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# Bat Management Plan for Jamaica

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## EXECUTIVE SUMMARY

The modern era of caving in Jamaica and by extension bat research began in the 1950's with formation of the then Jamaica Caving Club (JCC) and the first publication of Jamaica Underground in 1977 by Alan G. Fincham. These early works highlighted the diversity of bats species, their distribution and their ecological importance. To date, it is not clear whether there has been a decline in Jamaica's bat population or a loss of bat species, what is certain is that there is a need for an increased understanding of the requirements for a healthy bat population in Jamaica. This document aims to provide information on the global and local status of Jamaica's bats and what strategies are required to protect the islands species and their habitats.

This Bat Management Plan provides clear and targeted actions for a five-year period based on the guiding principles of the *Ecosystem-based Approach, Integrated Management, Collaboration and Stewardship and Adaptive Management*. These principles foster both biological and social resilience and the actions if fully implemented will help to ensure the protection and conservation of all bat species.

The goal of this management plan is to guide research, enhance public awareness and conservation, and foster information sharing and collaboration between countries on bat research and conservation. Recommendations to enhance the conservation of bats include:

- Protection of caves which have been determined to host high species richness and species numbers and the forest cover of the area surrounding the cave.
- Conservation of the island's largest caves for protection namely: St. Clair Cave, Windsor Cave, Oxford Cave, Portland caves and Mount Plenty
- Protection of key sites.

The plan also encourages citizens to actively participate and share in the responsibility to maintain our biodiversity. Every plan encounters challenges of funding which is usually the determining factor with regards to implementation of projects. In addition to government funds, the Agency, stakeholders and collaborators will have to employ creative ways of sourcing funds, such as seeking grants and writing proposal

## 1.0 INTRODUCTION

Jamaica is ranked fifth in islands in terms of endemic plants and is also noted to have a high level of endemism for a number of animal species (NEPA, 2003). Bats are one group of such species and Jamaica has been recorded as having four endemic species and eight endemic sub-species. Bogan (2003) stated that a decline in the bat populations is critical as “In many tropical ecosystems, bats are keystone species by virtue of their roles as pollinators and seed dispersal agents”. It is not clear whether there has been a decline in Jamaica’s bat population or a loss of bat species, what is certain is that there is a need for an increased understanding of the requirements for a healthy bat population in Jamaica.

The National Strategy and Action Plan on Biological Diversity in Jamaica (2003) recognized the need for the protection of the island bat species with the inclusion of the section entitled “Sustainable Management of Bat and Dolphins Species”. Outputs suggested included a feasibility study of the guano mining conducted; assessment of bat populations; identification of cave tours; training and certification for cave tour guides; preparation of public information brochures and a management strategy. The development of this document fulfils the last project output.

### **RATIONALE**

*This management plan will guide activities which will result in the conservation of bats and their habitats through research and effective collaboration between government and non-government stakeholders.*

To this end and in the continuation of its mandate to manage and protect Jamaica’s biological diversity, the National Environment and Planning Agency through the Ecosystems Management Branch identified the need to develop a management plan for the island’s bat population. Genoways *et. al.* (2005) noted that caves were the single most important conservation area for bats in Jamaica along with large areas of native vegetation. He stated that a healthy bat population depends largely on suitable roost, native plants and insects. In his publication “*Bats of Jamaica*” Genoways urged the protection of St. Clair Cave, Portland Cave, Windsor Cave, Oxford Cave and Mount Plenty Cave and the exclusion of human activity in the caves. He also further recommended that Bagdale Cave, Cousins Cave, Ferry Cave, Monarva Cave, Ramble Bat Hole, Two Sisters Cave and Wallenford Cave should also have limited to no human activity.

### **OBJECTIVE**

*The goal of the plan is ensure the conservation of bats and their habitats by guiding research enhancing public awareness and fostering information sharing and collaboration both locally and internationally.*

## 1.1 Bats in Jamaica

Jamaica is a mountainous island and features two distinct mountain ranges, the John Crow Mountains (maximum height of 1000 m) and the Blue Mountains (peak reaches 2290 m) and numerous hills and plateaus along the central and western two-thirds of the island. Almost two-thirds of the surface rocks of the island are faulted limestones with much of the inland terrain being rugged areas of *Cockpit*<sup>1</sup> and *Tower*<sup>2</sup> karst, interspersed with poljes. The most developed karst topography is in the Cockpit Country. Caves are a common feature of the limestone regions.

Bats (Chiroptera) are considered to be among the most diverse and geographically dispersed of all living mammals, and are the only mammals that can fly (Nowak, 1994). In Jamaica, the presence of bats has been recorded since the 1800s (Donaldson and Griffiths, 1997) and are classified in the sub-order Microchiroptera or New World bats. The New World Bats are represented by 16 families and possess a diverse global distribution with eight restricted to the Old World, six to the New World and three in both hemispheres. Locally, 21 species have been recorded as either resident or endemic to the island and represent 6 families; five of which are endemic to the island<sup>3</sup>. Included in the group are 4 endemic species, 8 endemic sub-species and 9 indigenous species (Appendix II). The families represented are Vespertilionidae (nearly global in distribution), Noctilionidae, Mormoopidae, Natalidae, Phyllostomidae (restricted to the New World) and Molossidae (found in both hemispheres).

The world population of bats is said to be on the decline, the status of Jamaica's bat population and their habitat is not fully known nor is it known whether any of the current 21 species have gone extinct. Historically, Jamaica has lost species evident by fossil remains of the species *Mormoops megalophyla*, *Tonatia saurophila saurophila* and *Brachphylla nana*. The reason for the extinction of *M. megalophyla* was not found, however in Genoways *et. al.* (2005) competition with other species was considered to be the reason for *T.s. saurophila* and *B. nana*.

The majority of Jamaica's bat species roost in caves, roofs or crevices; only one roosts primarily in trees. Much of what is known about microchiropterans has been based on studies conducted on temperate species which form large maternity and hibernating colonies. Little research on species in the tropics has been conducted and this is also true for Jamaica. More than 1100 caves have been recorded island-wide; Fincham (1977) revealed that 149 caves have been confirmed as bat roosts (Figure 1).

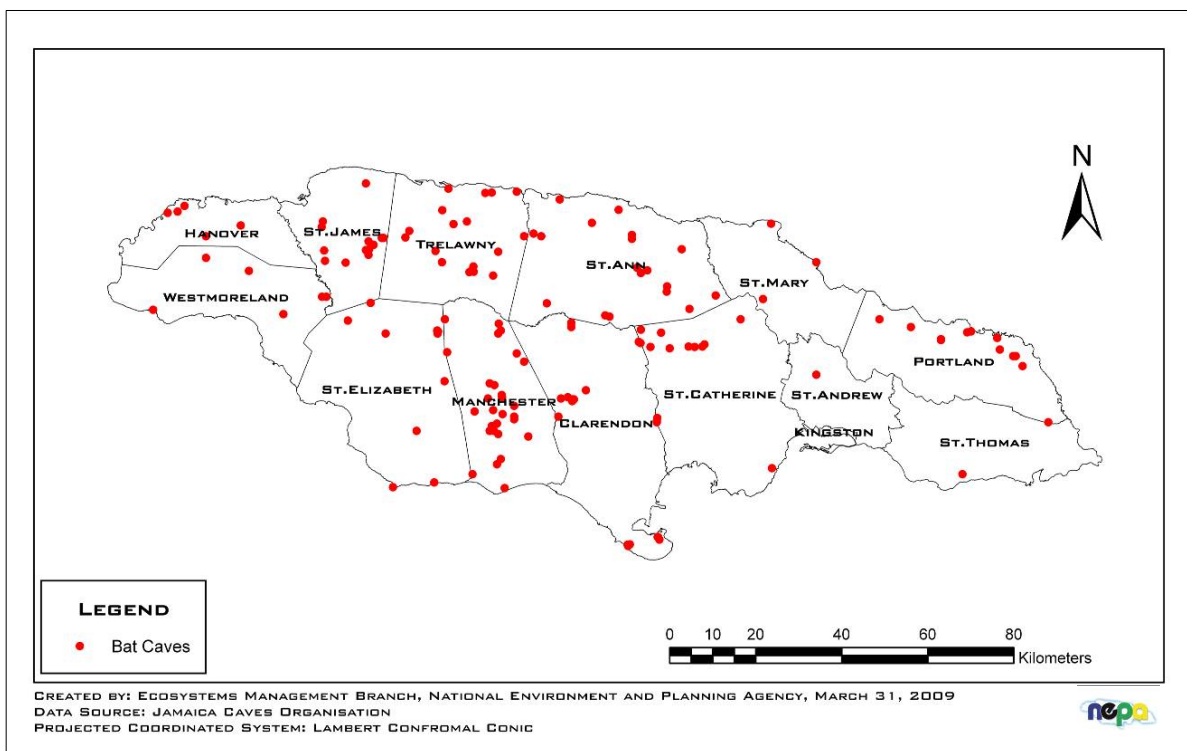
Since Fincham's 1977 book, work has been conducted to map Jamaica's cave systems. In 1997, Fincham republished his book with the updated information. The Jamaica Cave Organisation has been visiting a number of caves mapping the interior and noting the presence or absence of bat species, plants and invertebrates and the National Environment and Planning Agency commenced a programme in 2006 of visiting and confirming the presence of bat species and confirming which caves are active. Appendix V provides a list of the caves that have been reconfirmed under this programme.

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<sup>1</sup> Cockpit karst or cockpit is conekarst in which the residual hills are chiefly hemispheroidal and the closed depressions often lobate (Fincham, 1997)

<sup>2</sup> Tower karst or turm karst is terrain constituting steep sided isolated limestone hills common on the fringes of the Cockpit Country (Fincham, 1997)

<sup>3</sup> <http://www.cockpitcountry.com/Bats.html>



**Figure 1** Map of Jamaica showing the distribution of known bat cave roost

## 1.2 Natural History of Bats

### 1.2.1 Roosting Behaviour

Bats spend more than half of their lives in roost environments. These roosts include caves, mines, rocks crevices and various man-made structures. Some species have specific roosting requirements (e.g. *Natalus* species in Jamaica) with some only roosting in one type of habitat (e.g. trees for the Jamaican species *Ariteus flavescens*). While some species are known to migrate (typically to warmer climates) it is not known if Jamaica’s bat species migrate. There are some microchiroptera, especially those which are insectivores and frugivores that follow the flowering and fruiting seasons.

### 1.2.2 Feeding Behaviour

Two hundred and sixty (260) species of bats are primarily frugivorous or nectarivorous and are represented by several sub-families of the New World group Phyllostomidae, while the majority, (approximately 625) in the microchiroptera are insectivorous. There are also carnivorous and sanguivorous species, which feed on meat and blood respectively. Bats which feed on fruits, nectar, meat and blood are confined to tropical and sub-tropical regions whereas insect feeders inhabit all latitudes.



In a review of Jamaica's bat population, Genoways *et. al.* (2005) stated that of the seven trophic guilds<sup>4</sup> recognized in the neotropic Chiroptera, five were represented in Jamaica. These five guilds are insectivores, nectivories, frugivores, piscivores and foliage gleaners. The trophic guild insectivores dominates with thirteen species; The frugivores are *Ariteus flavescens* and *Artibeus jamaicensis* and the only piscivore is the species *Noctilio leporinus*. One species *Macrotus waterhousii* is placed in three guilds, insectivore, foliage gleaner and frugivore.

#### **Nectivores**

*Glossophaga soricina*  
*Monophyllus redmani*  
*Erophylla sezekorni*  
*Phyllonycteris aphylla*

#### **Foliage gleaners**

*Glossophaga soricina*  
*Monophyllus redmani*  
*Phyllonycteris aphylla* (maybe)

#### **Frugivore**

*Artibeus jamaicensis*

#### **Insectivores**

*Mormoops blainvillii*  
*Pteronotus macleayii*  
*Pteronotus parnellii*  
*Pteronotus quadridens*  
*Natalus micropus*  
*Natalus stramineus*  
*Lasiurus degelidus*  
*Eptesicus lynni*  
*Eumops auripendulus*  
*Eumops glaucinus*  
*Tadarida brasiliensis*  
*Nyctinomops macrotis*  
*Molossus molossus*

The food consumed by the microchiroptera of Jamaica includes lepidopterans, coleopterans, other soft-bodied to hard-bodied insects, small fish, nectar from plants such as *Passiflora* and fruits such as almond and naseberry. The distance travelled for food varies with species, habitat, colony size and food availability. Telemetry studies conducted on some microchiroptera found that they feed within a range of 10 -15km of their roost. The sense of smell is also well developed in fruit and nectar feeding species and is an added aid in food detection.

### **1.2.3 Social Behaviour and the cave system**

Bats either roost as mother and young or as a large aggregation to form a colony. These colonies can range in size from fewer than a dozen to many millions. The largest colony of bats is said to be formed by molossids and vespertilionid species. In Jamaica colony sizes have been estimated for a few caves in Trelawny; Bristol Cave is estimated to house 100,000 to 200,000 bats, Deeside Roaring River Cave less than 50 bats, Dromilly Cave 5,000 to 50,000 bats, Home Away From Home Cave 50,000 to 100,000 bats and Windsor Great Cave 50,000 to 100,000 bats (Koenig, 2002). Within the colonies for some species social organization and mating systems range from monogamy to polygamy. Not much is known about the social behaviour of Jamaican bats, however some species have been shown to establish harems while in some, young females leave and form a roosting cluster or form a new group.

Since as early as 1929 Jamaica's underground systems have been explored and mapped through the work of groups such as Jamaica Caving Club, Leeds University, Bristol University and more recently the Jamaica Cave Organization. Two thirds of the island's land surface is composed of massive cavernous limestone that

<sup>4</sup> Group of organisms that exhibit similar habitat requirements and that responds in a similar way to changes in their environment [http://www.biology-online.org/]

has led to the formation of numerous caves of varying sizes and shapes. According to Donaldson & Griffiths (unpublished 1997) these caves range in size from the large river caves (the Wallingford Cave in St. Elizabeth); caves with large passages, (Windsor Cave in Trelawny; to small caves (Bath Mountain Cave in Westmoreland).

The islands largest cave systems can be divided into three categories – river caves, shafts and fossil systems. River caves are those having river systems flowing through them (Wright’s Hole and Morgans Pond Cave in Manchester which are shafts and potholes), with few being very deep and only Quashies River Cave in Trelawny having a large waterfall. Windsor Cave in Trelawny and Runaway Bay Cave in St. Ann are examples of fossil caves. These fossil caves were roosts for large bat colonies and had thick layers of guano which were mined for fertilizer.

In the 1940’s, a number of caves were analyzed by the Department of Agriculture in Jamaica to determine the nutrient content and value as a fertilizer. This analysis revealed that when dry the guano is high in nitrogen content; this would be valuable to Jamaican soils which are naturally high in phosphate and low in nitrogen content (Cousins, 1943). Caves such as Good Hope Cave in Trelawny (from 1938 to 1942) and Richmond Park Cave in Clarendon were mined for guano at various times in the past and it is believed that even today some extraction for use as fertilizer happens across the country (Donaldson & Griffiths, unpublished 1997).

#### **1.2.4 Reproduction and Life History Characteristics**

The pattern of reproduction is either seasonal monoestry or polyoestry. Monoestrous females produce one litter per year while a female who is polyoestrous produces two or three litters per year. Polyoestry is common in the tropics. The length of gestation varies in response to environmental conditions among and within species. Bats ensure that birth is synchronized with food availability by using various mechanisms to adjust the timing or length of the pregnancy. Two of these mechanisms are delayed fertilization and delayed implantation (delayed development).

Unlike other mammals, bats have a slow rate of foetal growth (pregnancy last 3 to 6 months), a low reproductive rate (1 or 2 young per year) and a long life span of (15 to 30 years). The young bats (pups) are large at birth averaging 25% of their mother’s body weight and are not weaned until they are 40% of the mother’s weight or 80% of adult body size. This trait highlights the fact that bats are unable to fend for themselves until their wings attain adult dimensions.

#### **1.2.5 Predation**

Information on predators of bats are limited, with most of the information noted being anecdotal or parts of a bat being found in the fecal matter of other animals. Some species identified as feeding on bats includes birds of prey, carnivores, other bats and snakes. In 2000 during the project “Assessment of Capture Methods for Long-Term Monitoring” Dr. Susan Koenig recorded a Jamaican Boa (*Epicrates subflavus*) capture a Jamaican Fruit Bat (*Artibeus jamaicensis*). The snake was observed hanging from a vine near the harp trap which was being used by Dr. Koenig. In Australia, the tree frog *Litoria cerulea* was observed eating the bent-winged bat *Miniopterus australis*. These predators wait at the entrances to roosts and capture bats when they exit and also seem to prey on them while they roost during the day.

### 1.3 Ecological and Economic Values of Bats

Through various studies bat species have been shown to have both ecological and economic value. Bats are said to play an important role in the re-vegetation of cleared areas and regulating nocturnal insect populations by consuming a significant number during the summer (Wilson, 1997). They are also thought to be important in transporting nutrients across distances, due to the volume of insects consumed (up to 100% body weight/night) and the long distances they travel (several kilometers/night). The insect species consumed includes species which have an economic impact on agriculture crops such as the cucumber beetles, June bugs, corn borer and Jerusalem crickets. These insect species are pest of crops such as corn, cotton and potatoes (Nowak, 1994).

Fruit and nectar-eating bats in the tropical regions are considered to be more valuable as they serve as agents for pollination and seed dispersal. Many plants of economic importance including bananas, avocados and peaches are pollinated by bats. The flowers of a number of plants have been shown to have adapted to be serviced by bats. The diet of the Kitti's hog-nosed bat a microchiropteran from Thailand includes nectar, fruits and insects and this facilitates their behaviour as pollinators, seed dispersers and insect control. This gives them an ecological and economic importance that cannot be overstated.

A bat's droppings, in addition to being used as fertilizer has historically been used in the production of gun powder and explosives. Bats are presently being studied by a number of researchers in the auditory field. The ability to ecolocate is being studied in relation to hearing for human applications. In Jamaica the species, has been collected for such research (Appendix VI).

### 1.4 Bats and Health Issues

According to the literature, in Jamaica there have been very few health issues related to bats, the main issue is however histoplasmosis. Histoplasmosis is a disease which is caused by the fungus *Histoplasma capsulatum* and if contracted by people, it can infect their lungs, skin, mucous membrane, bones and eyes. In the Caribbean Epidemiology Centre Surveillance Report, 1978, it was stated that there were few reports of histoplasmosis. Histoplasmosis affects persons who visit roosting areas for birds or caves inhabited by bats. The fungi are found in the excreta and infections occur through aerosolization.

### 1.5 Conservations Issues

Nowak (1994) stated that bat populations are declining in almost every country they are found and noted that microchiroptera species such as *Mystacina robusta* from New Zealand and *Nyctophilus howensis* from Lord Howe Island have gone extinct. Genoways (2005) recorded three species *Mormoops megalophylla*, *Brachyphylla nana* and *Tonatia saurophila saurophila* as being extinct from the Jamaica since the 1950's. In more recent times Dr. Don McFarlane of Claremont University, has indicated that he believes that the endemic species *Phyllonycteris aphylla* may be extinct (pers. com. 2005). During his expedition to Jamaica in 2005 he did not record the species in St. Clair Cave which is known to be one of its main habitats. While other species have not gone extinct some have been reduced in the extent of their distribution as their numbers have declined and for some there are just remnant populations.

The conservation of bat species is made difficult by the lack of knowledge and the inherent difficulties in studying them which have precluded the use of typical extinction models (Kunz and Fenton 2003). Their slow population growth, natural rarity and genetic isolation also make the use of the extinction model difficult. It therefore is difficult to predict and thus manage those factors which could lead to extinction. Increased human actions such as use of pesticide, roost destruction and closure, habitat loss and extermination as pests have been highlighted as factors affect bat populations.

Bats range widely to forage and thus habitat modification through urbanization, agriculture and other land use practices which affect the plant and insect populations will affect the food sources of the bats. Global warming is also thought to likely affect bats indirectly through the interruption or altering of the phenology<sup>4</sup> of the plant species they utilize. An example given by Bogan (2003) is “a mean global warming of 3°C will change climates sufficiently so that 7-11% of vascular plants in North America will no longer occur within the appropriate climate envelope”. These plants will thus have to adapt/move to stay within their climate or die; all of which will affect the bats.

In comparing the species composition in Jamaica with other Caribbean Islands, Genoways *et. al.* (2005) stated that Jamaica and Cuba shared fifteen extant species and two fossil species. Not shared were Jamaica’s endemic species, *Glossophaga soricina*, *Eumops auripendulus* and the extinct species *Tonatia saurophila*. When comparing Jamaica with Mexico and Central America, eleven extant species and two fossil species are shared. These are *Noctilio leporinus*, *Pteronotus parnellii*, *Mormoops megalophylla* (extinct), *Tonatia saurophila*, *Glossophaga soricina*, *Artibeus jamaicensis*, *Natalus stramineus*, *Eumops auripendulus*, *Eumops glaucinus* and *Molossus molossus*. Additionally there is an endemic Antillean species *Mormoops blainvillii* which is shared between the Lesser Antilles and Jamaica.

There is limited information available on the ecology, physical description and habit requirements for a number of Jamaica’s species. A description of Jamaica’s species is provided in Appendix III and in a number of instances will not be specific to species from Jamaica but information on similar species from other countries. Also where available the IUCN conservation status for the species has been included and an explanation of the rankings is provided in Appendix IV. Included along with the species description are the distribution map based on information from Genoways *et. al.* (2005), Donaldson & Griffiths (unpublished 1997) and NEPA (2006, 2007).

It should also be noted that the impact of the introduction of invasive species into cave systems has not yet been examined. The American Cockroach (*Periplaneta americana*), an invasive, is noted to have become abundant in some caves. As a scavenger it out-competes the other invertebrate scavengers in the cave and thus these species starve. Some of these invertebrate scavengers species also serve as food for cave dwelling invertebrate predators (Stewart *et. al.*, 2005).

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<sup>4</sup> A science that treats relations between climate and periodic biological phenomena that are related to or caused by climatic conditions, such as the budding of trees and the migration of birds.

## **2.0 International and Local Legislation Relevant to Bat Species**

### **2.1 International Treaties**

Jamaica has either signed or ratified some of the international treaties which have some relevance to bats. These treaties either specifically refer to bats or through their implementation offer some conservation measures to the species and their habitat.

#### **2.1.1 Convention on Wetlands of International Importance Especially as Waterfowl Habitat 1971 (Ramsar Convention)**

The Ramsar Convention allows for the designation and protection of wetland areas of international importance. Aquatic areas are important as feeding areas for bats and thus the designation and management could provide direct benefit to bat populations. Jamaica has three such sites designated, Palisadoes-Port Royal, Portland Bight Wetlands and Cays and Black River Lower Morass Ramsar sites. The first, the Black River Lower Morass Ramsar site was declared in 1997.

#### **2.1.2 UNESCO Programme on Man and the Biosphere 1971**

The protected areas category of 'biosphere reserves' are declared under this treaty. Some of the objectives of this designation include conserving the diversity and integrity of communities of plants and animals within natural ecosystems and safeguarding genetic diversity of species. Areas designated as Biosphere Reserves are therefore likely to protect any bat populations in them and have the potential to be significant for bat populations.

#### **2.1.3 Convention Concerning the Protection of the World Cultural and Natural Heritage 1972 (World Heritage Convention)**

Some natural features are designated as World Heritage Sites and are based on amongst other things on their aesthetics or scientific value as well as their importance for the conservation of threatened species. Some bats are threatened and hence the designation of World Heritage Sites could also support significant bat populations.

#### **2.1.4 Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES)**

The Convention seeks to regulate the trade in endangered species, only the Macrochiropteran genus *Pteropus* and *Acerodon* are listed in the CITES Appendices. Jamaica became a party to this Convention in 1995 and the Endangered Species (Protection, Conservation and Regulation of Trade) Act (2000) was enacted to enable the island to implement the Convention's objectives. Microchiroptera species are not listed on any of the Convention's three Appendices, however Parties through their local legislation can establish a list of species for which they wish to regulate trade. The Endangered Species Act (2000) therefore has a fourth schedule which has these species and includes nine bat species (see 2.2.2).

### **2.1.5 Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)**

The Convention relates to migratory species which cross political boundaries. Agreements or Memoranda of Understanding to protect such species are possible under the Convention. One such instrument is the Agreement on the Conservation of Bats in Europe 1991 which covers all European Microchiroptera. There are no records to indicate that Jamaica's bat species migrate to neighbouring islands or continents, however should this prove to be the case, protection through an MOU with the country of migration could be developed under this agreement.

### **2.1.6 Convention on Biological Diversity 1992 (The Rio Convention)**

The Convention on Biological Diversity requires that Parties amongst other things take measures to rehabilitate and restore degraded ecosystems, and promote the recovery of threatened species through the development and implementation of plans and other management strategies for the conservation and sustainable use of biological diversity. Jamaica became a party to the Convention in 1995 and has been implementing various aspects of the work programmes developed by the Convention. Implementation has involved the preparation of management and conservation strategies for species and ecosystems and public awareness activities (poster, brochures) and the development of the National Strategy and Action Plan on Biological Diversity in Jamaica.

## **2.2 Local Legislation**

### **2.2.1 Wild Life Protection Act (1945)**

The Wild Life Protection Act, enacted in 1945, seeks to protect a number of animal species and the habitat of bird species through the establishment of Game Reserves. Specific protection under this Act, for bat species or their roosting habitat has not yet however been provided. This can however be remedied through the amendment of this Act.

### **2.2.2 The Endangered Species (Protection, Conservation and Regulation of Trade) Act (2000)**

This Act was enacted in 2000 to enable Jamaica to implement its obligations as a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Act seeks to regulate the movement of wild flora and fauna into and out of Jamaica. Four schedules are listed under the Act, of which three are Appendices of the CITES convention and the fourth includes species not listed by the Convention for which Jamaica wishes protection. Nine of Jamaica's bat species are found on this Schedule and includes *Ariteus flavescens*, *Brachyphylla nana*, *Mormoops blainvillii*, *Phyllonycteris aphylla*, *Pteronotus macleayi*, *Pteronotus quadridens*, *Tadarida brasiliensis*, *Natalus micropus* (which was re-described as *Chilonatalus micropus*) and *Natalus stramineus*. Any request to collect or export any of these species is reviewed to determine whether such a trade would be detrimental to the survival of the species.

### **2.2.3 Natural Resources Conservation Authority Act (1991)**

This Act focuses on management and protection of the environment and thus includes provisions related to species/habitat management, through the following sections/instruments/mechanisms:-

- Declaration and management of national parks, protected areas, public recreational facilities and development of policies regarding the management, development, conservation and care of the environment.
- Development and implementation of plans/programmes necessary for the conservation and protection of the natural resources and research where needed.

### **2.2.4 Forest Act (1996 )**

The Forest Act includes provisions for the establishment of the role and function of the Forestry Department and the vesting of the development and maintenance of a forestry inventory in the Conservator of Forests. A number of forest areas have been designated Forest Reserves and Forest Management Areas and as protected areas could also be protecting the roosting and foraging habitat of bats.

### 3.0 ACTION PLAN for BATS

McFarlane (1989) stated that there is a lack of sound ecological and distribution data on most of Jamaica's bat species. A number of the islands endemic species and endemic subspecies are known from a few large caves or collection sites indicating either their vulnerability to extinction with loss of these site or biases in collection methodology. McFarlane (1989) also states that there are few if any large bat caves left to be discovered and therefore there is a need to study the smaller bat caves. Additionally for species which do not roost in caves but in manmade structures or trees there is a need to identify methodologies to determine their status. Information on the foraging areas for bats is limited to unavailable. Bats can be observed flying at night however, the extent of loss of foraging areas due to development or farming activity is not known. It is vital that this is determined so as to protect the roosting areas without which conservation efforts would be defeated.

Currently there has been no specific provision for the designation of caves as protected areas and the majority of bat caves are found outside of existing areas declared under the NRCA and Forestry Act. There are however protected areas in which bat caves are located including the Portland Bight Protected Area, Negril Environment Protection Area, Blue and John Crow Mountains National Park and the Cockpit Country.

Four major information requirements to achieve the conservation of bats have been identified, they include:

- Current status of the species (distribution and abundance including population size and structure).
- Identification of potential threats or causes of decline (natural or man-made changes).
- Ecological requirement (ecological factors which are essential to the continued existence of the species, including interrelationship with other organisms).
- Conservation application (research on approach to avoid or mitigate predicted or actual threats).



## Action Plan for the Conservation of Bat Species

STRATEGY	OBJECTIVE	ACTIVITY	Year 1	Year 2	Year 3	Year 4	Year 5
STATUS ASSESSMENT	<ul style="list-style-type: none"> <li>Investigate species composition of smaller bat caves.</li> </ul>	Complete assessment of all populations in all known bat caves to identify species composition.	√				
		Identify other roosting areas used by bats which are not caves.	√	√			
	<ul style="list-style-type: none"> <li>Assess Education and outreach needs.</li> </ul>	Develop and implement a public education and awareness programme including preparing brochures on bats and cave tours; values and functions of bats in general.	√	√	√		
		Conduct assessment of the Plan.	Assess effectiveness of management plan.			√	
THREAT DETERMINATION	<ul style="list-style-type: none"> <li>Identify threats to the survival of each of the species, especially those which have restricted habitat requirements.</li> </ul>	Conduct research on the ecology of each species to determine breeding seasons and feeding grounds.		√	√		
	<ul style="list-style-type: none"> <li>Investigate the impact of the introduction of invasive American Cockroach (<i>Periplameta americana</i>) into cave systems.</li> </ul>	Conduct assessment of cave-dwelling invertebrate scavenger species to determine impact on invertebrate species composition.				√	√
ECOLOGICAL REQUIREMENTS	<ul style="list-style-type: none"> <li>Determine the ecology, physical description and habit requirements for endemic species.</li> </ul>	Conduct literature review and field assessments to inform caves and roosts to be protected.	√				
	<ul style="list-style-type: none"> <li>Investigate seasonal or time specific use of roosts.</li> </ul>						
CONSERVATION EFFORTS	<ul style="list-style-type: none"> <li>Identify management and educational requirement for the conservation and protection of Jamaica's bat species.</li> </ul>	Identify and analyze caves suitable for recreational tours.		√			
		Determine user capacity for each cave selected for tours and closed season for tours based on breeding season analysis.			√		
		Conduct training and certification of tour guides.				√	
	<ul style="list-style-type: none"> <li>Identify specific actions required to enable NEPA to better protect Jamaica's bat species and by extension their roosting and foraging</li> </ul>	Identify alternatives habitats, such as bat boxes for bats occupying buildings and causing a nuisance.			√		

STRATEGY	OBJECTIVE	ACTIVITY	Year 1	Year 2	Year 3	Year 4	Year 5
CONSERVATION EFFORTS	sites.	Establish a monitoring programme for caves with large populations and those with endemic species to monitor implementation of management strategies.			√		
	• Protect key sites if appropriate.	Propose caves for protection which have either a high biological diversity or is a roost for endemic or endangered species.		√		√	
	• Establish local monitoring network and boost the membership of Jamaica Cave Organisation.	Foster volunteerism and promote the importance of biodiversity and the responsibility to care for endemic species.	√		√		√
	• Investigate the feasibility of a regional network.	Promote the exchange of data and information on best practice.	√				√

\*activities extracted from NBSAP 2003

## 4.0 FINANCING MECHANISMS

To effectively fund and maintain long-term conservation efforts, a sustainable financing mechanism has to be developed. The mechanism can take several forms including but not limited to government funds, small grant schemes, ecosystem services tax, proposal writing and creative fund raising.

### ***PROPOSED ACTIVITIES***

- Create effective synergies among government agencies such as NEPA, UDC, Forestry Department and other relevant organizations to identify and allocate funds towards a small grants fund to support targeted research and conservation of bats.
- Build capacity of NGOs and other organizations to enable them to effectively access internationally available financial resources.
- Promote and identify the economic valuation of bats and the services they offer. This will help to demonstrate a case for financial support from public, private and international sources.
- Encourage community-based fund-raising activities
- Improve financial accountability of environmental management agencies and organizations.
- Provide training and technical assistance to environmental management agencies and organizations in the design and implementation of fund-raising programs, financial management and accounting.
- Encourage the creation of dedicated environmental funds for bat management, research, management, and capacity building.
- Facilitate development of revenue generating opportunities from parks and protected areas; services such as entrance and user fees, concessions, contributions, tourism related-activities, merchandizing.

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## APPENDICES

## APPENDIX I - Systematic Nomenclature

Order	<b>CHIROPTERA</b>	
Suborder	<b>MICROCHIROPTERA</b>	
Family	NOCTILIONIDAE	<i>Noctilio leporinus mastivus</i> (Vahl, 1797)
Family	MORMOOPIDAE	<i>Pteronotus parnellii parnellii</i> (Gray, 1843) ** <i>Pteronotus macleayi grisea</i> (Grosse, 1851 Gray, 1839) <i>Pteronotus quadridens fuliginosus</i> (Gray, 1843)) <i>Mormoops blainvilli</i> (Leach, 1821)
Family	PHYLLOSTOMIDAE	
Subfamily	PHYLLOSTOMINAE	** <i>Macrotus waterhousii jamaicensis</i> Rehn, 1904
Subfamily	BRACHYPHYLLINAE	<i>Brachyphylla nana</i> (extinct), Miller, 1902
Subfamily	PHYLLONYCTERINAE	** <i>Erophylla sezekorni syops</i> (G.M. Allen, 1917) * <i>Phyllonycteris aphylla</i> (Miller, 1898)
Subfamily	GLOSSOPHAGINAE	** <i>Glossophaga soricina antillarum</i> Rehn, 1902 ** <i>Monophyllus redmani redmani</i> Leach, 1821
Subfamily	STENODERMATINAE	* <i>Ariteus flavescens</i> (Gray, 1831) <i>Artibeus jamaicensis jamaicensis</i> (Leach, 1821)
Family	NATALIDAE	<i>Natalus micropus micropus</i> Dobson, 1880 ** <i>Natalus stramineus jamaicensis</i> Goodwin, 1959
Family	VESPERTILIONIDAE	
Subfamily	VESPERTILIONIAE	* <i>Eptesicus lynni</i> Shamel, 1945 * <i>Lasiurus degelidus</i> Miller, 1931
Family	MOLOSSIDAE	** <i>Tadarida brasiliensis murina</i> (Gray, 1827) <i>Nyctinomops macrotis</i> (Gray, 1840) <i>Eumops auripendulus auripendulus</i> (Shaw, 1800) <i>Eumops glaucinus glaucinus</i> (Wagner, 1843) ** <i>Molossus molossus milleri</i> Johnson, 1952

Note : \*endemic species; \*\*endemic subspecies;

## APPENDIX II

## STATUS OF JAMAICA'S BAT SPECIES BASED ON LITERATURE REVIEW

Scientific Name	Common Name	Status in Jamaica (Genoways <i>et. al</i> , 2000)
ENDEMIC GENUS		
<i>Ariteus flavescens</i>	Jamaican Fig-eating Bat	Common, widespread**
ENDEMIC SPECIES		
<i>Eptesicus lynii</i>	Big Brown Bat	Not widely distributed**
<i>Phyllonycteris aphylla</i>	Jamaican Flower Bat	Uncommon***
<i>Lasius degelidus</i> ****	Jamaican Red Bat	Uncommon***
ENDEMIC SUBSPECIES		
<i>Erophylla sezekorni syops</i>	Buffy Flower Bat	Uncommon**
<i>Macrotus waterhousii jamaicensis</i>	Mexican Big-eared bat	Wide spread and common**
<i>Glossophaga soricina antillarum</i>	Long-tongued bat	Wide spread and common**
<i>Molossus molossus melleri</i>	Pallas' Mastiff Bat	Abundant***
<i>Pteronotus macleayii gries</i>	Macleay's Mustached Bat	Common***
<i>Tadarida brasiliensis murina</i>	Brazilian Free-Tail	Common***
<i>Natalus stramineus jamaicensis</i>	Mexican Funnel-eared Bat	Very rare***
<i>Monophyllus redmani redmani</i>	Leach's Long-tongued Bat	Common & widely distributed**
INDIGENOUS SPECIES		
<i>Pteronotus parnellii parnellii</i>	Parnell's Mustached bat	Common and widespread**
<i>Pteronotus quadridens fuliginosus</i>	Sooty Mustached Bat	Restricted distribution and common at roost
<i>Nyctinomops macrotis</i>	New World Free-tailed bat	Unknown***
<i>Artibeus jamaicensis jamaicensis</i>	Jamaican Fruit Bat	widespread and common**
<i>Mormoops blainvillii</i>	Antillean Ghost-faced Bat	Uncommon**
<i>Noctilio leporinos mastivus</i>	Greater Fishing Bat	uncommon***
<i>Natalus micropus micropus</i>	Cuban Funnel-eared Bat	Rare***
<i>Eumops auripendulus auripendulus</i>	Shaw's Mastiff Bat	Rare**
<i>Eumops glaucinus glaucinus</i>	Wagner's Mastiff Bat	Rare**

Source: NEPA 2008

Key: The genus *Phyllonycteris* and *Erophylla* are endemic to the Caribbean [\*\*\*\*Endemic status needs further review] Source of information: \*\*Genoway *et. al.* (2005); \*\*\*Donaldson and Griffiths (unpublished 1997)

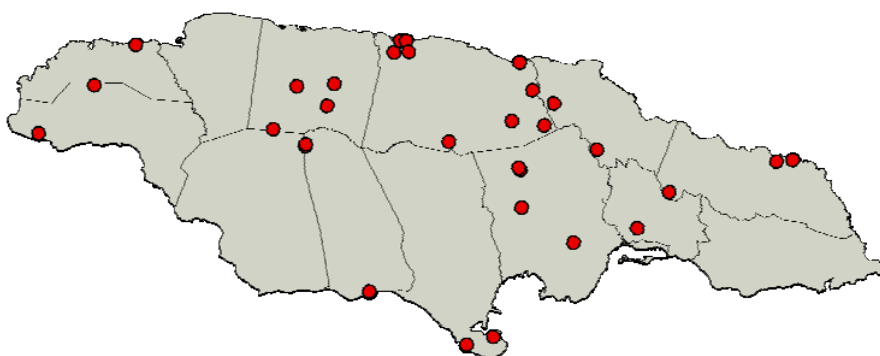
## APPENDIX III

### SPECIES DISCRIPTION AND DISTRIBUTION MAPS

#### **FAMILY - MORMOOPIDAE (Ghost-faced, Naked-backed, Mustached bats)**

Mormoopidae is composed of eight species and two genera distributed from Brazil to the United States of America. The family is thought to be closely related to Phyllostomidae but appear to be closer to Noctilionidae. Mormoopidae are small to medium sized bats with a well-developed noseleaf absent. Their mouth is distinctively shaped like a funnel when opened and their name, “mustached bat”, is due to the fringe of stiff hairs on their mouth. The species typically roost in large colonies, are gregarious and can be found in a wide range of habitat types from rainforest to arid deserts. The species of this family which are found in Jamaica are *Mormoops blainvillii*, *Pteronotus parnellii*, *Pteronotus macleayii* and *Pteronotus quadridens*.

#### ***Mormoops blainvillii* [Antillean Ghost-faced Bat]**



Global Distribution: Found in Cuba, Dominican Republic, Haiti, Puerto Rico and Jamaica (UNEP-WCMC Species Database).

Local Distribution: Records for the species are mainly from the parishes of Trelawny, St. Ann and St. Catherine. There are however no records were found for St. Elizabeth and St. Thomas.

Habitat: They are obligate cave-dweller and therefore their distribution could be limited by the availability of appropriate roost sites (Genoways, *et. al.* 2005).

Physical Description: Information on the physical characteristic is limited; however species collected in Jamaica have had forearm length range between 43mm and 49.1mm and 45.7mm & 46.4mm for females and males respectively and weighed between 15g & 28g and 15g & 20g for males and females respectively. *Mormoops* hair colour on their back is light brown and “buffy” below. There is a dark phase where the upper parts are dark brown and the underparts are ochraceous tawny. *M. blainvillii* lower lip has a peglike projection, the chin has a leaf-like projection and the nose is upturned, short with grooves, ridges and pits.

Reproduction: Information on typical reproductive behaviour was not found in the literature, however in Jamaica no pregnant or lactating females were found during surveys between the months of January to March, June or July. Pregnant females were recorded in April.

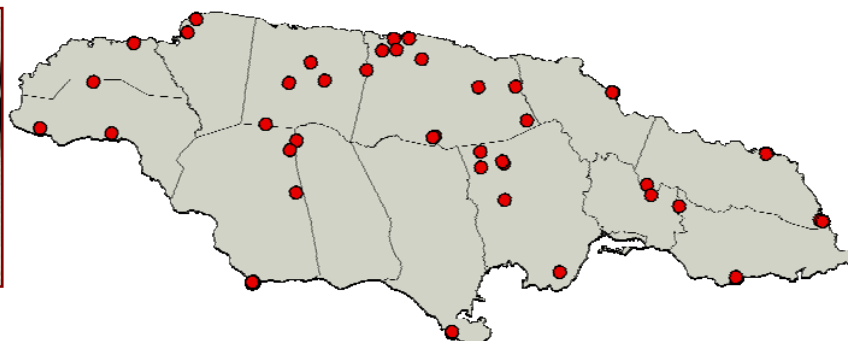
Behaviour: They fly fast, getting to extraordinary speed even in narrow cave passages and also fly with agility (Nowak, 1983). They roost deeper in caves than other Jamaican bat species and also enters small crawl-ways and small chambers. It is believed the species inhabits only the large cave systems in Jamaica and forage in areas associate where water is found (rivers or large ponds).

Food habits: They are insectivores.

IUCN Conservation Status (2000 Red List): They are categorized as Lower Risk - near threatened (LR/nt).

Status in Jamaica: They are considered uncommon Genoways *et. al.* 2005).



***Pteronotus parnellii parnellii* [Mustached Bat]**

**Global Distribution:** Found in Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Honduras, Mexico, Nicaragua, Panama, Peru, Puerto Rico, St. Vincent & the Grenadines, Suriname, Trinidad & Tobago, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** They have been recorded from all parishes in Jamaica. The subspecies *P. p. parnellii* has been identified for Jamaica and Cuba.

**Habitat:** They inhabit areas from coastal lowland to 3000 m and are obligate cave dweller. The species roost in the largest chambers in large humid caves but are not as choosy as other *Pteronotus*. They may also be found in relatively small chambers or hanging beneath shelf-like projects along the sides of the caves passageway. They live on the edges of habitats which range from humid to dry and also moist areas in forest.

**Physical Description:** Individuals captured in Jamaica have had forearm lengths between 52.04 – 52.58mm for males and 50.20 – 52.85mm for females and weighed between 20 & 25g for males and 25g for females. Hair colour often vary from light or dark brown, grayish brown to orchoraceous orange and the underpart is usually paler. Tufts of hair stick out from the side of the species mouth, thus their name “mustached bat”. The wings are long and narrow with the wing aspect ratio being greater than most other bat species. There is an annual molt between May and July where the fur becomes dark brown/blackish colour to a brilliant orange/fulvous. The males are usually larger than females.

**Reproduction:** Females are monestrous<sup>5</sup> and while the time of their pregnancy varies from region to region, it is generally from January to July. However, in Jamaica pregnant females have been recorded in April and December in Jamaica. During mating males and females roost together.

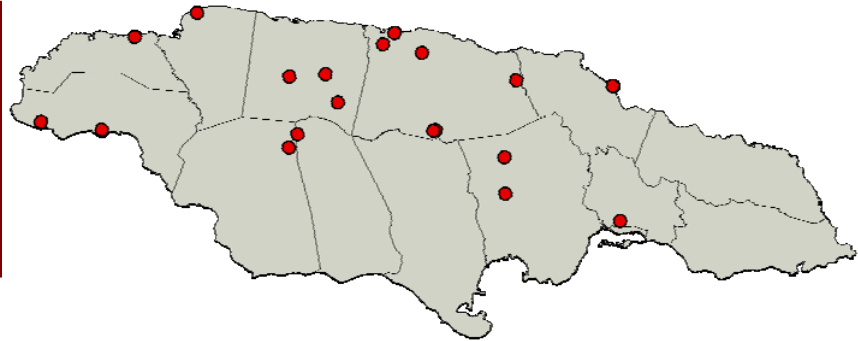
**Behaviour:** Shortly after sunset they leave their roost to feed and remain in flight for about five to seven hours.

**Food habits:** Feed on moths, butterflies and beetles.

**IUCN Conservation Status (Red List 1996):** Categorized as lower risk-least concern (LR/lc).

**Status in Jamaica:** Considered to be common and widespread (Genoways *et. al.* 2005).

<sup>5</sup> Having one estrous cycle per year (<http://www.thefreedictionary.com/>)

***Pteronotus macleayii* grisea [Macleay's Mustached Bat]**

Global Distribution: Present only in Cuba and Jamaica.

Local Distribution: Has been recorded in all parishes except Portland, Clarendon and St. Thomas. *P. m. grisea* is an endemic subspecies on Jamaica.

Habitat: Recorded mainly in low to moderate elevations roosting in caves.

Physical Description: Individuals captured in Jamaica have had forearm lengths between 41.2 – 47.80mm for males and 41 – 49.1mm for females and weighed between 15 & 25g for males and between 20 & 25g for females.

Reproduction

The literature did not provide information on reproductive pattern for the species; however pregnant species have been recorded in April and June.

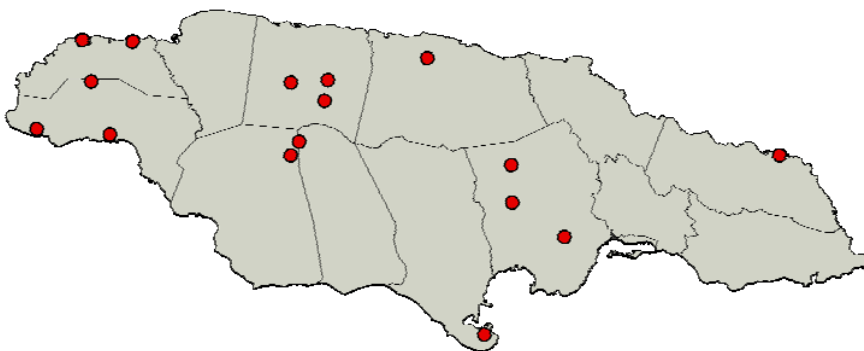
Behaviour

The species is said to be an obligate cave-dweller (that is they are restricted to cave dwelling) as the majority of the species were collected in studies conducted in or near caves.

Food habits: The members of the genus are insectivores.

IUCN Conservation Status (2007 Red List): Categorized as VU A2c.

Status in Jamaica: Classified as common (Donaldson & Griffiths unpublished, 1997)

***Pteronotus quadridens fuliginosus* (Sooty Mustached Bat)**

**Global Distribution:** Endemic to the Greater Antillean islands of Cuba, Dominican Republic, Haiti, Puerto Rico and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** Found in all parishes except, St. James, St. Mary, Kingston & St. Andrea and St. Thomas. *Pteronotus quadridens fuliginosus* is the subspecies in Jamaica, Hispaniola and Puerto Rico.

**Habitat:** The species is an obligate cave dweller and has been recorded roosting in close association with *Monophyllus redmani*, *P. macleayii* and *P. parnellii*. The species has a preference for extensive deep wet cave systems and large high-domed chambers away from the cave entrance.

**Physical Description:** They are the smallest of the *Pteronotus*. Individuals captured in Jamaica have measured between 36 & 39.8 mm for males and 37.3 & 39.3 mm for females in forearm length. In terms of weight these measurements have varied from 5, 15 and 20g for both males and females. They are fully furred and colour ranges from grayish brown to yellowish brown with some individuals having an orange-brown phase. The wing and tail membrane are naked. A noseleaf is absent and the ears are relatively narrow and pointed.

**Reproduction:** The species is monestrous and uniparous<sup>6</sup>. Pregnant females have been recorded in Jamaica during June and July. When born, the offsprings form clusters of 50 to 200 individuals in shallow depressions of the cave wall. The young are carried by the mothers during foraging. There is possibly separation of the sexes during the maternity period as this was noted in Puerto Rico.

**Behaviour:** They are found to congregate in small to medium sized clusters at the highest point of the

chamber. Goodwin (1970) recorded <1000 individuals in thirteen caves surveyed. In Cuba the species has been observed in hot caves with temperatures reaching 39.6°C with a relative humidity of 99%. The species has been recorded roosting with *P. parnellii*, *P. macleayii*, *M. blainvillii*, *M. redmani* and *Erophylla sezekorni*. *P. quadridens* is the first species to exit the cave at dusk commencing the exit 10 to 11 minutes after sunset. They may fly into the open or through the corridors of trees. Most of the individuals will return to the cave 10 to 17 minutes after sunrise.

**Food habits:** They feed on flying insects within the forest understory and consumed coleopterans, dipterans, lepidopterans, orthopterans, and homopterans.

**IUCN Conservation Status (2007 Red List):** Categorized as Lower Risk - near threatened (LR/nt).

**Status in Jamaica:**

The species is considered the least common member of the Mormoopidae in Jamaica (Genoways *et. al.* 2005) and is restricted in its distribution as it noted in only six caves (Geneva Mountain Rat Bat, Oxford, Monarva, St. Clair, Windsor and Thatchfield caves). Work conducted by NEPA during 2006 and 2008 recorded the species in four other caves; therefore it is likely that further work is needed to determine whether their distribution is restricted.

<sup>6</sup> uniparous means producing only one offspring at a time

### Family – NOCTILIONIDAE (Bulldog Bats or Fisherman Bats)

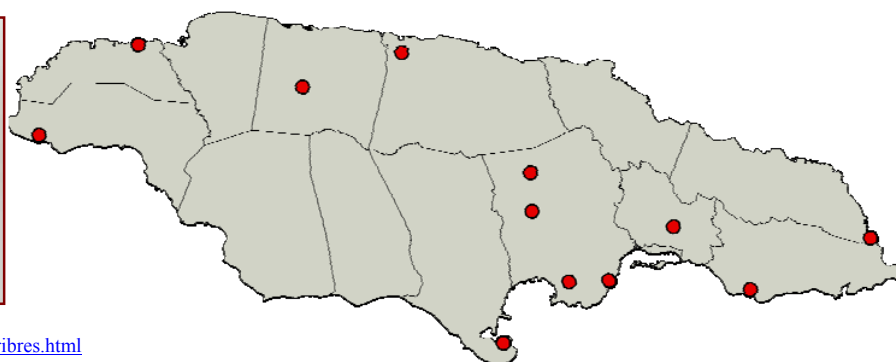
The family Noctilionidae is subdivided into two species and one genus. Its common name is Bull-dog or Mastiff Bats. None of the species are considered threatened by the IUCN (The IUCN Species Survival Commission, 2007). They are medium sized animals with often brightly coloured hair. The feet and claw of the species are relatively large in *Noctilio albiventris* to relatively enormous in *N. leporinus* in size. *N. leporinus* is the larger of the two species. Their legs are proportionally longer than most bats.

### *Noctilio leporinus mastivus* (Bulldog Bat or Fisherman Bat)



(Source: Bat Head)

<http://biomicro.sdstate.edu/pederses/caribres.html>



**Global Distribution:** Recorded in Antigua & Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Suriname, Trinidad & Tobago, U.S. Virgin Islands and Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** Recorded mostly in St. Catherine, however there are records for eight other parishes. The subspecies *N. l. mastivus* occurs in Jamaica, Mexico, Central American, Northern and South America and throughout the Antillean islands.

**Habitat:** They roost near streams, coastal marine habitats, major river basins and other moist places. In Jamaica the species is noted to be expected in coastal and lowland areas and anywhere there are large ponds and slow moving rivers which allow them to catch fish (Genoways *et. al.* 2005).

**Physical Description:** *Noctilio* head-body length is between 98 - 132 mm and forearm length is 70 - 92 mm. Males are larger than the females with the male weighing up to 79g and the female 60g. The males have reddish to orange pelage on the back and the females are usually has a grayish or dull brown fur. The underside of both sexes is paler and the fur is quite

short. Facially, *N. leporinus* has a pointed mouth and no noseleaf. The nose is tubular and projects beyond the lips while the upper lip is large and swollen in appearance. The cheeks of the animal are elastic and can be expanded. An internal pouch (a pocket like structure in the mouth) is present. The wings are long and narrow and are more than two and half times the length of the head and body. The ears are large and slender and are separate while the tail extends between the well developed wing membrane (uropatagium). The species also has long hind limbs with very large hind feet having strong gaff-like claws; the hind feet measuring 1.8 to 3.9 times larger than other non-fishing bats (University of Michigan Museum of Zoology).

**Reproduction:** The males roost apart from the females but when they reside with the females they stay for two or more reproductive seasons. Females bear a single offspring and pregnancies occur from September until January while lactation has been reported from November until April. The pattern however can vary with each geographical location with reproduction corresponding to when food is greatest. Offspring's do not leave the roost until they are nearly adult size at which time they are less than one month of age.

**Behaviour:** The species roost in caves, rocky crevices, or hollow trees. There are occasions that they are found in buildings. Roost as large as 100 individuals have been recorded but there are also roosts with small groups of up to 30 individuals. The species forage in groups of 5 to 15 and they usually feed at dusk and night. They fish over ponds, rivers and at the edge of

ocean surf flying within 20 to 50cm above the water surface and catching fish up to 100mm in length from depths greater than 25cm.

**Food habits:** They are primarily a fish eater (piscivore) but also eat aquatic crustaceans, stinkbugs, crickets, scarab beetles, moths, winged ants and other insects.

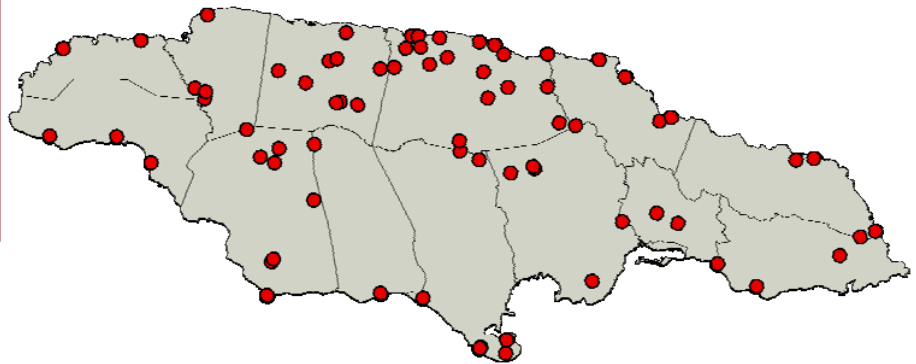
**IUCN Conservation Status (1996 Red List):** Categorized as lower risk-least concern (LR/lc).

**Status in Jamaica:** The species is considered to be uncommon (Donaldson & Griffiths, unpublished, 1997)

#### **Family - PHYLLOSTOMIDAE (American Leaf-nosed Bat)**

Phyllostomidae is a common and diverse family which includes one hundred and forty-nine (149) species and forty-nine (49) genera which are carnivores, insectivores and frugivores. IUCN classifies thirty (30) of the species as threatened (The IUCN Species Survival Commission 2004). The Glossophaginae (subfamily) are nectar feeders featuring an adaptation of the tongue and rostrum for extracting nectar and pollen, and have the ability to hover. The subfamily Brachyphyllinae (extinct from Jamaica) is a fruit and nectar feeders restricted to the West Indies. The most conspicuous characteristic of the family is the noseleaf. This is a fleshy protuberance on the nose which range in size from as long as the head to completely absent. This family is represented in Jamaica by the species *Macrotus waterhousii*, *Erophylla sezekorni*, *Phyllonycteris aphylla*, *Glossophaga soricina*, *Monophyllus redmani*, *Ariteus flavescens* and *Artibeus jamaicensis*. *Brachyphylla nana* was in Jamaica but is now extinct.

#### ***Artibeus jamaicensis jamaicensis***



**Global Distribution:** Recorded on Anguilla, Antigua & Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Suriname, Trinidad & Tobago, United States of America, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** Collected in all parishes in Jamaica. The subspecies *A. j. jamaicensis* is found on Jamaica, Hispaniola, Puerto Rico, Virgin Islands, the Lesser Antilles, Providencia and San Andrés.

**Habitat:** The species has a relaxed roost requirement and roost in caves, tree holes, foliage and anthropogenic structures. They occupy habitats from sea level to 2135m. In Jamaica the species has not however been recorded above 1000m. Not an obligate cave dweller, the species presence in a cave is usually indicated by a garden of pale, spindly plant seedlings on the cave floor beneath where they roost.

**Physical Description:** This is a medium sized bat with a well developed noseleaf. Individuals captured in Jamaica had forearm measures of between 52.0 to 67.4mm while total body length is 78 to 89m. Their uropatagium is hairless. No head body?

**Reproduction:** The species has a bimodal polyestrous cycle with a peak of parturition in March and April and a second peak in July and August. Females produce a single offspring, rarely twins

**Behaviour:** The species roost in areas where significant light penetrates. They are seldom closely associated with other bat species in the cave.

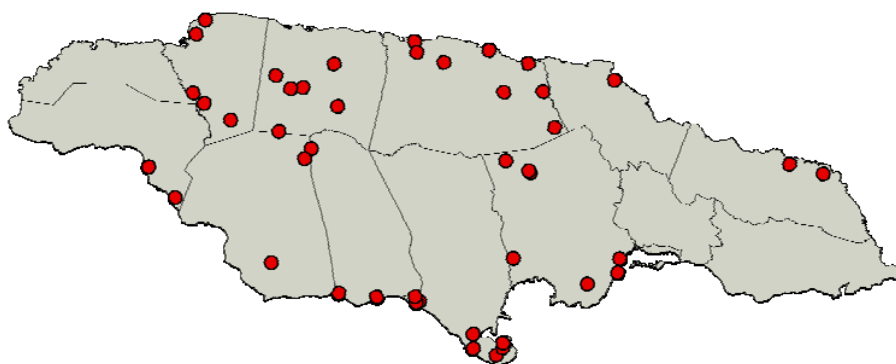
**Food habits:** The species feeds mostly on fruits but is also noted to feed on ants, nectar and leaves. Plants identified in the caves in which they roosts includes *Andira inermis* (Cabbage Bark Tree), which Goodwin

(1970), states is a staple of the species and *Brosimum alicastrum* (Breadnut).

**IUCN Conservation Status (1996 Red List):** Categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** It is one of the most common bat species in Jamaica.

### ***Macrotus waterhousii jamaicensis* (Waterhouse's Leaf-nosed Bat)**



**Global Distribution:** This species *Macrotus waterhousii* has been recorded on the Bahamas, Cayman Islands, Cuba, Dominican Republic, Guatemala, Haiti, Mexico, Puerto Rico and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** The subspecies *Macrotus waterhousii jamaicensis* is endemic to Jamaica. It was been recorded from all parishes except two, Hanover and St. Thomas and is found in caves and subterranean human constructed habitats. They are absent from sites above 500-600m in elevation.

**Habitat:** The species can be found in areas from sea level to at least 1400m (in Mexico) and is found in tropical and subtropical areas. Caves are the chief dwelling site for the species, however they have been found to occupy mine tunnels and buildings. Temperature can influence the selection of a roost.

**Physical Description:** *M. waterhousii* has sexual dimorphism which is noted in the adult females which are grey while the males have a distinct reddish cast. The furs of subadults are grey and darker and finer in texture than females. This is the only species in Jamaica where fur colour is correlated to their sex.

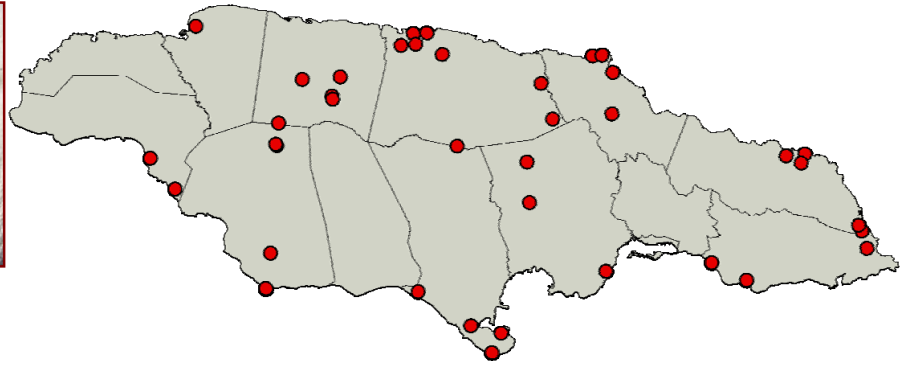
**Reproduction:** During the summer months, females separate into maternity colonies and males into smaller groups

**Behaviour:** The species does not require complete darkness and thus are oftentimes found within 10 to 30m of the entrance of their roost. They emerge 30 minutes or more after sunset.

**Food habits:** The species seems to be a total insectivorous feeder, eating orthoptera, noctuid moths, scarab beetles, sphinx moths and cicadas. In Jamaica during the capturing of the species in 2006, it was noted to have dropped a large moth. The food is probably taken from the ground or vegetation.

**IUCN Conservation Status (1996 Red List):** Categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** The species is considered to be common and widespread (Genoways *et. al.* 2005).

***Glossophaga soricina antillarum* [Pallas' Long-tongue Bat]**

**Global Distribution:** The species *Glossophaga soricina* has been recorded on Argentina, Bahamas, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Grenada, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad & Tobago, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** The species is considered to be widely distributed throughout the island (Genoways *et al.* 2005). Jamaica is the only island in the West Indies where the species occurs. The subspecies *Glossophaga soricina antillarum* is endemic to Jamaica.

**Habitat:** The species forages mostly in areas described as moist and open; however it is felt that it maybe absent from areas above 750m.

**Physical Description:** Average weight for the *G. soricina* varies from region to region. In Colombia, on its north coast the average weight of the species was 9g while other populations weighed 10.5g.

**Reproduction:** Similar to physical characteristics, the reproductive behaviour of the species varies between geographical locations, however the two main characteristics seems to be their continuous year round

breeding and bimodal polyestry. Females normally give birth to a single offspring.

**Behaviour:** In Colombia, on their north coast, two types of foraging behaviour have been recorded. Some individuals defend their foraging area chasing away intruders while others have a trap-line behaviour which involves a routine of visiting a variety of plants each night following the same route. The bats feed during the first four hours after sunset and forage by hovering or hanging on the flower. Colonies of up to 1000 individuals have been reported in a roost.

**Food habits**

*G. soricina* feeds on pollen, nectar, flower parts, fruits and insects. It is known to feed on at least thirty-four different species of plants.

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** The species is considered to be common (Genoways, *et al.* 2005).

***Monophyllus redmani redmani* (Leach's Long-tongued Bat)**

**Global Distribution:** The species *Monophyllus redmani* has been recorded on the Bahamas, Cuba, Dominican Republic, Haiti, Puerto Rico, Turks and Caicos Islands and Jamaica (UNEP-WCMC Species Database). However, Genoways *et. al.* (2005) has stated that the species only occurs on the islands of the Greater Antilles.

**Local Distribution:** The species is widely distributed throughout the island. Subspecies *Monophyllus redmani redmani* is endemic to Jamaica and has been recorded in Oxford Cave, St. Clairs Cave, Windsor (Great) Cave, Mount Plenty and San Sousi Grottos.

**Habitat:** The species has been found from sea level to over 1500m, however have not been recorded at higher elevations like in the Blue Mountains. It seems to prefer large deep caves which have high humidity, occupying chambers which were large and dome-shaped having high ceiling. Colonies in excess of 1000 individuals have been recorded broken into small and medium sized clusters. They are considered to be obligate cave dwellers.

**Physical Description:** The head-body length of the species is 50 to 80mm and a forearm length of 35 to 45mm. Weights averaging 8 to 13g have been recorded. Fur colour varies in shades of brown with gray. Facially, the species has an elongated mouth with a long tongue with papillae. Half of the tail projects beyond the edge of the interfemoral membrane.

**Reproduction:** The reproductive cycle of the species closely fits the monestry pattern (Genoways, *et. al.* 2005). The females produce only one offspring per year during each breeding season. Gestation occurs in late November with parturition from March to May and lactation from March until July. The cycle is highly synchronous. In Jamaica, pregnant females were noted in December, January and February. The species sexes may be segregated

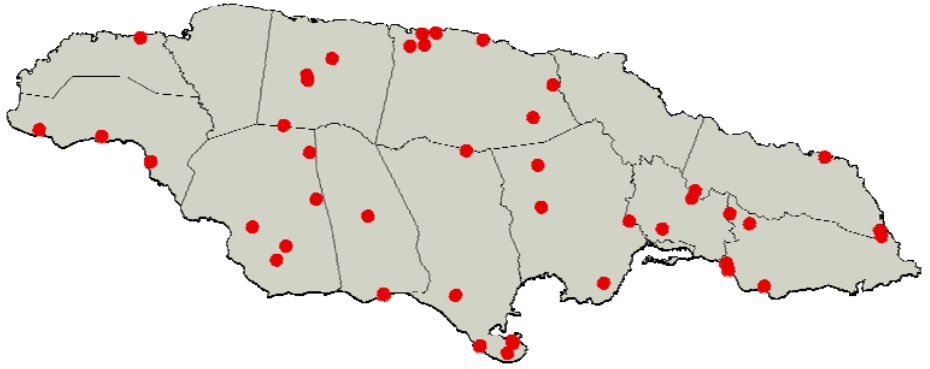
**Behaviour:** Information specific to the species was not found.

**Food habits:** The anatomy of the species tongue and mouth suggest that it is mainly a nectivore similar to the species *Glossophaga soricina*. There is no firm data on their feeding habits, however, the species is likely to feed on soft fruit or nectar and possibly some insects.

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** The species is considered to be common in Jamaica (Genoways *et. al.* 2005).



***Ariteus flavescens* (Jamaican Fig-eating Bat)**

Global Distribution : The genus and species is endemic to Jamaica.

Local Distribution: The species has a widespread distribution and is found throughout the island. They however have not been recorded at elevations above 1500m.

Habitat: The species is found in forested areas as this is a tree roosting species. Information on habitat is limited as most of the bat studies conducted in Jamaica has been mainly in relation to cave-dwelling species.

Physical Description: The head-body length is about 50 – 67mm and forearm length is 40 – 44mm. A weight of 9.2 – 13.1g has been recorded for the species. In terms of colouration they are light reddish brown above and paler below with a small white patch on each shoulder.

The reproductive information on the species is incomplete however some conclusions are drawn regarding the species. It is felt that the species is

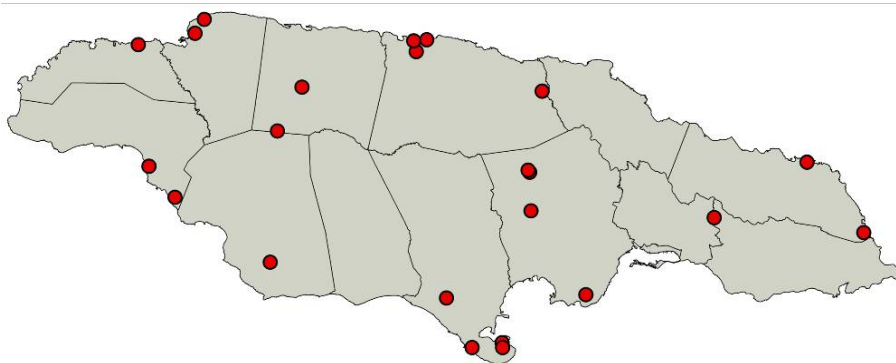
polyestrous based on the collection of pregnant females early April until late July. The females seem to have synchrony in breeding as most in April, June and July were pregnant.

Behaviour: Limited information was found on the behaviour of the species, however Nowak (1983) states that they begin flying and feeding shortly after sunset.

Food habits: Individuals have been netted in orchards of bananas, rose apple (*Syzygium jambos*), cashew (*Anacardium occidentale*), cocoa (*Theobroma cacao*) naseberry (*Manilkara zapota*). It is considered to be a fruit bat.

IUCN Conservation Status: The 2007 IUCN Red List of Threatened Species, categorized the species as vulnerable (VU, A2c, D2). This category is based on dated from 1996.

Status in Jamaica: The species is considered to be common on the island.

***Erophylla sezekorni syops* (Brown Flower Bat)**

Little is known about the ecology of the species in Jamaica, however McFarlane (1989) states that it is similar to *Phyllonycteris aphylla*.

**Global Distribution:** The genus *Erophylla* is endemic to the Greater Antilles and the Bahamas with *E. sezekorni* found on the Bahamas, Cayman Islands, Cuba, Turks and Caicos Islands and Jamaica (UNEP-WCMC Species Database). Genoways *et. al.* (2005) however has stated that the species is found only on Jamaica, Cuba, and the Bahamas.

**Local Distribution:** The subspecies *E. s. syops* is endemic to Jamaica and has been recorded in all parishes except three (Manchester, Kingston and St. Andrew). McFarlane (1989) stated that the species was known from three caves, Mount Plenty Cave, Sewell Cave and St. Clair Cave.

The species has not been found to be abundant in any of the sites recorded. Largest roosting colony recorded in Jamaica was in the St. Clair Cave.

**Habitat:** The species has been recorded from sea level to 1300m. The species is an obligate cave dweller and has been found roosting with the *Phyllonycteris aphylla*, *Pteronotus parnellii*, *Monophyllus redmani* and *Artibeus jamaicensis*.

**Physical Description:** The dorsal hair of the species is distinctly bicoloured with more than half of the basal portion being white, with the distal portion tipped with chestnut brown. The hair on the head and face is paler, shorter and unicoloured. Ventrally the hair colour is wood-brown and the base of the hair is whitish. The length of their forearm ranges between 45.4 – 46.6mm. In the genus, head-body length measures 65 – 75mm. Externally the genus resembles *Phyllonycteris* and similar to *Glossophaga* they have a long tongue which is protrusible and armed with bristlelike papillae. Their noseleaf is notched/forked at the tip.

**Reproduction:** The species mating behaviour has not been studied. Pregnant females have however been collected in June/July in Puerto Rico and in February in Cuba. The species appear to be a seasonal breeder possibly bearing a single offspring a year.

**Behaviour:** The species has been found to roost in the dark interior of the caves and also in the areas which are exposed to daylight. However they have also been reported to only roost in the deep and dark portions of the cave in the Bahamas. The species leave their roosting areas later in the evening approximately 53 to 100 minutes after sunset. Feeding does not occur under direct light.

**Food habits:** The species feeds on fruits, pollen, nectar and insects.

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** The species is considered to be uncommon (Genoways *et. al.* 2005) however Genoways believes there is more to learn about the ecology and roosting behaviour of the species in Jamaica. McFarlane (1989) considered the species to be rare. He stated that St. Clair Cave population was the one of the most significant size (several hundred individuals)

***Phyllonycteris aphylla* (Jamaica Flower Bat)**

Little is known about the ecology of the species however what has been discovered is presented.

Global Distribution: The genus *Phyllonycteris* is endemic to the Great Antilles and the species is endemic to Jamaica.

Local Distribution: McFarlane (1986) stated that the species was only known from three caves, St. Clair, Riverhead Cave and Mount Plenty Cave. Fossil remains have been found in Dairy Cave (Runaway Bay Cave), Wallingford Cave.

Habitat: Based on capture records, the species appears to be absent on the southern coast of the central area and the Blue Mountains. It is believed that the south coast could be too hot and dry for the species to inhabit. The caves occupied by the species are typically associated with abandoned river resurgences (McFarlane, 1986).

Physical Description: Limited information was found on the species, however the genus head-body length is 64-83mm and forearm length is 43 – 50mm. Three *P. aphylla* captured weighted between 14.0 and 14.8g. The species has a light yellowish brown on its upper and lowerparts. In the genus the tongue is long, protruisble and armed with bristlelike papillae while their noseleaf is said to be rudimentary.

Reproduction: There is limited reproductive data for the species however it is suggested that gestation occurs in

January and June and lactation in January and July. It thus appears that the species is polyestrous, whether this is a bimodal pattern is not known (Genoways, *et. al.* 2005).

Behaviour: The species is gregarious and is an obligate cave dweller. They form colonies of up to a few hundred individuals in large cave entrances.

Food habits: The species has been captured in orchards with fruit trees such as mango, banana and papaya and also in areas associated with eater either rivers or large ponds. In McFarlane (1989), it was stated that the species is unable to bite into firm fruits but feeds on juice and pulp from overripe and damaged fruits on the ground. The structure of their tongue implies that they are pollen and nectar feeders. What is likely is that the species feeds on pollen and nectar in the dry season and fruits in the wet season.

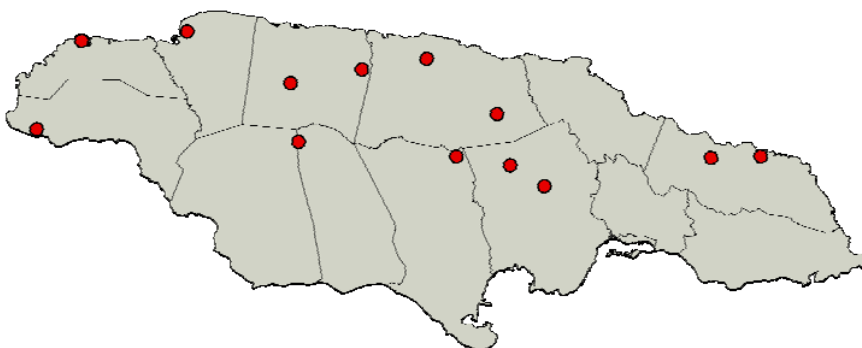
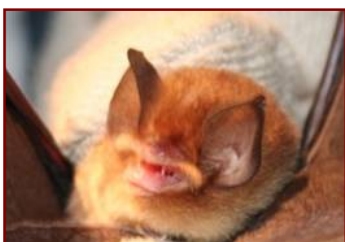
IUCN Conservation Status: The 2007 IUCN Red List of Threatened Species, categorized the species as Endangered (EN - B1+2c)

Status in Jamaica: In January 2005, Dr. Donald McFarlane (2005) visited Jamaica to conduct the project entitled *Evaluation of the Conservation Status of St. Clair Cave, Jamaica*, did not record any individuals of this species or the species *Erophylla sezekorni*. He therefore concluded the species could be considered of the highest priority for conservation and efforts are needed to locate and secure roost for the species before it becomes extinct.

### Family - NATALIDAE

The family Natalidae is composed of five species and one genus and is found in the tropical lowlands of the New World. One of the species is considered to be threatened by the IUCN (The IUCN Species Survival Commission, 2004). These are small bats with relatively long legs. They are quite common in some places found roosting in caves and mines with social groups ranging from very large to less than ten. Species flight is fluttery and moth-like. Two of the five species are found in Jamaica, *Natalus micropus* (reclassified as *Chilonatalus micropus*) and *Natalus stramineus*.

#### *Chilonatalus micropus* (Cuban Funnel-eared Bat)



**Global Distribution:** The species *Chilonatalus micropus* has been recorded in the Colombia, Cuba, Dominican Republic, Haiti and Jamaica (UNEP-WCMC Species Database). While Genoways *et. al.* (2005) stated that the species occurs only on the three largest islands in the Greater Antilles.

**Local Distribution:** The subspecies *Natalus micropus micropus* is found on Jamaica and Hispaniola. It is distributed across Jamaica and has been recorded in all parishes except St. Thomas, St. Mary and St. Elizabeth. The species has not been found in abundance except in the Oxford, St. Clair and Windsor Caves.

**Habitat:** The species is found throughout Jamaica at low to intermediate elevations. This is an obligate cave dweller and has been recorded in the St. Clair, Monarva and Windsor Caves. These caves are known to be warm, very humid and support large populations of several bat species.

**Physical Description:** This is a small sized bat and is smaller than the other *Natalus* species on Jamaica.

Captured *N. m. micropus* had forearm length recorded below 36.0mm while *N. stramineus* had forearm measurements were not less than 43.0mm. There appears to be colour polymorphism in the species as individuals collected from the Oxford Cave colour varied from brownish grey to yellowish chestnut (Genoways, 2005).

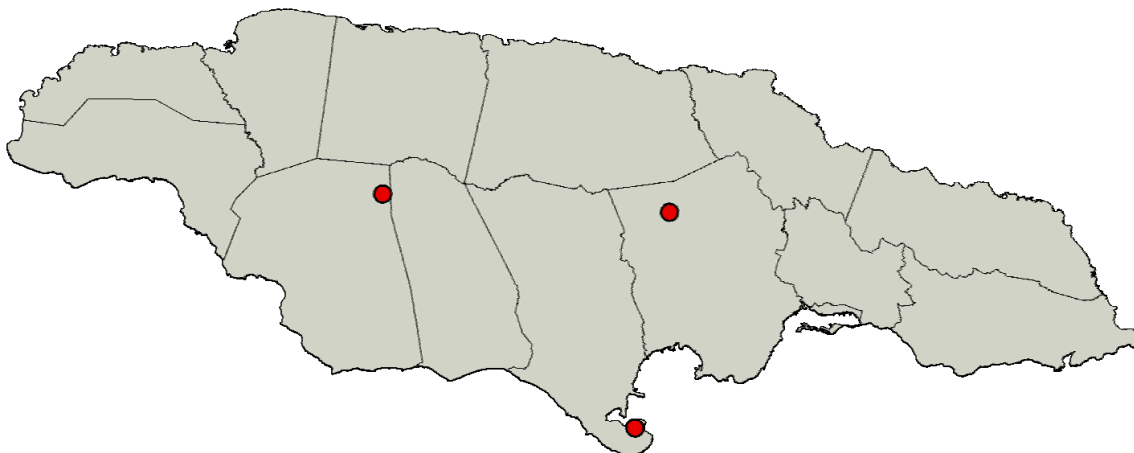
**Reproduction:** Reproductive data for the species on Jamaica was not found.

**Behaviour:** The species appears to only inhabit large caves and is a slow flier.

**Food habits:** *N. micropus* is strictly an insectivore.

**IUCN Conservation Status (2009 Red List):** Categorize the species near threatened.

**Status in Jamaica:** Based on the level of collected specimens and their distribution pattern, it is likely that the species could be considered to be uncommon. The population was estimated at several hundred.

***Natalus stramineus jamaicensis* (Large Funnel-eared Bat)**

The ecology of the subspecies is presumed to be similar to *N. micropus* and similar to the mainland *N. stramineus* which is also poorly studied.

**Global Distribution:** The species *Natalus stramineus* have been recorded on Anguilla, Antigua & Barbuda, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba (extinct), Dominica, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, St. Kitts & Nevis and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** The species is more restricted in their distribution in comparison to any other species of bat in Jamaica as it is only known from St. Clair Cave (Genoways *et. al.* 2005). The species in Jamaica is the endemic subspecies *N. stramineus jamaicensis*.

**Habitat:** *N. stramineus* generally occupy dry and semi-deciduous forest, secondary growth forest and may also be found in evergreen forest. They have been recorded at elevations of up to 2,400m but are typically found at 300m. The caves in which they roost are generally moist for example the St. Clair Cave. The species has delicate wing membranes which are subject to rapid dehydration thus their day roost has to have a relative high humidity (Hoyt & Baker, 1980).

**Physical Description:** This is a very small and delicate species with a high surface to body ratio. It has long, narrow wings and range in weight from 3 to 5g with a head/body length of 38 to 46 mm and forearm length of 36 to 39mm. The hair of the species is pale orange-brown or yellowish in colour on the upper part and yellow on the underside. Their ears are funnel shaped, broad and cream in colour with black edges, while the eyes are very small and the skin on their face is pale

pink with a mustache over the side of the mouth. The tail of the species is longer than head/body length (unique to the species) and is enclosed in the interfemoral membrane. This membrane is pale brown in colour with short hair on the edges.

**Reproduction:** There is limited information on the reproductive behaviour for *N. stramineus*, however, some information is available for specific countries. In El Salvador and Mexico, the species is said to breed during the dry season while in Mexico pregnant females have been recorded from January to July. Females are believed to be monoestrus producing a single offspring yearly which weights about half the weight of an adult. The sexes are separate during the breeding season.

**Behaviour:** The species roost in deep, moist caves and are typically found in groups of up to 300 bats. They space themselves widely in the cave caverns. The species are mainly active within two hours after sunset and fly with great speed and agility through the vegetation. It is estimated that they leave their roost 30 minutes after sunset to feed.

**Food habits:** The species feeds on small flying insects.

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica**

Based on the very limited distribution, the species can be considered rare. It is rarer than *N. micropus* and is less well known.

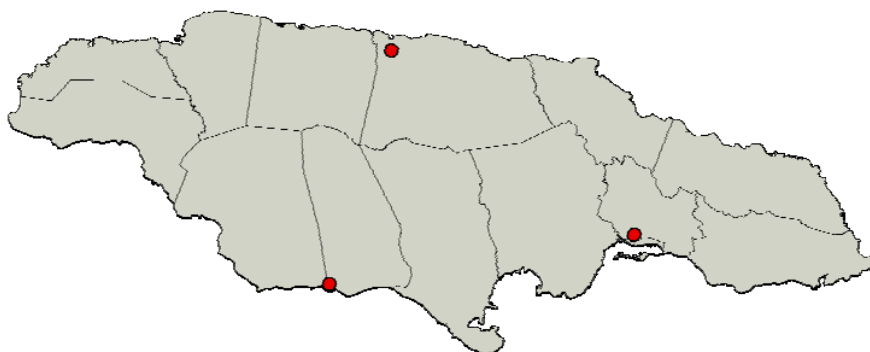
### Family - MOLOSSIDAE

There are eleven genera and ninety species found in the family, they are distributed throughout the warmer parts of the world. Seventeen of the species are considered to be threatened (IUCN Species Survival Commission, 2004). This group of bats roosts in caves, tunnels, and hollow trees, under bark, in foliage, the decayed wood or logs and the crevices of rock cliffs, under rocks, in holes in the earth and buildings and other human structures such as corrugated iron roofing. The presence of this species is characterized by a musky odour. Insectivorous, the insect species are often the hard-shelled form. This family is represented by the species *Tadarida brasiliensis*, *Nyctinomops macrotis*, *Eumops glaucinus*, *Eumops auripendulus* and *Molossus molossus* in Jamaica.

#### *Eumops auripendulus aurepenulus* [Shaw's Mastiff Bat]



(Source - wikimedia.org)



**Global Distribution:** The species *Eumops auripendulus* has been recorded in Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** The species has been recorded from three localities in Jamaica, Alligator Pond, Queenhythe, and Kingston. *E. auripendulus auripendulus* is known from Mexico, Central American, northern South America and Jamaica. Genoways *et. al.* (2005) has stated that the population in Jamaica is the only one on any of the Antillean islands.

**Habitat:** The species have been found in highland and coastal areas. Like reproduction, depending on the geographical region, the species are found in different locations. Mexico has recorded the species in dense forest and coastal plains. Their roosting sites are also varied as they have been recorded in loose slabs of bark, beneath corrugated iron roofs and in attics. In Jamaica all the locations at which the species was recorded was at 400m (Genoways *et. al.* 2005).

**Physical Description:** This is a medium sized free-tailed bat (tail extends about one and a half its length beyond the wing membrane-uropatagium). The colour of the fur on the dorsal side of the bat is dark blackish brown or dark reddish brown, the ventral side is paler and the

sides are grayish. The base of the dorsal hair is buffy white. Long hairs are present on the feet and extend past the tips of the claws. The ears are moderately large, broad and round. The mouth of the bat is obtuse with shallow wrinkles present on the lips.

**Reproduction:** *E. auripendulus* is polyestrous with the females breeding period varying with geographical regions. In French Guiana, pregnant females have been recorded in February while in Trinidad lactating females have been recorded in August while Bolivia had pregnant females in August.

**Behaviour:** The species have been observed at dusk. They tend not to hang head down but rather they crawl into cracks and small recesses. If disturbed they do not fly but escape by running.

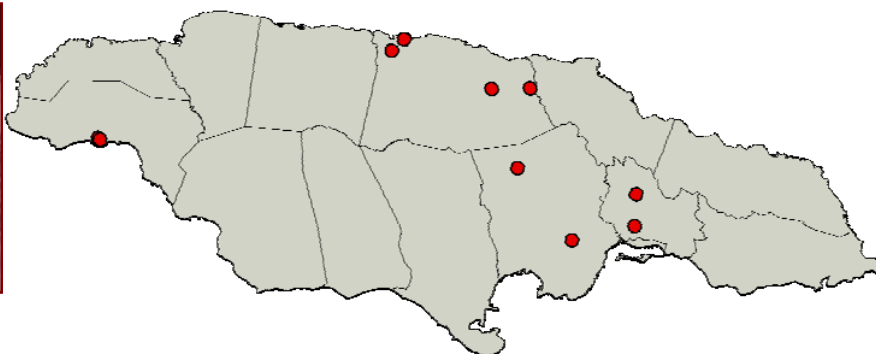
**Food habits:** The species are insectivores.

**IUCN Conservation Status:** The Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** Based on the collection records, it is likely that this is a rare species.

***Eumops glaucinus glaucinus* [Wagner's Mastiff Bat]**

(Source – Bat Conservation International)



**Global Distribution:** The species *Eumops glaucinus* has been recorded on Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Ecuador, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, United States of America, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** This species seem to have a wider distribution than *E. auripendulus* as it has been recorded in more areas such Half Way Tree, Stony Hill Road, Queenhythe, Savanna-la-Mar, Mount Plenty Cave, Runaway Bay Caves, St. Clair Cave and Phoenix Park. The subspecies *E. g. glaucinus* is found in southern Mexico, Central America, the northern half of South America and Jamaica.

**Habitat:** *E. glaucinus* typically inhabit subtropical forest and urban areas throughout its range. The habitat types will vary according to geographical location. In Florida its habitat is subtropical forest, while in Cuba and Costa Rica it is urban areas, in Venezuela and Mexico it is tropical moist forests and deserts and in Argentina it is scrublands and montane forest.

**Physical Description:** This is a medium sized bat compared to other species in the genus. Their fur varies in colour from black or brownish grey to chestnut. The underside of the bat is noticeably lighter. There is no noseleaf and the mouth is elongated, its ears are wider than long and extends beyond the mouth if brought forward. The tail extends beyond the margin of the wing membrane and the species is also said to have a pungent musky odour, the function of which is unknown. In the genus, head-body length measures 40 – 130mm while forearm length is 37 – 83mm.

**Reproduction:** Limited information on the species in Jamaica was found, however it was noted that *E. glaucinus* females lactate for five to six weeks

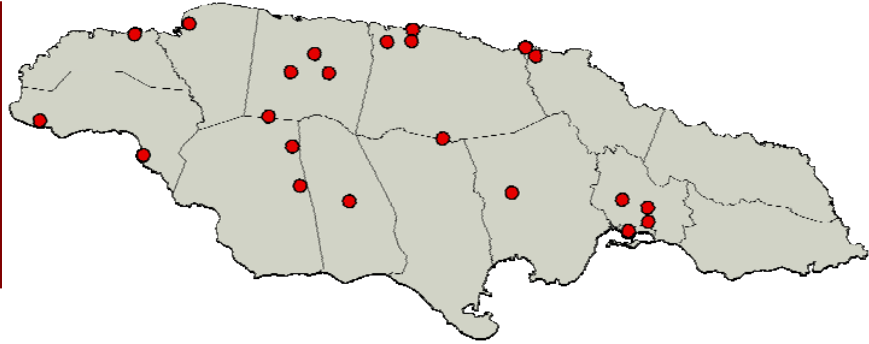
**Behaviour:** A colony of the species consists of one male and several females. Colonies roost together with

roosting commencing after sunrise. The species is inactive in cooler climates, however it is not known to hibernate.

**Food habits:** The species is an insectivore and flies high and in a straight line to detect insects. Using echolocation, they detect insects at distances of three to five meters catching them in flight. Insects consumed includes beetles (Coleoptera), true flies (Diptera), true bugs (Hemiptera), moths and butterflies (Lepidoptera) and grasshoppers (Orthoptera).

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** The species is considered to be rare (Genoways, *et. al.* 2005).

***Molossus molossus milleri* (Pallas' Mastiff Bat)**

**Global Distribution:** The species *Molossus molossus* has been recorded on Anguilla, Antigua & Barbuda, Argentina, Belize, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent & the Grenadines, Suriname, Trinidad & Tobago, United States of America, U.S. Virgin Islands, Uruguay, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** The subspecies *M. m. milleri* is endemic in Jamaica and has been recorded in all parishes in Jamaica except for Portland and St. Thomas.

**Habitat:** The species in Jamaica has been found in low and intermediate elevations but is absent from higher elevations. It has also not been recorded on dry, hot southern coast except the Kingston area. Genoways *et. al.* (2005) conducted a review of the records of bat species in Jamaica and showed no evidence of the species being collected in the parishes of Portland or St. Thomas. No reason for the absence was hypothesized as it was difficult to explain due to the level of collection that has occurred in that area. Goodwin (1970) stated that this species is not an obligate cave dweller and has been primarily found in attics, crawl spaces beneath roofs or hollow trees.

**Physical Description:** Information on the physical description of the species in Jamaica was not available.

For the genus however head-body length measures 50-95mm and forearm length measures 33 – 60mm. The genus weighs between 10 -30g. In terms of hair colour they are reddish brown, dark chestnut brown, dark brown, rusty blackish or black. All the species of the genus may have two colour phases. Externally they are similar to *Tadarida*. The base of the ears meets at the forehead.

**Reproduction:** Reproductive activity in Jamaica was not found, however a number of records exist for a number of areas for the genus. Some include Trinidad, where the species produces two litters per year, Nayarit, Mexico where pregnant females have been collected in July and the Yucatan where pregnant females were collected from April to August. All reproductive records for the genus have only reported a single offspring.

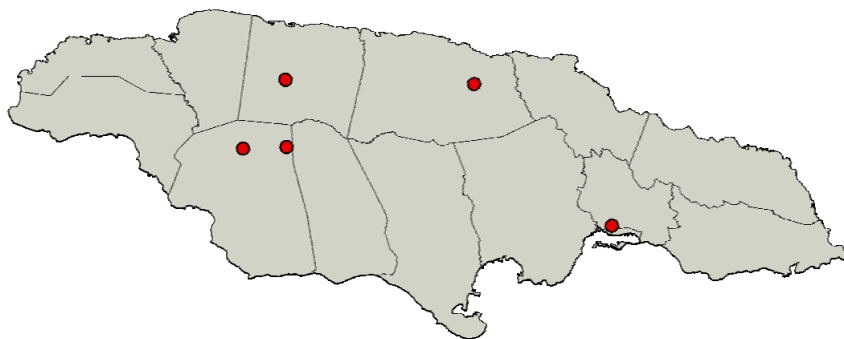
**Behaviour:** The species in the genus fly early in the evening often before sunset. They roost in groups of several hundreds with males and females roosting in different areas.

**Food habits:** They are likely to be insectivores.

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status on Jamaica:** It is considered to be one of the most abundant species in Jamaica.



***Nyctinomops macrotis* (Big Free-tailed Bat)**

Very little is known about the natural history of the species in Jamaica.

**Global Distribution:** The species *Nyctinomops macrotis* have been record on Argentina, Bolivia, Brazil, Canada, Colombia, Cuba, Dominican Republic, Ecuador, Guyana, Haiti, Mexico, Paraguay, Peru, Suriname, United States of America, Uruguay, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** This species has only been recorded in a few locations in Jamaica, including Kingston, Grove Cave, Balaclava, Bagdale Cave, Maggotty, Ewart Town Bat Cave and Wallingford Roadside Cave. In 2007, the presence of the species was recorded by NEPA during an assessment of cave systems in Canoe Valley.

**Habitat:** The species has been collected at intermediate elevations in St. Ann and St. Elizabeth and is noted in rugged and rocky terrain. There are populations which migrate seasonally from Mexico to south-western United States preferring rocky cliffs in weathered rock fissures and crevices. In these areas, the species has also been found to roost in buildings and terrestrial plants including Ponderosa pines and Douglas firs and desert shrubs.

**Physical Description:** Adult males have a head-body length of between 140 to 160mm and females 120 to 139mm. Their coats are very velvety and glossy, almost greasy to the touch and are bi-coloured being dark red to dark brown on the back and much lighter on the ventral area. The wings of the species are long and narrow with the wing membrane being thin and leathery and the tail extending freely beyond membrane. The face of the species is black and the ears lay forward, joined at their bases on the top of the head. The mouth is thin with the upper lip very furrowed and their legs are short but very strong.

**Reproduction:** The pregnant female and males do not roost together and each sex forms a colony within the cave. Pregnant females rely on their stored body fat and their colony to provide food for unborn young and once lactating, the female will care for its offspring for between 2 to 3 months. Three pregnant females were collected in Jamaica during the month of June.

**Behaviour:** The species is strictly nocturnal only leaving the roost after sundown to forage. They are also mainly solitary hunters occasionally hunting in small groups and are strong flyers.

**Food habits:** The species primarily feed on large months but are known to hunt ground dwelling insects such as crickets, stinkbugs and flying ants.

**IUCN Conservation Status:** The IUCN Red List 1996 categorized the species as lower risk-least concern (LR/lc).

**Status in Jamaica:** Based on the distribution record it is likely that this species is rare on the island.

***Tadarida brasiliensis murina* (Brazilian Free-Tailed Bat)**

**Global Distribution:** The species *Tadarida brasiliensis* has been recorded on Antigua & Barbuda, Argentina, Bahamas, Belize, Bolivia, Brazil, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands (Malvinas), Guadeloupe, Guatemala, Haiti, Honduras, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Trinidad & Tobago, Turks & Caicos Islands, United States of America, Uruguay, Venezuela (Bolivarian Republic of) and Jamaica (UNEP-WCMC Species Database).

**Local Distribution:** The subspecies *T. b. murina* is endemic to Jamaica and has been recorded in all parishes except Westmoreland and Hanover. The species *T. brasiliensis* has one of the most extensive geographic ranges of any of the New World bats.

**Habitat:** Records for the species have been concentrated between intermediate and the highest elevations. The species does not seem to inhabit the dry and hotter southern coast but are primarily along the northern coast of Jamaica. The species prefers undisturbed habitats and often roosts near water. The literature states that the species is primarily a cave dweller but it appears with human occupation of areas, the species is frequently found in man-made structures such as under bridges or in buildings. Goodwin (1970) stated that in Jamaica, the species primarily inhabits man-made structures.

**Physical Description:** These are medium sized bats with fur that is reddish to dark brown but can also be grey, while the ears are black. Body wise this is a broad bat. The lips are wrinkled which is characteristic of the family and the ears joined in the midline. The distal half of the tail extends freely beyond the

uropatagium. In the genus, head-body length measures, 45-121mm and forearm length measures 27-66mm. Species in the genus weight between 17 and 31 grams.

**Reproduction:** The species is known to migrate from Mexico to Texas (it is not known to migrate in Jamaica) and upon arrival the males and females mate and separate into different colonies. Not all females reproduce every year and the majority of pregnant females give birth within the first week of June. A single offspring is produced and it is nursed for five to six weeks.

**Behaviour:** These are social species roosting in large colonies containing millions of individuals. All emerge at sundown to forage and fly further than most species to forage. This is due to the competition which is created by the size of the colony. Emergency on average is 15.9 minutes after sunset. It appears that light levels seem to affect the emergence pattern of the species. Other factors which may affect emergence include size of the cave opening, size of the colony and climatic factors. Average time for the bats to be away from the cave is 3 to 48 minutes. Time of peak return to the cave and last bat to return correlates to sunrise.

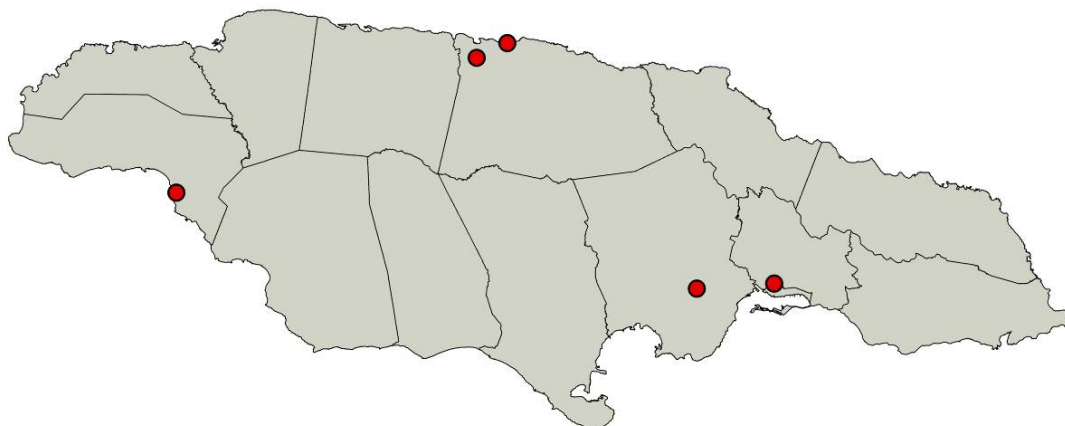
**Food habits:** They are insectivores feeding on flying insects such as mosquitoes, flies, beetles and moths. They can consume their body weight in food each night. It is estimated that 250 tons of insects can be consumed every night.

**IUCN Conservation Status:** The 2007 IUCN Red List of Threatened Species as Lower Risk - near threatened (LR/nt -)

**Status in Jamaica:** The species is considered to be common (Donaldson & Griffiths, unpublished 1997).

**Family - Vespertilionidae [Plain-nosed Bats]**

Vespertilionidae consist of three hundred and sixty-seven species and thirty-five genera and is the largest family of bats. Nine of the species are considered to be threatened by the IUCN (The IUCN Species Survival Commission, 2004). They are called evening bats and have small eyes and no noseleaf. They range in sizes from animals weighing 4g to others weighing up to 50g. Many are cave dwellers but the group also roosts in mine shafts, tunnels, trees, rock crevices and buildings. The group has a worldwide distribution living in tropical forest, deserts and temperate zones. The species representing the family in Jamaica are *Lasiurus degelidus* and *Eptesicus lynni*.

***Lasiurus degelidus* (Jamaica Red Bat)**

Global Distribution: The species is endemic to Jamaica.

Local Distribution: The species is limited in distribution and has been collected from scattered sites. Where they have been collected they have been few in number.

Habitat: The species has been recorded in areas below 400m. No specimens of this species have been recorded in or near any caves and thus it is considered to be a tree dweller. This is similar to other members of the genus *Lasiurus*. Specimens collected in Jamaica have been collected over water. The genus generally is found in wooded areas and roost in foliage and occasionally in tree holes and buildings.

Physical Description: The upper parts of the species lack the grayish frosting which is typical of *L. borealis* and the underparts are darker than the mainland species of *L. b. borealis*. There is a size difference between males and females. Body-head measurements for the females is between 53-57cm and forearm length of 45cm. The genus hair colour is brick red to rusty red usually washed with white. The males tend to be more brightly coloured than the females.

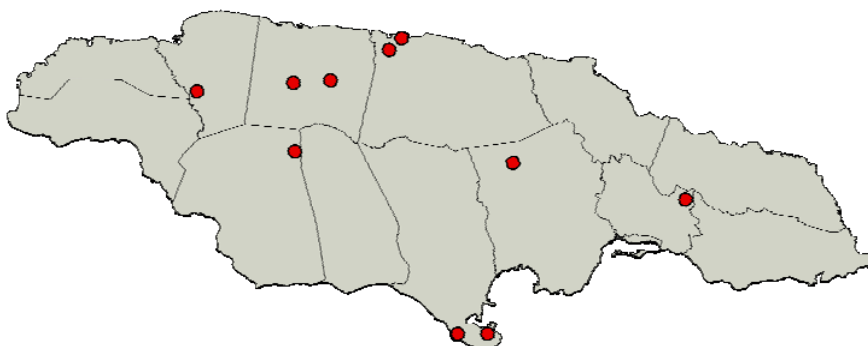
Reproduction: The genus is the only group of bats where more than two young per birth is common. Normal litter size is two or three.

Behaviour: The genus tend to be solitary individuals, however the females form a small nursery colony for their offspring. They may also flock up to several hundred.

Food habits: The species are insectivores have been known to feed on maggots, and flies.

IUCN Conservation Status: No status provided by the IUCN-WCMC Database.

Status in Jamaica: This is one of the rarest and poorest known species of bat in Jamaica (Genoways, *et. al.* 2005).

***Eptesicus lynnii* (Jamaican Brown Bat)**

Very little is known about the ecology of this species but is said to be similar to *Genus*.

Global Distribution: The species is endemic to Jamaica.

Local Distribution: The species has been recorded throughout Jamaica but was not abundant at any of the collection sites. The most recent collection was in Canoe Valley in October 2007.

Habitat: The species inhabit caves at or near sea level which is characterized by ruinate vegetation. It has also been collected in lowland areas which are arid and at elevations up to 1500m. In Venezuela, *Eptesicus* have been collected mainly in moist wooded areas with most roosting in holes in trees or logs. In Jamaica the species has been collected in caves.

Physical Description: Measurements recorded for species from Jamaica included forearm length of 43.5mm. For the genus, head-body length is 35 – 75mm and forearm is 28 – 55mm. In the genus hair colour is dark brown to black above and paler below

Reproduction: In temperate regions in the north, offsprings are usually born from April through to July. Pregnant species of *E. furinalis* are pregnant in April and lactating in July.

Behaviour: It seems likely to be an obligate cave dweller in Jamaica but like the other endemic species very little of the natural history is known.

Food habits: Based on the genus it is expected to *E. lynnii* are insectivorous.

IUCN Conservation Status: No status provided by the IUCN-WCMC Database.

Status in Jamaica: Based on the records it is assumed that this is maybe common where it is found but limited in distribution.

## APPENDIX IV

### IUCN CATEGORIES

#### 2001 Categories & Criteria (version 3.1)

##### THE CATEGORIES

**EXTINCT (EX)** - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

**EXTINCT IN THE WILD (EW)** - A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

**CRITICALLY ENDANGERED (CR)** - A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) as described below.

**ENDANGERED (EN)** - A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) as described below.

**VULNERABLE (VU)** - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as described below.

**LOWER RISK (LR)** - A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (cd)**. Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (nt)**. Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (lc)**. Taxa which do not qualify for Conservation Dependent or Near Threatened.

**DATA DEFICIENT (DD)** A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are

available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

**NOT EVALUATED (NE)** A taxon is Not Evaluated when it is has not yet been assessed against the criteria.

### **The criteria for Critically Endangered, Endangered and Vulnerable**

#### **CRITICALLY ENDANGERED (CR)**

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

- 1) An observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
  - a) direct observation
  - b) an index of abundance appropriate for the taxon
  - c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
  - d) actual or potential levels of exploitation
  - e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.
- 2) A reduction of at least 80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B) Extent of occurrence estimated to be less than 100 km<sup>2</sup> or area of occupancy estimated to be less than 10 km<sup>2</sup>, and estimates indicating any two of the following:

- 1) Severely fragmented or known to exist at only a single location.
- 2) Continuing decline, observed, inferred or projected, in any of the following:
  - a) extent of occurrence
  - b) area of occupancy
  - c) area, extent and/or quality of habitat
  - d) number of locations or subpopulations
  - e) number of mature individuals

3) Extreme fluctuations in any of the following:

- a) extent of occurrence
- b) area of occupancy

- c) number of locations or subpopulations
- d) number of mature individuals
- C) Population estimated to number less than 250 mature individuals and either:
  - 1) An estimated continuing decline of at least 25% within three years or one generation, whichever is longer or
  - 2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
    - a) severely fragmented (i.e. no subpopulation estimated to contain more than 50 mature individuals)
    - b) all individuals are in a single subpopulation
- D) Population estimated to number less than 50 mature individuals.
- E) Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer.

#### **ENDANGERED (EN)**

A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the following criteria (A to E):

- A) Population reduction in the form of either of the following:
  - 1) An observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
    - a) direct observation
    - b) an index of abundance appropriate for the taxon
    - c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
    - d) actual or potential levels of exploitation
    - e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.
  - 2) A reduction of at least 50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d), or (e) above.
- B) Extent of occurrence estimated to be less than 5000 km<sup>2</sup> or area of occupancy estimated to be less than 500 km<sup>2</sup>, and estimates indicating any two of the following:
  - 1) Severely fragmented or known to exist at no more than five locations.
  - 2) Continuing decline, inferred, observed or projected, in any of the following:
    - a) extent of occurrence

- b) area of occupancy
  - c) area, extent and/or quality of habitat
  - d) number of locations or subpopulations
  - e) number of mature individuals
- 3) Extreme fluctuations in any of the following:
- a) extent of occurrence
  - b) area of occupancy
  - c) number of locations or subpopulations
  - d) number of mature individuals
- C) Population estimated to number less than 2500 mature individuals and either:
- 1) An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, or
  - 2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
    - a) severely fragmented (i.e. no subpopulation estimated to contain more than 250 mature individuals)
    - b) all individuals are in a single subpopulation.
- D) Population estimated to number less than 250 mature individuals.
- E) Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer.

#### **VULNERABLE (VU)**

A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the following criteria (A to E):

- A) Population reduction in the form of either of the following:
- 1) An observed, estimated, inferred or suspected reduction of at least 20% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
    - a) direct observation
    - b) an index of abundance appropriate for the taxon
    - c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
    - d) actual or potential levels of exploitation
    - e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.



- 2) A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.
- B) Extent of occurrence estimated to be less than 20,000 km<sup>2</sup> or area of occupancy estimated to be less than 2000 km<sup>2</sup>, and estimates indicating any two of the following:
- 1) Severely fragmented or known to exist at no more than ten locations.
  - 2) Continuing decline, inferred, observed or projected, in any of the following:
    - a) extent of occurrence
    - b) area of occupancy
    - c) area, extent and/or quality of habitat
    - d) number of locations or subpopulations
    - e) number of mature individuals
  - 3) Extreme fluctuations in any of the following:
    - a) extent of occurrence
    - b) area of occupancy
    - c) number of locations or subpopulations
    - d) number of mature individuals
- C) Population estimated to number less than 10,000 mature individuals and either:
- 1) An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, or
  - 2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
    - a) severely fragmented (i.e. no subpopulation estimated to contain more than 1000 mature individuals)
    - b) all individuals are in a single subpopulation
- D) Population very small or restricted in the form of either of the following:
- 1) Population estimated to number less than 1000 mature individuals.
  - 2) Population is characterised by an acute restriction in its area of occupancy (typically less than 100 km<sup>2</sup>) or in the number of locations (typically less than five). Such a taxon would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically Endangered or even Extinct in a very short period.
- E) Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

## APPENDIX V

### SOME BAT SPECIES IN JAMAICA AND THEIR CAVE ROOSTS

The following information is based on literature review and work conducted by the National Environment and Planning Agency between 2006 and 2009

<i>Artibeus jamaicensis:</i>	River Sink Cave (Worthy Park); Riverhead (or Braham's) Cave [4 km from Worthy Oark]; Mount Plenty Cave (St. Ann); Sewell Cave (Montego Bay); Vauxhall Cave (St. Elizabeth); caves in Clarendon, Mosely Hall; Ferry caves.
<i>Macrotus waterhousii:</i>	Portland Ridge Cave; Colbeck Castle (Clarendon); Portland Cave (Clarendon); Vauxhall Cave (St. Elizabeth); Grove Cave; caves near Salt Island Lagoon (St. Elizabeth); caves on the slope of the John Crow Mt. Above Ecclesdown.
<i>Pteronotus parnellii:</i>	Oxford Cave; cave in Mosely Hall; Mount Plenty Cave (St. Ann); St. Clair Cave (St. Catherine); Windor Great Cave (Trelawny).
<i>Pteronotus quadridens:</i>	Swansea Cave (Worthy Park); St. Clair Cave (St. Catherine); Riverhead Cave (St. Catherine).
<i>Chilonatalus micropus:</i>	Monarva Rat-bat Cave (western tip Jamaica); St. Clair Cave (St. Catherine).
<i>Monophyllus redmani:</i>	Swansea Cave (Worthy Park); Riverhead (or Braham's) Cave; Mount Plenty Cave; Windsor Great Cave (Trelawny) Oxford Cave; caves in Moseley Hall; St. Clair Cave; Mount Plenty Cave.
<i>Erophylla sezekorni:</i>	Sewell Cave; Mount Plenty Cave; St. Clair Cave; Riverhead Cave (St. Catherine).
<i>Phyllonycteris aphylla:</i>	Dairy Cave (St. Ann); Wallingford Cave (St. Elizabeth); St. Clair Cave; caves in Mount Plenty; Riverhead Cave (St. Catherine).
<i>Glossophaga sorcinia:</i>	caves in Sewell and Mosely Hall; sea cave near Oracabessa (St. Mary) and Portland Ridge; Portland Cave (Clarendon); caves on the slope of the John Crow Mt. Above Ecclesdown; River Sink Cave (Worthy Park); Riverhead Cave (St. Catherine); St. Clair Cave (near Ewarton).
<i>Noctilio leporinus:</i>	Two Sisters Cave and Sandy Hills Bay (Hellshire, St. Catherine).

<i>Mormoopa blainvilli:</i>	Mount Plenty Cave; St. Clair Cave (St. Catherine); River Sink Cave (Worthy Park); Riverhead Cave (St. Catherine); Oxford Cave; Moseley Hall.
<i>Pteronotus macleayii:</i>	Mount Plenty Cave (St. Ann); St. Clair Cave (near Ewarton); Windsor Great Cave (Trelawny).
<i>Molossus molossus:</i>	Monarva Rat-bat Cave (western tip of Jamaica).
<i>Tadarida brasiliensis:</i>	Swansea Cave (Worthy Park);
<i>Natalus stramineus:</i>	St. Clair Cave (St. Catherine).
<i>Tadarida macrotis:</i>	Vauxhall Cave (St. Elizabeth)

APPENDIX VI  
**TYPES OF STUDIES CONDUCTED ON JAMAICAN BAT SPECIES**

Few ecological studies have been conducted on Jamaica's bat species however some of the types of research conducted includes (some of the information has been taken from Donaldson 2006 (unpublished)). :

- i. Systematic reviews of particular genus for example Anderson & Nelson (1965), Buden (1976), Dalquest (1950), Dobson (1876) and Eger (1977) and identification of species (e.g. Allen (1917), Allen (1889a, b) and Henson & Novick (1966));
- ii. Information on the ecology of all the species or a single species or habitat but with some comment on the status of Jamaica's bat fauna, e.g. Goodwin (1970), Bain (1985), Koopman & Williams (1951), Williams (1952) and McFarlane (1985, 1986); Genoways (2005).
- iii. Research on Jamaica bats species, e.g. McNab (1976), Pumo *et al* (1988), McDaneil *et. al.* (1982), Mennone *et. al.* (1986), McFarlane, *et. al.* (2006), Donaldson & Griffiths (1997 unpublished), Dávalos & Eriksson (2005), Genoways (2005) and NEPA (2007).
- iv. Research related to the auditory system and echolocation for example Kossel *et. al.* (1996), Vater (1996) and Kanwall *et. al.* (2003).
- v. Cave and bat population assessment studies for example Donaldson (1997), Vogel (1998), Koenig (2000, 2002), Stewart *et. al.* (2005) and NEPA (2006, 2007).