 1.7.2 Age of sexual maturity

In *Cyrtopholis femoralis,* maturity is reached estimated after 5-6 years based on observations at Chester Zoo. After maturity is reached males survive another 1-1.5 years (until the first shed), whilst females continue to grow, shedding roughly once a year and surviving for a further 5-6 years (T. Papp, pers. obs.).

### 1.7.3 Seasonality of cycling

No details of seasonality for *Cyrtopholis femoralis* are known.

### 1.7.4 Clutch size

No wild data for *Cyrtopholis femoralis* clutches exists. Observations in captivity found a single egg sac to contain around 220 eggs (T. Papp, pers. obs.).

## 1.8 Behaviour

### 1.8.1 Activity

*Cyrtopholis femoralis* has a cryptic ecology, individuals spending most of their lives in terrestrial burrows (Fig. 6). Burrows consist of a 5-20cm tunnel at a 45-90$^{o}$ angle to the ground surface and a roughly oval chamber, 10-15cm long and around 5cm wide (G. Garcia, pers. obs.).

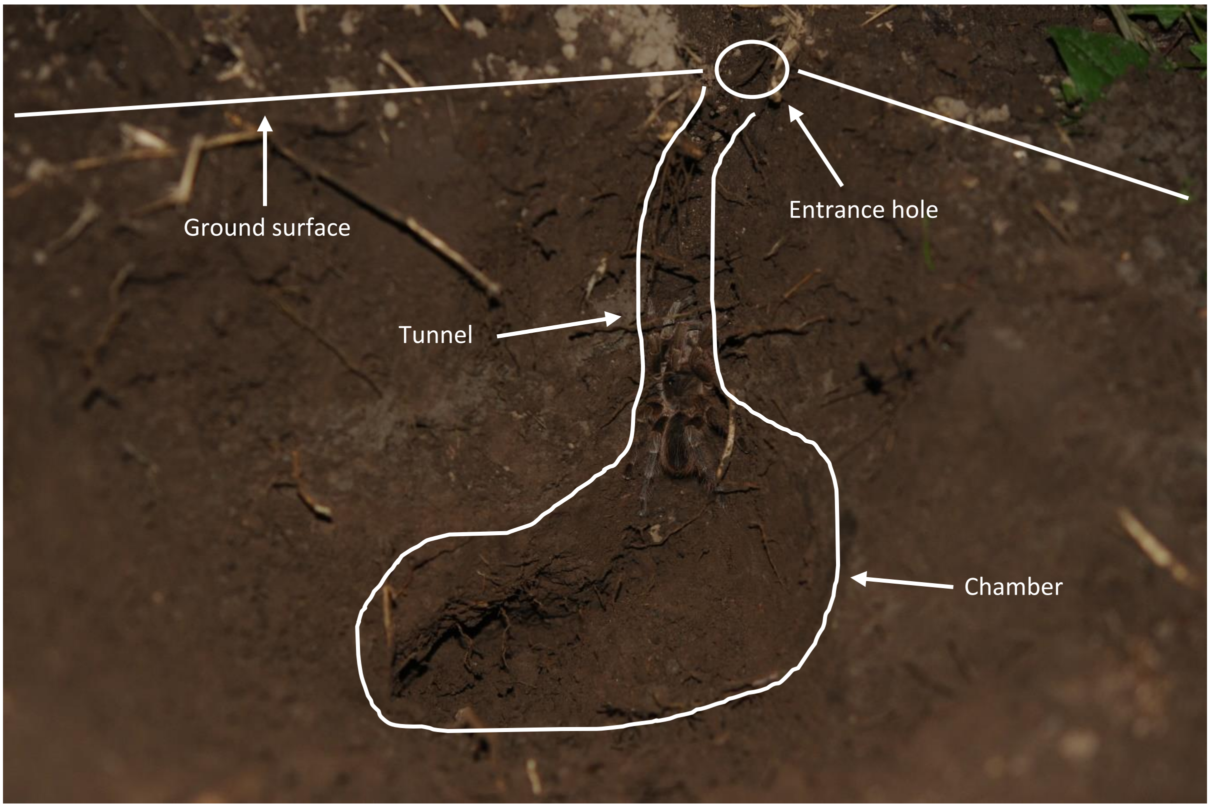


Figure 6. Schematic of a *Cyrtopholis femoralis* subterranean burrow after excavation.

### 1.8.2 Locomotion

Adult *Cyrtopholis femoralis* spend the majority of their lives in subterranean burrows of soil/ leaf litter, or waiting near the entrance to ambush prey. Males can often be found walking along the ground potentially traveling large distances to find females (further research is required to confirm this is the case, see section 2.8) (G. Garcia, pers. obs.; Rosa et al., 2013)

### 1.8.3 Predation

*Leptodactylus fallax* have been observed feeding on *Cyrtopholis femoralis* in the wild, and are potentially a major predator of this species (Rosa et al., 2013). *L. fallax* capture *C. femoralis* by either a sit-and-wait ambush technique or by active pursuit. When actively pursued *C. femoralis* will exhibit defensive behaviour, raising pedipalps and the anterior pairs of legs in a threat display (Petrunkevitch, 1926; Rosa et al., 2013). A number of invasive introduced species on Montserrat are also potential predators of *C. femoralis* (see section 1.5.4).

### 1.8.4 Vocalisation

Observations from captivity have shown male *Cyrtopholis femoralis* to loudly tap the substrate and the walls of enclosures with their front legs as part of the mating process, females will often reply in kind (see section 1.8.5). This process involves rapid burst of several taps.

### 1.8.5 Sexual behaviour

Courtship and mating  behaviour in *Cyrtopholis femoralis* is the same as in most other terrestrial tarantulas (T. Papp, pers. obs.), such as that described by Minch (1979):

- **Sperm induction:** Before insemination can occur, male spiders must charge their palpal bulbs with sperm previously deposited onto a specialised web (the 'sperm web') from the gonopore on the ventral surface of the abdomen. The male constructs the sperm web (usually around the size of the abdomen and cephalothorax combined), between two fixed surfaces of different angles, often slightly further apart than the tarantula's width, deposits sperm on the upperside, and then assumes an upright position over the web. Prior to induction the male moistens his palps for around 10 minutes, before extending them down and under the edge of the web where he dips them into the semen alternately and rapidly . This process may continue for between 20 minutes and an hour and a half. Males will often destroy the web after sperm induction is complete. Web building and sperm induction may take place several times prior to mating.
- **Locating a mate:** Following sperm induction males will leave their burrows and begin wandering in search of a mate. Males appear to locate burrows by the presence of surrounding strands of silk, which may extent over a meter from the burrow mouth. These silk remnants can contain traces of deposited pheromones that may indicate aspects about the status of their source, e.g. the condition or reproductive status of the female. Once a burrow is located the male will begin a series of scratch like movements with the palps, leg vibrations and taps, or even jerking of the whole body near the burrow mouth (see section 1.8.5), at other times backing away and repeating. If successful, this may result in a reply from the female by a short series of heavy leg taps, and more importantly the emergence of the female from the burrow, or at least her exposure to the outer part of the burrow entrance.
- **Insemination:** Once physical contact is achieved between the male and female, the female may begin to expose her fangs in an apparently aggressive position. If the female remains quiet, the male may move his entire body rapidly up and down several times while slowly moving his palps alternately, or taps on the anterior part of her body with his front legs, or a combination of these acts. This causes the female to further assume the apparently aggressive position if she had not done so upon original contact, whereby the female may rear back more, opening the chelicerae wide and expose the fangs. Males never enter into insemination until this position is adopted by the female. In this species, the ventral portion of the males front leg tibiae is each equipped with a dual branched spur which he places onto the female's spread fangs to enclose them as the pair face each other. This allows the male to maintain the fangs at a safe distance from his body while further pushing the female back and up on her hind legs, exposing her genital area. At this time as well as during insemination some females resist by pushing against the male with their front legs and pedipalps. If the female gets free or manages to dislodge one of her fangs from the male's tibial spurs, the male at once withdraws, but approaches again and attempts to restrain the female. If successful from both parties, the female's body will notably arch backwards, which fully exposes her genital opening on the middle of the abdomen underside. The male may then initiate insemination with either palp, and males may switch initial palps in different inseminations. Mating usually proceeds with palp insertions alternating with 1-7 insertions per palp. Insemination lasts between 20 seconds and 5 minutes.

- **Post copulation.** After insemination is successful (or in event that he cannot insert), the male will begin to attempt to back away, keeping forelegs in contract with the female until the last moment as she relaxes down, then he will quickly turn and attempt to flee a safe distance, during which time he will appear especially nervous and react to any intervention. It may be advisable to restrain or enclose the female at the beginning of this final stage, to prevent her from aggressively attacking the male (but see below).

*Cyrtopholis femoralis* has been observed in captivity to be a relatively non-aggressive species compared to other terrestrial tarantulas. Females have never been seen to kill males after mating as in other species, following a successful mating one pair were observed to occupy the same tank without conflict for over 12 hours (T. Papp, pers. obs.).

Following mating *Cyrtopholis femoralis* lays its eggs after roughly 10 weeks. During this period, it can be advisable to increase the availability of food items and their diversity. After the eggs are laid into a sac like cocoon, the female may block the entrance to her burrow until the eggs hatch (T. Papp, per. obs.). During incubation, it can be advisable to prevent any disturbances to the female, such as movements of her enclosure, or even limit or avoid addition of food items.

# Section 2: Management in Zoos and Aquaria

## 2.1 Enclosure

Adult *Cyrtopholis femoralis* should be maintained in simple plastic invertebrate tanks typically around 40 x 20 x3 0cm (Fig. 7A). Tanks no shorter in high than this should be used to ensure sufficient substrate depth can be achieved, taller tanks can also be used.

For newly hatched juvenile *Cyrtopholis femoralis* small specimen tubes (25ml) should be used (Fig. 7B). After the first year, once juveniles have reached around 12-15mm in leg span, individuals should be moved to larger 50ml specimen tubes (Fig. 7C). Lids of these tubes should have air holes drilled in. After two years (around 25mm leg span), individuals should be moved to large plastic pots (roughly 10cm diameter, 20cm height).

### 2.1.1 Boundary

No specific boundaries are required.

### 2.1.2 Substrate

Given that *Cyrtopholis femoralis* is a habitual burrower, provision of suitable substrate is arguably the most important component of husbandry for the species. Substrate should be well compressed and packed within a tank to almost fill the entire tank. A minimum depth of 15cm is required for adults as burrows are typically this deep, however, deeper substrate depths of 30-40 cm are preferable as this ensures a layer of substrate remains below the burrow to allow drainage. In tubes and tubs used for growing juveniles substrate should be packed in similar proportions, filling 75-80% of the enclosure.


Figure 7. Enclosures for *Cyrtopholis femoralis* at different life stages: (A) Faunarium for adults (Exo Terra, Rolf C. Hagen (UK) Ltd., Castleford, UK); (B) 25ml specimen tube suitable for newly hatched individuals; (C) 50ml specimen tube suitable for juveniles of 12-15ml leg span; (D) Plastic pots used for two year old individuals (T. Jameson).

Substrate types should be selected that hold their shape to allow burrows to be constructed without the risk of collapse. Similarly, substrates with roughly neutral pHs are preferable to prevent any issues associated with excess acidity or alkalinity. Coir has been found to be an excellent substrate for *Cyrtopholis femoralis*, holding its shape well, allowing specimens to easily and safely construct their own burrows without risk of collapse. Furthermore, coir holds moisture well and is avoided by mites and other parasites and pests (T. Papp, pers. obs.). Either a 100% coir or a coir and sand mix should therefore be used.

### 2.1.3 Furnishings and maintenance

Minimal furnishings are required for *Cyrtopholis femoralis*. For adults a small water bowl should be provided, this should be small enough to not cause excessive flooding of the tank if spilt. Plastic bottle caps are suitable. A small cork tunnel can be provided buried in the substrate to provide the start to a burrow if desired. Some individuals will make use of this, whilst others will ignore it totally and dig a burrow from scratch (T. Papp, pers. obs.). No furnishings are necessary for juvenile enclosures.

The maintenance requirements of *Cyrtopholis femoralis* are minimal. For adults fresh water should always be available. Water bowls should be filled once per week and tanks lightly sprayed. Both adults and juveniles need only be fed once per week.

### 2.1.4 Environment

*Cyrtopholis femoralis* is a hardy species, tolerating and thriving in a wide range of environmental condition. Humidity in both adult and juvenile enclosures must be kept high, this can be achieved by light spraying once per week with tap or RO water. No specific heating or lighting fixtures are necessary, ambient temperatures between 18 and 30°C are suitable though temperatures between 20 and 27°C are preferable. Temperature and rainfall records from Montserrat (Fig. 8) can be used as a guide for environmental conditions in captivity.

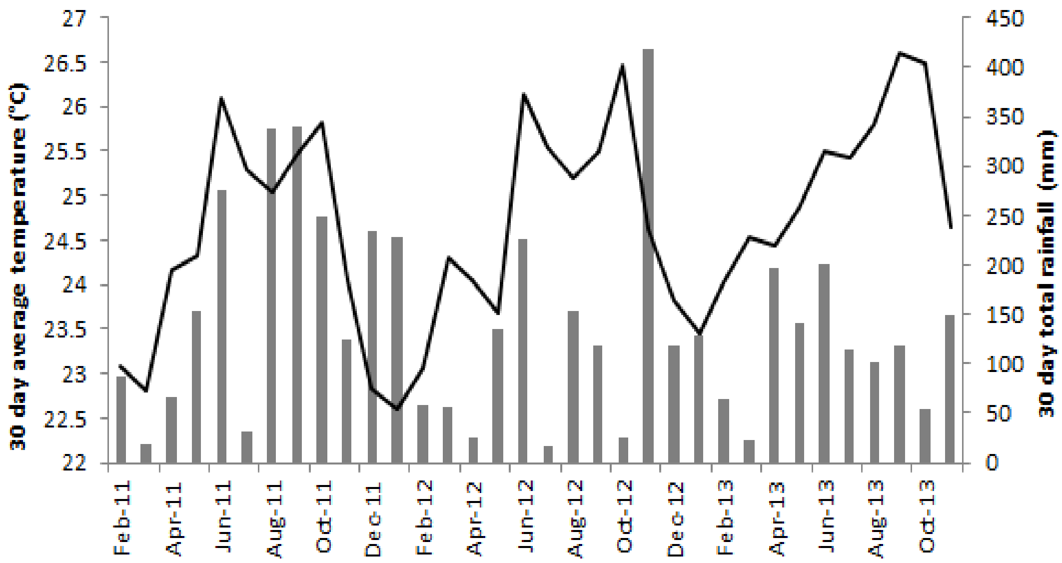


Figure 8. Monthly temperature estimates of 30-day mean temperature and 30-day accumulated rainfall averages for Sweet Water Ghaut, Montserrat. Black line represents temperature, and grey bars represent rainfall. From Hudson et al. (2019).

### 2.1.5 Dimensions

In selecting an appropriate enclosure for *Cyrtopholis femoralis* the key is to provide suitable dimensions to allow unimpeded construction of a burrow when filled with substrate. For adults minimum dimensions should be 40 x 20 x 30cm. Even deeper tanks may be preferable to ensure a sufficiently deep layer of substrate remains beneath the floor of the burrow for drainage. The same principle applies to juvenile enclosures (see section 2.1).

Single adult individuals of *Cyrtopholis femoralis* have been displayed at Chester Zoo. An attempt was made at keeping multiple specimens (0.0.5) in the same enclosure, but after roughly 3 months only 1 specimen remained alive, thought to be the result of conspecific predation. This did not improve their visibility to the public. The species is very secretive and hid within the darkest parts of the enclosure, which doesn't provide a positive viewing experience for the visitors. A tunnel attached to the viewing window was incorporated to try to address this issue, however the specimens would often choose not to occupy this space, and visitors shining lights here to try and get a better view is believed to have caused the animals stress. The spiders would also dig their own tunnels in more favourable areas of the exhibit, which meant viewing them at all was very difficult, and made the likelihood of escapes greater. To enhance the display, artefacts such as sampling equipment and notebooks with diagrams were stationed within the enclosure (Fig. 9).


Figure 9. Display of Montserrat tarantula at Chester Zoo (A) Section of the tunnel marked in white. (B) Sampling equipment and notebook with diagrams stationed inside the exhibit.

## 2.2 Feeding

### 2.2.1 Basic diet

A variety of invertebrates can be offered to *Cyrtopholis femoralis* including black crickets (*Gryllus bimaculatus*), brown crickets (*Gryllus assimilis*), and locusts (S*chistocerca gregaria*). As a general rule prey items should be smaller than the abdomen of the individual they are being fed to. Very small spiderlings/ juveniles can be fed on fruit flies (*Drosophila sp.*).

### 2.2.2 Special dietary requirements

Food items should be fed on a sufficiently nutritionally complete diet to ensure that they themselves are nutritionally complete. Food items should be fed on a diet of bran, oranges and lettuce and gut loaded 24 hours prior to feeding my adding nutrient supplements (e.g. Repashy calcium plus) to the diet.

### 2.2.3 Method of feeding

Individuals of all ages should be fed one live prey items once per week.

### 2.2.4 Water

Fresh clean water should always be available for adults. This should be provided in a small bowl, to be changed as required, but a minimum of once per week. Tap water is suitable; however, filtered RO water is preferable. Juveniles need not be provided with a water bowl but should have their tanks lightly sprayed to maintain high humidity levels once per week.

## 2.3 Social structure

### 2.3.1 Basic social structure

Although *Cyrtopholis femoralis* may exhibit some level of colonial behaviour in the wild (see section 1.5.3) it is recommended that individuals be kept is separate enclosures in captivity. Further work confirming the reality of colonial living in this species and the exact nature/ social structure of any such arrangement is necessary before such populations can be safely established in captivity (see section 2.6). In Chester Zoo a small number of *C. femoralis* were kept together in a public enclosure. All but one individual eventually died, though whether through intraspecific aggression, natural causes, or other means is unknown.

### 2.3.2 Changing group structure

Once hatched *Cyrtopholis femoralis* spiderlings should be removed from the maternal tank and placed within individual tubes (see section 2.1). Individuals should be kept separate except for in cases of breeding (see section 2.4).

### 2.3.3 Sharing enclosure with other species

*Cyrtopholis femoralis* should not be mixed with other species. Any species similar in size to *C. femoralis* or smaller are at risk of predation by *C. femoralis*, whilst larger species may predate *C. femoralis* and/ or disturb and collapse burrows. If disturbed *C. femoralis* may pose non-predatory risks to other species through bites and urticating bristles that may cause illness or death to other species.

## 2.4 Breeding

### 2.4.1 Mating

Details of mating in *Cyrtopholis femoralis* are given in section 1.8.5. When a male starts to display courtship behaviour (tapping) he should be removed from his own tank and placed in that of an adult female. If the male is unsuccessful in courting the female he should be removed from the tank as quickly as possible to prevent him being killed by the female. Similarly, if mating is successful the male should be removed from the tank as quickly as possible to prevent aggression. This said a male and female *Cyrtopholis femoralis* were left together overnight to mate at Chester Zoo and both were found uninjured the next morning (T. Papp, pers. obs.).

#### 2.4.2 Egg laying

Female *Cyrtopholis femoralis* will lay around 220 eggs enclosed in an egg sac within their burrows (see section 1.7).

### 2.4.3 Hormone induced reproduction

No assisted reproduction has been carried out or is necessary/ currently possible in *Cyrtopholis femoralis*.

### 2.4.4 Hatching

See section 1.7 for details of development and hatching of *Cyrtopholis femoralis*. Once hatched spiderlings should be removed from the maternal enclosure and separated into individual tubes as described in section 2.1.

### 2.4.5 Development and care of young

Details of care of juvenile *Cyrtopholis femoralis* are given in section 2.1.

### 2.4.6 Hand-rearing

N/A

### 2.4.7 Population management

No formalised EAZA breeding program (e.g. ESB or EEP) exists for *Cyrtopholis femoralis*. The species is only kept at one collection (Chester Zoo) and is managed as a group, however, individuals are kept separately, so control of breeding and parentage is possible. Only one breeding event has occur and the parentage of all these offspring is known. It would therefore be possible to convert the current situation into a breeding program and studbook if necessary.

## 2.5 Behavioural enrichment

No specific behavioural enrichment is required beyond provisioning of suitable substrate and food items (see section 2.1.2 and 2.2).

## 2.6 Handling

### 2.6.1 Individual identification and sexing

No individual identification is currently used for *Cyrtopholis femoralis* in captivity beyond keeping individual separately and marking their enclosures with individual identifier. Marking theraphosids is particularly difficult as any external markings will be lost with regular moults (Reichling & Tabaka, 2001). A technique for a permanent internal marking of theraphosids using Passive Integrated Transponders (PIT tags) has been developed by Reichling & Tabaka (2001):

"We used the Trovanw (Grossbuilesheimer, Str. 56, Euskirchen 16, Germany) reader (Model LID 500) and transponders in all trials. The location for implantation of the transponder was on the dorsolateral aspect of the opisthosoma in an area between the heart and the intestinal tract (Fig. 9). Tarantulas were restrained by hand during the procedure. A 20-gauge hypodermic needle was used to scrape the setae from a 1.5 x 1.5 mm area of the opisthosoma, and swabbed with a 10% povidone-iodine solution. The sterile needle was used to cut the exoskeleton. The sharp apical edge of the needle was used like a scalpel rather than creating a puncture wound. The transponder was inserted into the opisthoma with sterile mosquito forceps. The surgical site was then swabbed dry and several drops of n-butyl cyanoacrylate adhesive glue (Vetabondw, 3M Animal Care Products, St. Paul, Minnesota) were used to close the wound."

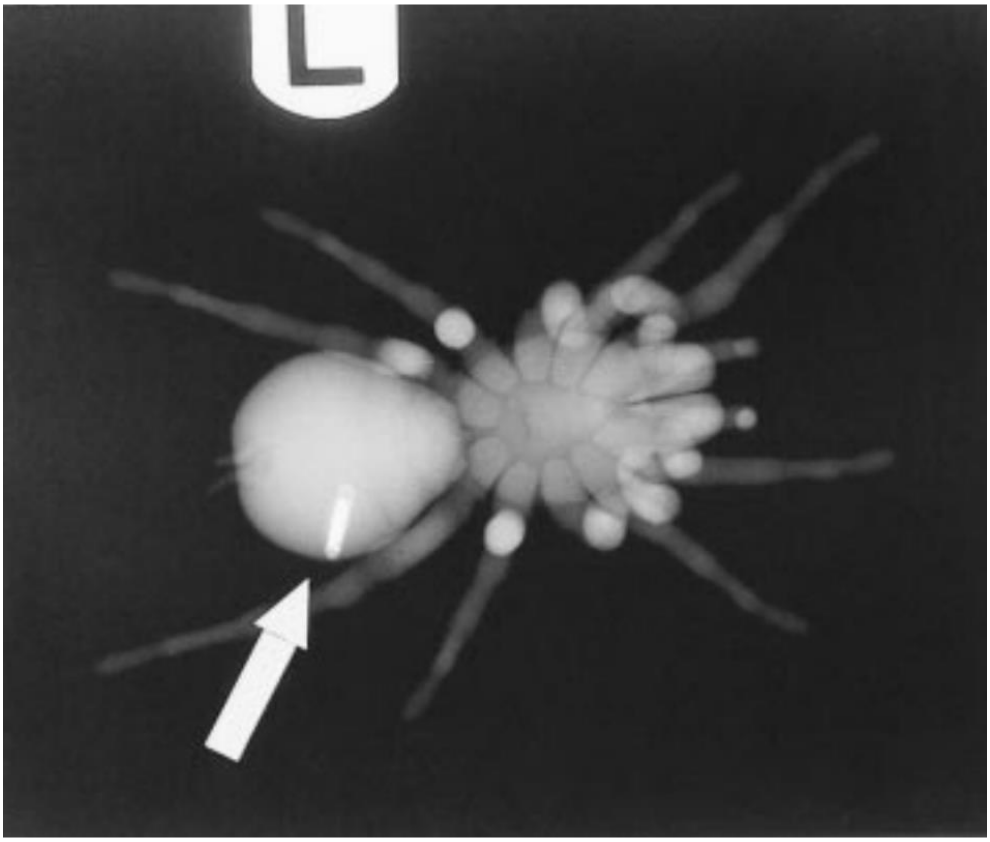

Figure 9. Radiograph showing Passive Intergrated Transponder (arrow) implanted in *Grammastola pulchra*. From Reichling & Tabaka (2001).

Though spiders that were not anaesthetised were not found to be adversely affected Reichling & Tabaka (2001) also trialled anaesthesia for this technique:

“Spiders were immobilized with isoflurane (Iso-thesiay, Abbott Laboratories, North Chicago, Illinois). A cottonball was soaked in the aesthetic agent and placed in a small plastic container away from the spider. The effect of the anaesthetic was monitored by leg movement. As the spiders became anesthetised the legs contracted followed by relaxation.”

All spider with implants successfully completed ecdysis within 3-7 months of the procedure, with no external evidence of the implant after moulting (Reichling & Tabaka, 2001).

This technique was found to be very effective for identifying individuals, allowing positive individual IDs of individuals even when in burrows up to 16cm underground (Reichling & Tabaka, 2001). This technique offers a potentially very effective method for individual identification of *Cyrtopholis femoralis.*

As with other theraphosids *Cyrtopholis femoralis* can be most reliably sexed through examination of the exuvia (moult). Female exuvia will include spermathecae, whilst this structure will be absent in males (Fig. 10). Spermathecae are particularly obvious in *C. femoralis*, a dark brown contrasting with the pale shades of the rest of the moult (Fig. 10). Newly hatched spiderlings cannot be sexed; sexing can only take place once slightly grown on after few moults, once the female genital structures develop. *C. femoralis* can be sexed by examination of exuvia as follows:

1. A moult is required with the abdomen flesh containing the book lungs intact. Fresh moults are preferable.
2. The moult must be softened to make it more pliable. Either soak the moult in a shallow disk of warm water with a drop of soap for a minute, or spray the moult with several squirts of warm water and wait for a minute, or several minutes if was previously dried.
3. Once the moult is softened, carefully place it on a piece of paper towelling to absorb excess moisture.
4. Move the moult to a contrasting surface (e.g. white foam board or plate). Position the moult so that it lies on the dorsal surface, fangs facing upwards.
5. Carefully and slowly, spread out the limbs and unfurl the abdominal skin using cotton swaps and toothpicks so that the inside of the abdomen is visible. Pin the moult in place if necessary.
6. Identify the epigastric furrow between the anterior book lungs and look for a pronounced “flap” above it (the uterus externus and spermatheca) (Fig. 10). The smaller the specimen the more difficult this area will be to see.


Figure 10. Exuvia of female *Cyrtopholis femoralis*. (A) Dorsal and interior view of female *C. femoralis* exuvia, arrow shows the uterus externus, behind which are the spermathecae. (B) Close up interior view of female *C. femoralis* exuvia, showing the inside of the lower abdomen. Arrow as in (A), *= anterior book lungs, #= posterior book lungs (T. Jameson).

### 2.6.2 General handling

Theraphosids should never be directly handled unless absolutely necessary, this is to prevent damage to specimens and eliminate any risk of injury to the handler. Any movement and manipulation of *Cyrtopholis femoralis* outside of its enclosure should involve placing specimens in smaller plastic boxes. It may be necessary to encourage/ push specimens into boxes by applying light pressure with a long tool such as forceps, where gently touching the lower rear legs may prove most effective. However, caution must be taken as this may initially lead to the spider using the hind legs to quickly brush off urticating hairs from the dorsal abdomen in a defensive response. To prevent problems from skin and eye irritation, any exposed skin should be covered including use of gloves, and eye protection (such as safety glasses) is recommended.

### 2.6.3 Catching/restraining

See section 2.6.2.

### 2.6.4 Transportation

For long-distance transportation of *Cyrtopholis femoralis* the following steps should be taken:

1. *Cyrtopholis femoralis* specimens should be placed in plastic cups, one individual per cup. Before adding any specimen, each cup can be partly lined with a thin layer of some dry paper towel, which the animal can brace itself, once added. A sponge like substance can also be used if glued to the interior of the cup beforehand, and the glue given time to dry well.
2. Dry paper towel should be lightly stuffed into the cup, taking care to leave a little space for the specimen at the bottom, but with enough additional paper added at this stage to partly restrict the spider movement and stop it from being unduly bounced inside the container, and a lid then attached. Several small holes should be made in each lid beforehand.
3. Multiple plastic cups should be placed together in a larger plastic container, itself padded with paper towel or similar.
1. The plastic container should itself be placed in a larger wooden crate surrounded by padding. A wooden IATA compliant crate (1cm thick, 52cm wide by 40cm deep by 42cm high) with an inner polystyrene box (2cm thick) is sufficient (IATA, 2015).
4. This crate can then be sealed ready for transport. During this stage it should be stored at a temperature, ideally in a quiet and shaded place away from strong light or heat.

### 2.6.5 Safety

*Cyrtopholis femoralis* are fanged and have the potential to bite. They also possess urticating hairs, which can irritate the skin in the short-term, or cause longer-term damage to eyes. It is recommended that the handling procedure outlined in section 2.6.2 be followed to eliminate this risk.

## 2.7 Veterinary: Considerations for health and welfare

No specific health issues are known for *Cyrtopholis femoralis*. Common health conditions of theraphosids, their treatments, and general veterinary procedures have been reviewed by Pellett et al. (2015) and are summarised below:

#### 2.7.1 Diagnostic approach

- **Examination:** Health issues are usually identified from changes in behaviour with reluctance to move, abnormal posture, and anorexia all common signs of a health problem. Spiders should be examined from all sides in a small clear-walled container, checking for masses, ectoparasites, wounds, fungal infections (usually visualised at the opening of the book lungs), and dehydration.

- **Imagining techniques**: Ultrasonography may be of value in detecting large endoparasitic acrocerid larvae in the opisthasoma and endoscopy is beneficial in providing magnification when examining oral discharges.

- **Cultures:** Bacterial and fungal cultures can be performed on oral, anal, and lesion discharges. Faecal analysis may be useful to identify protozoans and gregarines.

- **Blood (haemolymph) smears**: Interpretation of this technique is still in its infancy, with differences in opinion on nomenclature of cell types. Haemolymph can be sampled using a 30 gauge insulin needle and syringe, collecting from the dorsal midline of the opisthosoma. After sampling, place a small amount of tissue adhesive onto the cuticle to prevent haemorrhage. An alternative method for sampling is by inserting the needle into the ventral area of the joint membrane of a limb.

- **Post-mortems:** Post-mortems must be carried out soon after death/ euthanasia due to the rapid breakdown of the gut. Post-mortem examination combined with histology can be used to visualise melanised inflammatory nodules, which are a typical inflammatory response by arthropods due to trauma and infection. Cytology (stained and unstained) can provide useful information for identifying bacterial, fungal and protozoal infections.

### 2.7.2 Common conditions

- **Alopecia:** Excessive stimuli may cause a theraphosid to kick off irritating (urticating) hairs. Hair loss can be seen on the dorsal and caudal aspect of the opisthosoma. In captivity this often indicates environmental stress. The hairs will not regrow but will be replaced after the moult. Treatment is not required but husbandry issues leading to hair loss must be addressed**.**

- **Dysecdysis:** Tarantulas in dorsal recumbency are normally undergoing ecdysis (normal moulting) and are very susceptible to trauma. Dysecdysis (abnormal or difficulty moulting) is a common presentation in theraphosids and optimum husbandry with the provision of good nutrition and hydration is important in order to minimise this. Assisting with the removal of the old cuticle must be avoided as pulling this will result in tearing of the new fragile cuticle underneath. The new cuticle is initially soft to enable body expansion and then will harden over a few hours to a few days. If limbs are trapped in the old cuticle it is better to wait until the new cuticle has hardened. Attempts then can be made to gently remove old cuticle using surfactants such as household detergent and water, taking care to avoid the book lungs which are situated on the ventral surface of the abdomen. Old cuticle can also be removed with fine scissors but in extreme cases autotomy of affected limbs may be an option, followed by the application of tissue glue adhesive at the site to prevent leakage of haemolymph. Autotomy can be induced by grasping the femur segment of the limb. Autotomy is usually performed by pulling the femur rapidly upwards, although the spider may shed the limb itself while the leg is being held. Regeneration of the limb will take place and it will return to normal size within the following two to three moults

- **Trauma:** Physical trauma and loss of haemolymph is serious in theraphosids. If a fall does occur then immediate first aid is essential. If the wound is not too big then it can be dried using pure talcum powder (with no added perfume or other additive), or it can be sealed with tissue glue. Limbs can be injured easily, for example, terrestrial theraphosids have fine hairs on their feet and these can catch on clothing fibres. This may result in autotomy or damage to the limb with loss of haemolymph from the joints. If this occurs, the limb should be removed at the joint. It is advisable to keep the tarantula on a paper towel substrate afterwards for 24-48 hours to monitor for any continued leakage of haemolymph. This should be visible on paper towel but would be missed on normal substrate as it is pale. Theraphosids may need to be treated for dehydration dependent on the volume of haemolymph lost.

- **Endoparasites:**
    - **Acrocerid (spider-fly) larvae:** Presence of acrocerid larvae can be confirmed by ultrasonography. No treatment is available. Larvae are deposited on the spider's body, crawl to the book lungs and penetrate the opisthosoma between the lamellae. Larvae may be present for months to even years. The mature fourth instar is the destructive feeding stage, consuming tissues and bursting out of the dorsal opisthosoma to pupate.
    - **Mermithid nematodes:** This infection may remain asymptomatic for years. Clinical signs include an enlarged asymmetrical opisthosoma, malformation of palps and shorter legs. Absence or poor development of male secondary sexual characteristics is also seen. Treatment is not available.

- **Oral nematodes:** Panagrolamid nematodes observed within the mouthparts of some theraposid species are an important disease of the group. The spider presents initially with lethargy, anorexia and a change in posture. White discharge can also be seen between the mouth and chelicerae during the later stages of infection. If infection is suspected the mouth can be flushed with physiological saline under a brief general anaesthetic (see section 2.7.4). The contents are examined under magnification; a mass of nematodes 0.5-3mm in length will be seen in infected individuals. Alternatively, examination by endoscopy will improve visualisation of these nematodes, due to magnification. The nematodes have a symbiotic relationship with bacteria which cause tissue necrosis. No treatment is currently available. The mode of transmission between spiders is unknown, but spread between infected containers, and vector transmission from *Phoridae* flies and mealworm beetles (*Tenebrio molitor*) have been speculated.

### 2.7.3 Supportive care

- **Rehydration:** Rehydration in theraphosids can be achieved by placing the cephalothorax of the spider in a shallow dish of water, taking care not to submerge the book lungs on the ventral surface of the opisthosoma. Most spiders will hydrate within a few hours. Severely dehydrated spiders are unable to move as extension of limbs is dependent on haemolymph pressure. Fluid therapy can be achieved by administering intrahaemolymph injections with isotonic fluids, using a 30 gauge insulin needle and syringe. Fluids are administered directly into the heart in the dorsal midline of the opisthosoma (Fig. 11A). If the heart is missed then fluids will still be effective as tarantulas have an open venous and closed arterial system. After injecting, seal the cuticle with tissue adhesive to prevent iatrogenic haemorrhage. A safer method to avoid haemorrhage it to administer fluids into a limb by inserting the needle in the ventral area of the joint membrane (Fig. 11B). The disadvantage of this method is that fluid administration is slow and only small fluid volumes can be given (less than 0.1ml).

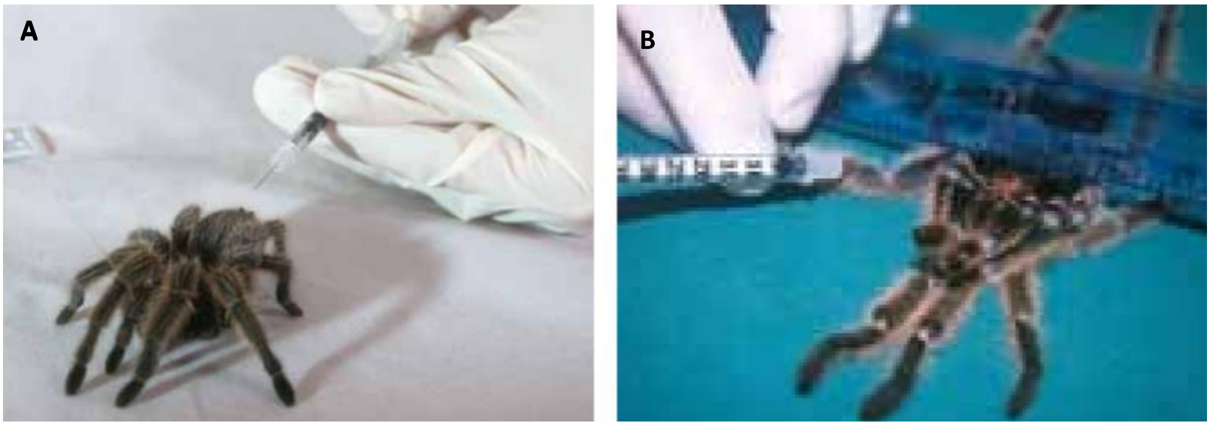


Figure 11. Rehydration of dehydrated captive theraphosids: (A) Administering fluids directly into the heart in the dorsal midline of the opisthosoma; (B) Administering small amounts of fluid into the limbs. From Pellet et al., (2015).

### 2.7.4 Anaesthesia

Gaseous anaesthetics are the method of choice for anaesthetising theraphosids. Isoflurane and sevoflurane are both effective and commonly used anaesthetic gases in the clinical setting. Induction can be slow, taking as long as 20 minutes before there is a loss of righting reflex.

Theraphosids can be anaesthetised using an induction chamber (Fig. 12A) or a large mammalian facemask (Fig. 12B) to pass gas over the body. The abdomen needs to be contained within the mask, as the book lungs are located on the ventral abdomen.

Another method of anaesthesia is to place the specimen in a closed container with a cotton ball saturated with isoflurane or sevoflurane liquid as outlined by Reichling & Tabaka (2001). Care must be taken not to allow the spider to come into direct contact with the saturated cotton wool ball. The primary concern with either of these methods is the risk of environmental gas exposure of personnel.

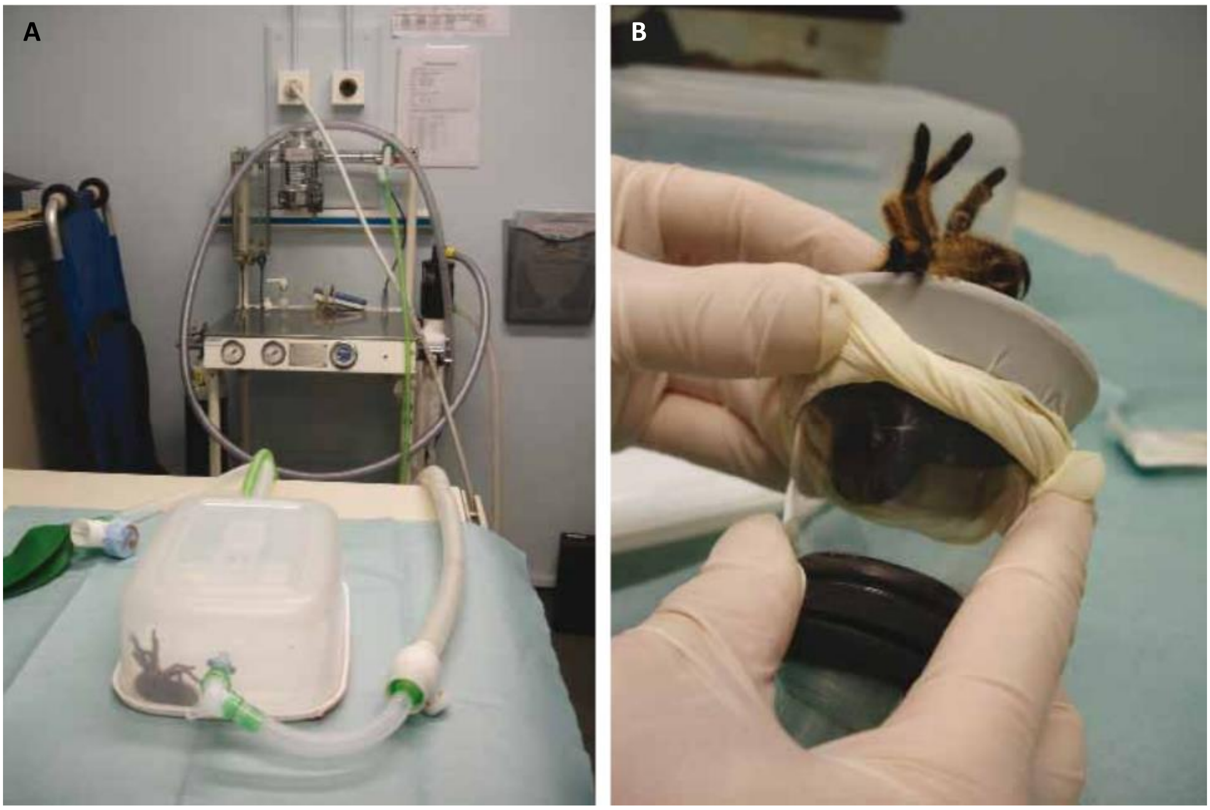


Figure 12. Anaesthesia of theraphosids using (A) an induction chamber or (B) a mammalian facemask with a modified latex glove to seal mask. From Pellet et al., (2015).

Monitoring anaesthetic depth can be a bit of a challenge: there is a lack of available methods other than the loss of the righting reflex, and a reaction or otherwise to noxious stimuli such as a hypodermic needle stick. Many invertebrates experience asystole when anaesthetised but recover without incident. Methods for detection of heart movement have been described but are not clinically feasible in most cases. It is best to keep the anaesthetic level as low as possible, while achieving and maintaining immobilisation. Recovery may require exposing the animal to oxygen in a mask or chamber.

### 2.7.5 Euthanasia

For euthanasia of theraphosids an inhalant agent such as sevoflurane or isoflurane with oxygen supplementation as described in section 2.7.4 should be used. Once the spider is anaesthetised, pentobarbitone can be injected into the haemocoel (Dombrowski & De Voe, 2007). Death can be confirmed with a Doppler probe demonstrating permanent cessation of circulation and heart rate.

Alternatively, the method of Bennie et al. (2013) can be used. Euthanasia is achieved, after immobilisation, through the use of an injection of potassium chloride (KCl) causing death through terminal depolarisation of the thoracic ganglia as a result of hyperkalosis. For euthanasia of theraphosids either a dose of 0.5% v/w 300mg/ml KCl can be administered centrally via the sternum into the prosoma ganglia or 1% v/w 300mg/ml KCl can be delivered via intracardiac delivery. This method is effective in ablating the nervous system and is nonrecoverable (Bennie et al., 2013).

## 2.8 Recommended research

In terms of published research, almost no work has been done on *Cyrtopholis femoralis*. Besides the original description of the species (Pocock, 1903), *C. femoralis* has only been briefly mentioned elsewhere in the literature: Either as a simple listing in various catalogues of spiders (e.g. *after* Petrunkevitch, 1911), or else only once noting the species as a prey item of *Leptodactylus fallax* (Rosa et al., 2013). As such, almost nothing is known about any aspect of the biology of the species.

The greatest priority for research on *Cyrtopholis femoralis* is a more thorough taxonomic treatment. *C. femoralis* is described from a single male specimen (Pocock, 1903), as such no information exists on variation within the purported species. Polymorphisms in colour across Montserrat (G. Garcia, pers. obs.) suggest that multiple species may be present, or at least that unknown genetic structure may occur within the species. A thorough investigation of the variation in *C. femoralis* across its range is required to distinguish how many species are present and inform other lines of research. All deceased specimens from the captive population have been preserved in formalin and/ or alcohol and are currently held at Chester Zoo awaiting taxonomic investigation.

Another priority for *Cyrtopholis femoralis* research is an assessment of the species conservation status. Apart from being endemic to Montserrat nothing is known of the species distribution. Although anecdotally thought to be historically common across Montserrat, no official assessments of population size of *C. femoralis* have been undertaken. An expected reduction in available habitat due to severe consequences of volcanism over much of the island, plus other habitat changes in remaining suitable areas have very likely reduced much of its former range (i.e. pre 1995). As such, a thorough survey of the distribution and abundances within the current *in-situ* population should be carried out, along with a detailed assessment of on-going or potential threats faced, in order to assess conservation status of the species, to allow appropriate conservation measures to be planned if necessary.

Similarly, nothing is known of the habitat requirements and ecology of *Cyrtopholis femoralis* beyond the species being a habitual burrower. These aspects should be investigated alongside aspects of distribution. In addition to aspects such as the associated flora to characterise habitat, some investigation of potential predators and prey types should be investigated. Furthermore, any local differences in abundance should be relatable to physiographic factors, in particular in altitude, aspect, canopy cover, and water availability. Furthermore, the behavioural ecology of the species is totally unknown beyond anecdotal reports of some level of colonial living (G. Garcia, pers. obs.). In particular, records of the emergence, survival and ideally the movements of mature males should be recorded, to inform questions about the window of opportunity for mating, and connectance between seemingly disjoint colonies (especially those with mature females). Equally, studies focused on the dispersal of young is vitally needed, to inform questions of their survival and ability to colonise new areas (or rather re-colonisation in areas where currently absent) should be carried out. Such information will be important for better informing the husbandry of the species in captivity.

*Cyrtopholis femoralis* would also benefit from genetic characterisation to better understand the relationship between this species and other members of the genus and other Caribbean tarantula genera. This will help inform wider studies about the uniqueness of the native tarantulas on Montserrat, to evaluate their potential as important endemics, ideally together with some estimate of genetic divergence-time shown against other allied species on other nearby Caribbean islands.

Similarly, an assessment of the genetic structure of the native population would be useful for assessment of its conservation status, to better contextualise any local threats to subpopulations or cryptic diversity, and hence as an additional tool to inform any required conservation planning.

## Section 3: References


Atkinson, I. A. E. (1985). The spread of commensal species of Rattus to oceanic islands and their effects on island avifaunas. In P. J. Moors (Ed.), *Conservation of Island Birds.* ICBP Technical Publication.

Atkinson, I. A. E., & Atkinson, T. J. (2000). Land vertebrates as invasive species on islands served by the South Pacific Regional Environment Programme. In *Invasive Species in the Pacific: A Technical Review and Draft Regional Strategy.* Samoa: South Pacific Regional Environment Programme.

Bennie, N., Loaring, C., Bennie, M., & Trim, S. (2013). An effective method for terrestrial arthropod euthanasia. *Animal Technology and Welfare*. https://doi.org/10.1242/jeb.074997

Buley, K. R. (2001). *Montserrat mountain chicken population and habitat assessment and a preliminary assessment of the other herpetofauna of Montserrat August & September 2001.*

Campbell, K., & Donlan, C. J. (2005). Feral goat eradications on islands. *Conservation Biology*. https://doi.org/10.1111/j.1523-1739.2005.00228.x

Cleton, F., Sigwalt, Y., & Verdez, J.-M. (2015). *Tarantulas: Breeding Experiance & Wildlife*. Frankfurt am Main: Edition Chimaira.

Cole, P., Bass, V., Christopher, T., Eligon, C., Fergus, M., Gunn, L., … Williams, P. (2010). *Report on Activity between 15 August 2009 and 28 February 2010. Part 1. Report to the Scientific Advisory Committee on Montserrat Volcanic Activity.*

Courchamp, F., Chapuis, J. L., & Pascal, M. (2003). Mammal invaders on islands: Impact, control and control impact. *Biological Reviews of the Cambridge Philosophical Society*. https://doi.org/10.1017/S1464793102006061

Cruz, F., Josh Donlan, C., Campbell, K., & Carrion, V. (2005). Conservation action in the Galàpagos: Feral pig (Sus scrofa) eradication from Santiago Island. *Biological Conservation*. https://doi.org/10.1016/j.biocon.2004.05.018

Dalsgaard, B., Hilton, G.M., Gray, G.A.L., Aymer, L., Boatswain, J., Daley, J., Fenton, C., Martin, J., Martin, L., Murrain, P., Arendt, W.J., Gibbons, D.W., Olesen, J.M. (2007). Impacts of a volcanic eruption on the forest bird community of Montserrat, Lesser Antilles. IBIS. 49(2), 298-312. https://doi.org/10.1111/j.1474-919X.2006.00631.x

Desender, K., Baert, L., Maelfait, J. P., & Verdyck, P. (1998). Conservation on Volcan Alcedo (Galapagos): Terrestrial invertebrates and the impact of introduced feral goats. *Biological Conservation*, *87*(3): 303–310. https://doi.org/10.1016/S0006-3207(98)00078-0

Dombrowski, D. S., & De Voe, R. S. (2007). Emergency Care of Invertebrates. *Veterinary Clinics of North America: Exotic Animal Practice*. https://doi.org/10.1016/j.cvex.2007.01.005

Falcón, W., Ackerman, J. D., Recart, W., & Daehler, C. C. (2013). Biology and Impacts of Pacific Island Invasive Species. 10. *Iguana iguana* , the Green Iguana (Squamata: Iguanidae). *Pacific Science*. https://doi.org/10.2984/67.2.2

Fukushima, C., Mendoza, J.I., West, R.C., Longhorn, S.J., Rivera, E., Cooper, E.W.T., Hénaut, Y., Henriques, S., Cardoso, P. (2019). Species conservation profiles of tarantula spiders (Araneae, Theraphosidae) listed on CITES. *Biodiversity Data Journal* 7, e39342. https://doi.org/10.3897/BDJ.7.e39342.

Global Invasive Species Database. (2018). Retrieved from http://www.issg.org/database

Haakonsson, J. (2016). Green iguana invasion. *FLICKER: Biomonthly Bulletin of the Cayman Islands Department of Environment's Terrestrial Resources Unit*, *23*, 2–4.

Hudon, M.A., Griffiths, R.A., Martin, L., Fenton, C., Adams, S.L., Blackman, A., Sulton, M., Perkins, M.W., Lopez, J., Garcia, G., Tapley, B. (2019). Reservoir frogs: Seasonality of *Batrachochytrium dendrobatidis* infection in robber frogs in Dominica and Montserrat. *PeerJ* 7:e7021 https://doi.org/10.7717/peerj.7021

IATA. (2015). *Live Animal Regulations* (42nd ed.). International Air Transport Association.

Kaderka R, Bulantová J, Heneberg P, Řezáč M (2019) Urticating setae of tarantulas (Araneae: Theraphosidae): Morphology, revision of typology and terminology and implications for taxonomy. PLoS ONE 14(11), e0224384.

Kokelaar, B. (2002). Setting, chronology and consequences of the eruption of Soufrière Hills Volcano, Montserrat (1995-1999). In T. Druitt & B. Kokelaar (Eds.), *The Eruption of the Soufriere Hills Volcano, Montserrat, from 1995 to 1999*. London: Geological Society.

Marske, K. A., Ivie, M. A., & Hilton, G. M. (2007). Effects of Volcanic Ash on the Forest Canopy Insects of Montserrat, West Indies. *Community and Ecosystem Ecology*, *36*(4), 817–825. https://doi.org/10.1603/0046-225X(2007)36[817:EOVAOT]2.0.CO;2

Minch, E. W. (1979). Reproductive behaviour of the tarantula Aphonopelma chalcodes Chamberlin (Araneae: Theraphosidae). *Bulletin of the British Arachnological Society*, *4*(9), 416–420.

Pedersen, Scott & Popowics, Tracy & Kwiecinski, Gary & Knudsen, David. (2012). Sublethal pathology in bats associated with stress and volcanic activity on Monserrat, West Indies. Journal of Mammalogy. 93. 1380-1392. 10.2307/23321947.

Pellett, S., Bushell, M., & Trim, S. A. (2015). Tarantula husbandry and critical care. *Companion Animal*, *20*(2), 119–125. Retrieved from http://www.magonlinelibrary.com/doi/abs/10.12968/coan.2015.20.2.119

Petrunkevitch, A. (1911). A synonymic index-catalogue of spiders of North, Central and South America with all adjacent islands, Greenland, Bermuda, West Indies, Terra del Fuego, Galapagos, etc. B. *Bulletin of the American Museum of Natural History*, *29*, 1–791.

Petrunkevitch, A. (1926). Tarantula versus tarantula-hawk: A study in instinct. *Journal of Experimental Zoology*, *45*(2), 367–397. https://doi.org/10.1002/jez.1400450202

Pocock, R. I. (1903). XIII.— On some genera and species of South-American Aviculariidæ. *Journal of*

*Natural History*, *11*(61), 81–115. https://doi.org/10.1080/00222930308678729

Reichling, S. B., & Tabaka, C. (2001). A Technique for Individually Identifying Tarantulas Using Passive Integrated Transponders. *The Journal of Arachnology*, *29*, 117–118. https://doi.org/10.1636/0161-8202(2001)029[0117:ATFIIT]2.0.CO;2

Rosa, G. M., Bradfield, K., Fernández-Loras, A., Garcia, G., & Tapley, B. (2013). Two remarkable prey items for a chicken: *Leptodactylus fallax* Müller, 1926 predation upon the theraphosid spider *Cyrtopholis femoralis* Pocock, 1903 and the colubrid snake *Liophis juliae* (Cope, 1879). *Tropical Zoology*, *25*(3), 135–140. https://doi.org/10.1080/03946975.2012.717795

St Clair, J. J. H. (2011). The impacts of invasive rodents on island invertebrates. *Biological Conservation*, *144*(1), 68–81. https://doi.org/10.1016/j.biocon.2010.10.006

St Clair, J. J. H., Poncet, S., Sheehan, D. K., Székely, T., & Hilton, G. M. (2011). Responses of an island endemic invertebrate to rodent invasion and eradication. *Animal Conservation*. https://doi.org/10.1111/j.1469-1795.2010.00391.x

Stephen, C. L., Reynoso, V. H., Collett, W. S., Hasbun, C. R., & Breinholt, J. W. (2013). Geographical structure and cryptic lineages within common green iguanas, *Iguana iguana*. *Journal of Biogeography*. https://doi.org/10.1111/j.1365-2699.2012.02780.x

Stinton, A. J., Cole, P. D., Odbert, H. M., Christopher, T., Avard, G., & Bernstein, M. (2014). Dome growth and valley fill during Phase 5 (8 October 2009 – 11 February 2010) at the Soufrière Hills Volcano, Montserrat. In Wadge (Ed.), *The eruption of the Soufrière Hills Volcano, Montserrat, 2000-2010*. London: Geological Society.

Stinton, A. J., Cole, P. D., Stewart, R. C., Odbert, H. M., & Smith, P. (2014). The 11 February 2010 partial dome collapse at Soufriere Hills Volcano, Montserrat. In Wadge (Ed.), *The eruption of the Soufrière Hills Volcano, Montserrat, 2000-2010.* London: Geological Society.

Varnham, K. J. (2010). *Invasive rats on tropical islands: Their history, ecology, impacts and eradication.* Royal Society for the Protection of Birds (RSPB): Issue 41 of RSPB research report. London.

Vuillaume, B., Valette, V., Lepais, O., Grandjean, F., & Breuil, M. (2015). Genetic evidence of hybridization between the endangered native species *Iguana delicatissima* and the invasive *Iguana iguana* (Reptilia, Iguanidae) in the Lesser Antilles: Management implications. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0127575

World Spider Catalog (2020). World Spider Catalog. Version 21.5. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on 24.06.2020. doi: 10.24436/2

Young, R. P. (2007). *A biodiversity assessment of the Centre Hills, Montserrat. Durrell Conservation Science Report 1.*