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Liverpool University Expedition to Jamaica

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LIVERPOOL UNIVERSITY EXPEDITION TO JAMAICA

Compiled and edited by D. A. McFarlane

During summer 1977, five members of the Liverpool University Potholing Club spent six weeks working and exploring in the caves of Jamaica. The team consisted of Don McFarlane, John Dye, Malcolm Macduff, Mike Roger and Barry Williams, all of whom contributed to this report.

The expedition base was at Troy, where the villagers are owed a debt of gratitude for their hospitality. This placed the expedition in the heart of the cave region, and a number of new caves and shafts were discovered and explored (fig. 1). The main discovery was the Still Waters Cave, located near Accompong, where 11,800 feet of passages were explored during the second half of the stay in Jamaica.

Studies were carried out not only in the cockpit karst around Troy, but also in the Hellshire Hills and Portland Ridge karsts on the south coast of the island. In addition, a flying visit was paid to the John Crow Mountains near the eastern end of the island. A single stalactite-adorned cave (Hog House Hole at Map Ref. 763 445) was discovered. Though only 30 feet long, this is significant, as it is one of the very few caves known in the John Crow Mountains, even though they consist of massive limestone in a high relief terrain with a high rainfall.

GEOLOGICAL AND GEOMORPHOLOGICAL SETTING

Jamaica consists of two distinct geological units which Zans (1962) named the Eastern Mountain Mass, mainly consisting of non-carbonate rocks, and the Main Block, consisting mainly of carbonate rocks which cover nearly two-thirds of the Island (fig. 2). It is in this latter area, where the karst has its maximum expression, that the expedition was based.

During the Middle Eocene, a marine transgression took place over the main block and initiated a series of cycles of largely carbonate sedimentation. During this period the Yellow and White Limestones were laid down and it is within these lithologies that cave development is most common. These two groups can be sub-divided into nine mappable formations, three of these representing the deeper water facies with the other six the shallow water facies. The Yellow and White Limestone groups are distinguished on the basis of percentage carbonate composition and purity. The White Limestones have a carbonate composition in excess of 99%, whilst the less pure Yellow Limestones have an average content of 93%.

Caves discovered during the expedition were found in both the Yellow and White Limestone groups. Marley Stalactite Cave for example is formed in the Troy-Claremont Limestone Formation of the White Limestone, whilst the nearby Wilson's Run Cave is formed in the Chapelton Member of the Yellow Limestone. Whilst the explored caves were found in both Yellow and White Limestones, the explored shafts were found solely in the White Limestone, e.g. The New Hall and Newport-Blenheim areas. The mode of formation of these 'cockpit' shafts is debatable and, whilst some show definite evidence of collapse, others show evidence of formation by solution only, e.g. The New Hall Sink Hole 4. The reader is referred to Smith, Drew and Atkinson (1972) for hypotheses of shaft development.

Many of the caves explored are associated with river and stream sinks. Since the Yellow and White Limestones in general drain rapidly, surface drainage may be sporadic, only occurring during storms at the base of cockpits with an appreciable cover of alluvium. In larger depressions with a greater area of impermeable cover (either alluvial or, in the case of caves along the Central Inlier, impermeable Cretaceous rocks) permanent rivers may occur giving rise to larger active cave systems.

In the case of Still Waters River Cave, the course of the river underground is largely joint-controlled, vividly illustrated by the plan of Tardis series. The general trend of the system is down dip with little vertical development except for the large collapsed area around the Hall of Rains, possibly associated with a fault.

Most of the caves explored were in cockpit karst, as described by Sweeting (1958). Other caves such as those found in the area around Blenheim were situated in more subdued topography of the doline karst type. The greater ruggedness of the Cockpit Country and Dry Harbour Mountain areas coupled with the growth of dense wet forest make cave

Fig. 1.

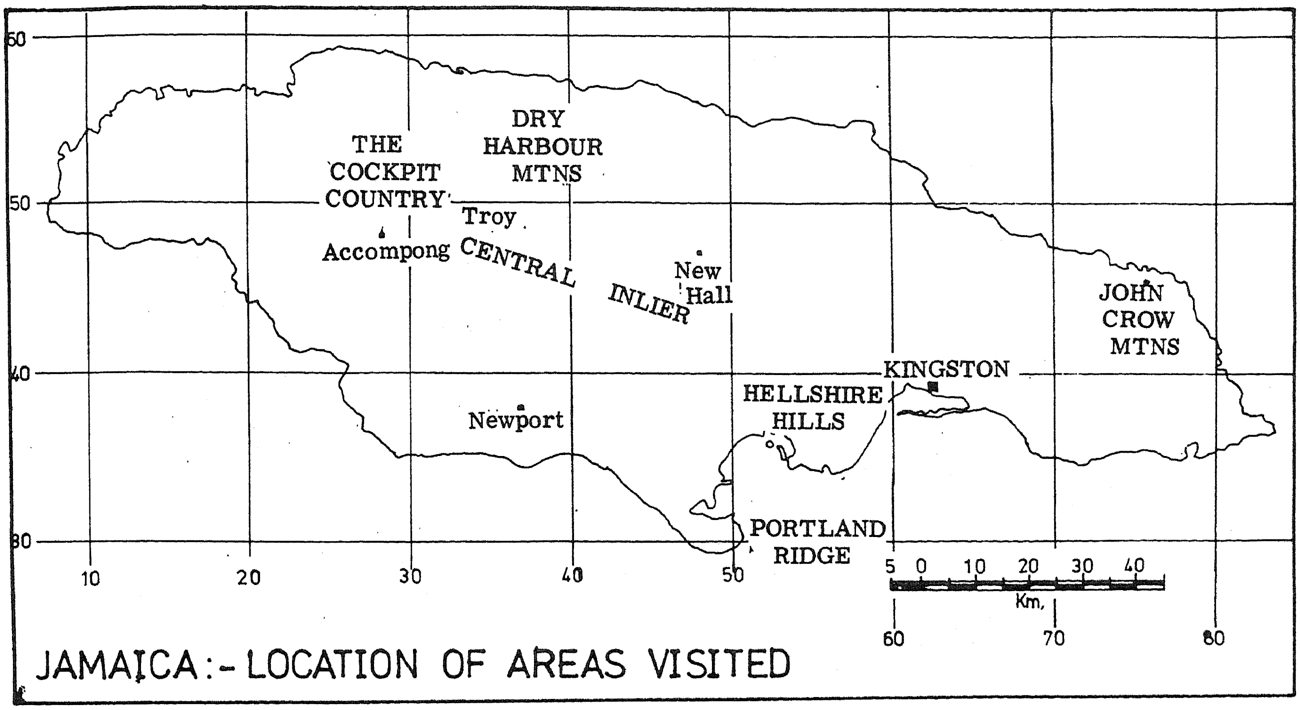
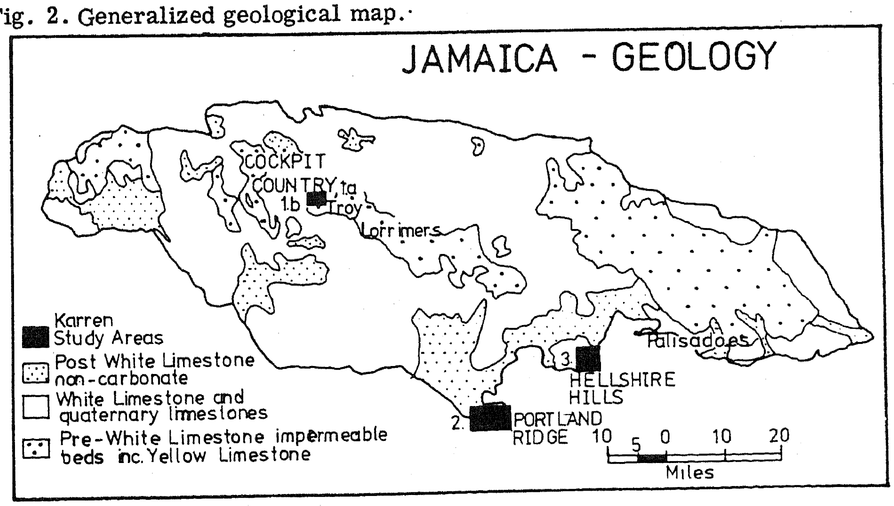


Fig. 2. Generalized geological map.



exploration in these areas more arduous than exploration in the more open vegetation found on the subdued doline karst in the south.

CAVE DISCOVERIES

Wilson's Run Cave, Troy, Length 650 feet, Map Ref. 328 494 (fig. 3).

Where the road from Troy to Heading finally crosses over to the left side of the valley, a footpath strikes off to the north, and this can be followed for 300 yards to a depression with a small stream rising and sinking again on the left. The depression and stream are well known to locals as Wilson's Run (fig. 3).

The small stream rises from an impenetrable bedding plane and flows for thirty yards across the floor of the glade before sinking into Wilson's Run Cave. The entrance is large and obvious. Just inside, the passage lowers to a crawl over boulders, followed by a second wallow, and then hands and knees crawling in the stream with gravel banks on the left. After the floor drops, the stream disappears into a tube too small to follow. The main route continues over mud and gravel until the floor drops again into a pool. A crawling-size passage follows the water for 20 feet until it opens into a small chamber. The stream issues from a short passage with false floors, leading to a small cascade with water coming from an inlet above and on the right. To the left above the cascade, an easy squeeze leads to a second small chamber and 70 feet of flat-out and very aqueous crawling past an aven to a calcited boulder choke with the water trickling through impenetrable cracks.

Continuing along the main route, a boulder pile is crossed to a constriction past some gour formations leading into Rat Hall. From the far side, two passages diverge. The right hand passage ends after a few yards, whilst the left hand passage runs for about 20 yards to a mud choke, with a low inlet on the right. This was followed as a crawl to a tiny chamber with a substantial mud choke and a four-inch rift in the floor where water could be heard. Despite its short length, the cave is quite sporting and the flood risk is serious

York Shaft I, New Hall, Depth 100 feet, Map Ref. 4787 4812 (fig. 4).

A large open shaft about 300 yards south of the road, reached via a path running past two houses which are set back from the road along a short track.

The shaft is most easily descended at the south end where a descent over two ledges leads to the top of a large boulder pile. There is no obvious way on at the bottom of the shaft, and loose rocks are a constant danger. (Plate 1, fig. 1).

Berry's Sinkhole, New Hall, Depth 180 feet, Map Ref. 4863 4765 (fig. 5).

A shaft in a shallow valley behind a house with a water-tank and a rain-catcher. It lies some 250 yards to the east of the road.

A small opening leads on to a 120 foot pitch to a small ledge where the rope can be rebelayed for a second pitch of 50 feet to the floor of the shaft. The bottom of the shaft is choked with boulders and a mudbank, and there is no way on.

New Hall Pot II, New Hall, Depth 25 feet, Map Ref. 4858 4728

Some one hundred yards further along the road from New Hall Sinkhole 1, and in the next depression, was a 25 foot deep shaft measuring 30 feet in length and 10 feet in width, with no obvious way on.

New Hall Pot III, New Hall, Depth 200 feet, Map Ref 4876 4712 (fig. 6).

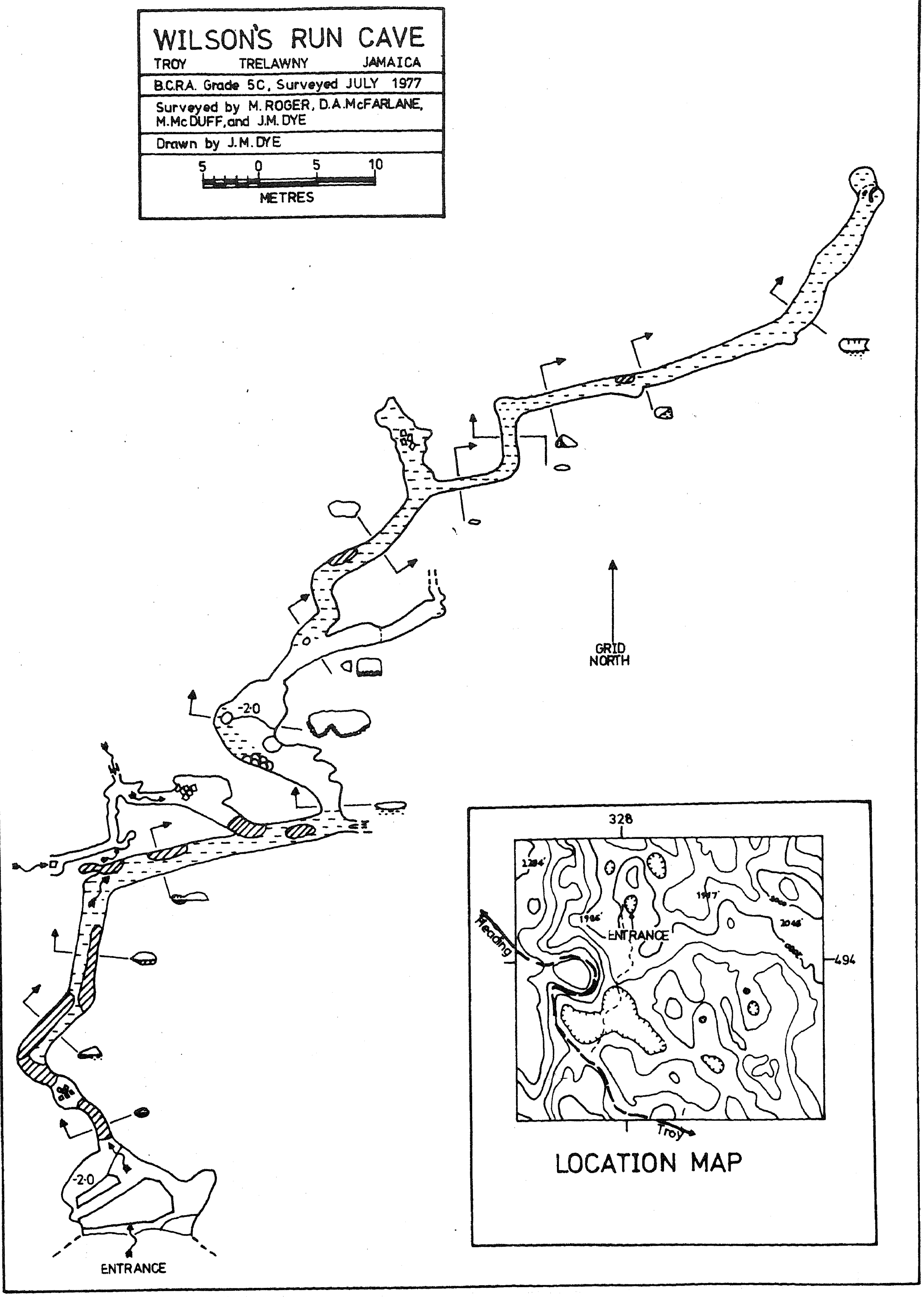
Just before the road deteriorates into a path, a group of houses are passed. The shaft is located on the south of the road in the bottom of a shallow depression behind these houses.

The shaft is descended as a single pitch. At 75 feet the shaft divides in two, but both shafts continue side by side to join again at the bottom at a boulder floor with no way on.

New Hall Pot IV, New Hall, Depth 105 feet, Map Ref. 4868 4719 (fig. 7).

Located to the north of the road from New Hall Sinkhole 1. A ten-foot climb amongst tree roots leads to the head of the first pitch, a narrow sharp rift. A descent of 41 metres lands on a false boulder floor with a broad ledge and choked hole 4 metres above. A small hole between the boulders (caution - these are precariously jammed) leads directly onto a second pitch of 21 metres, also very sharp, landing on a floor of rock and boulders. A very small water worn passage leads off but is obstructed by mud and rocks. The shaft was unique amongst those examined by the Expedition in that it ended in a solid rock floor with some evidence of subsequent horizontal development.

Fig. 3.



WILSON'S RUN CAVE
TROY TRELAWNY JAMAICA
B.C.R.A. Grade 5C, Surveyed JULY 1977
Surveyed by M. ROGER, D.A. McFARLANE, M.Mc DUFF, and J.M. DYE
Drawn by J.M. DYE
5 0 5 10
METRES
GRID NORTH
-2·0
-2·0
ENTRANCE
LOCATION MAP
328
494
ENTRANCE
Troy

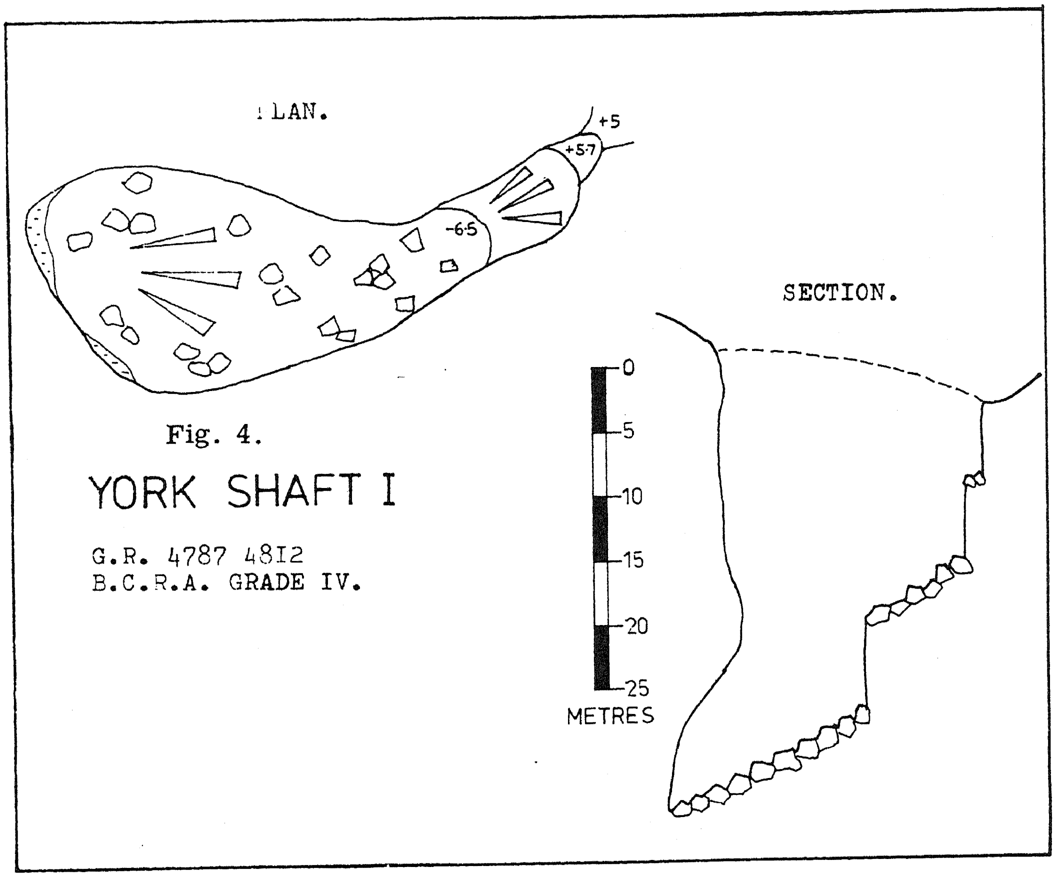


Fig. 4.

YORK SHAFT I

G.R. 4787 4812
B.C.R.A. GRADE IV.

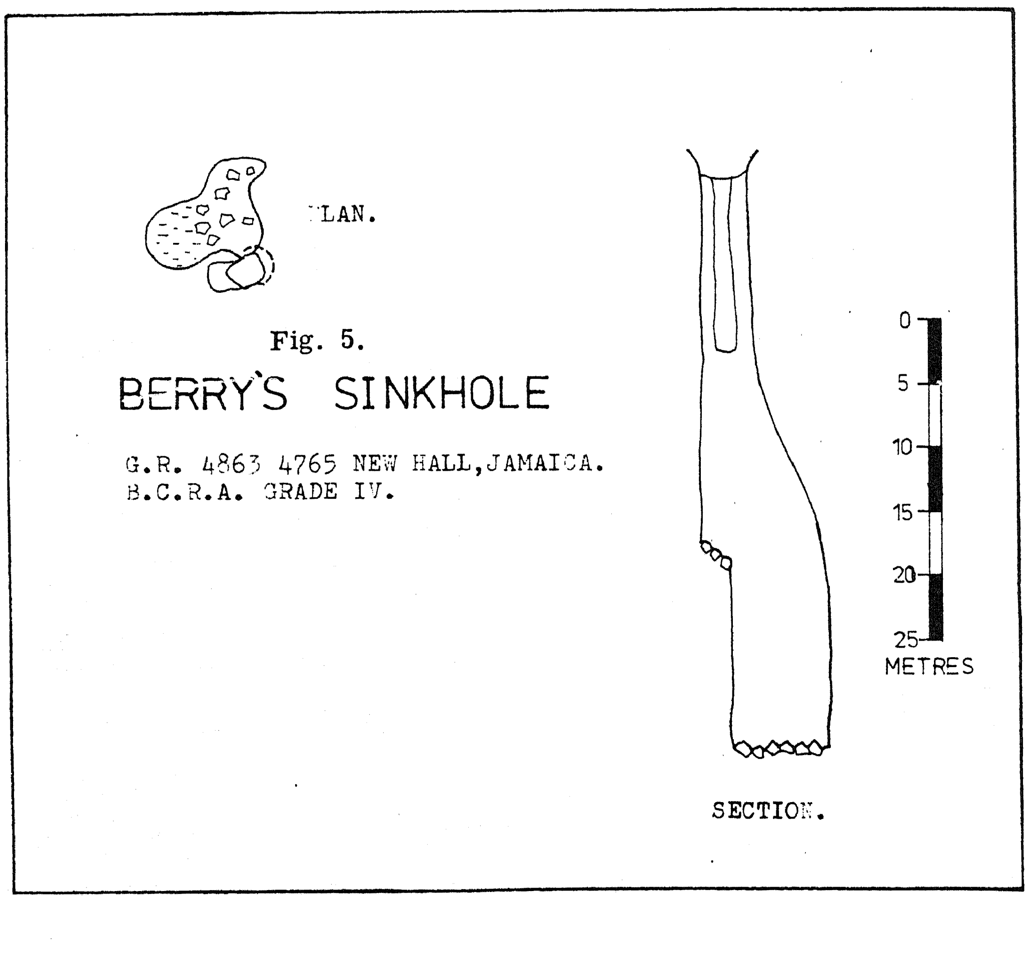


Fig. 5.

BERRY'S SINKHOLE

G.R. 4863 4765 NEW HALL, JAMAICA.
B.C.R.A. GRADE IV.

Marley Stalactite Cave, Auchtembeddie, Length 200 feet, Depth 100 feet, Map Ref. 333 378 (fig. 8).

Difficult to find. Follow the path down into the Marley River depression. Once past the last houses start to descend, and half way down and 30 yards to the left is the entrance to the cave, beneath a small cliff located in thick bush.

Several holes lead down through large jammed boulders to the Upper Chamber. Two holes in the floor lead down climbs into the Middle Chamber, a larger chamber with much flowstone, notably some large stalactites hanging from the roof. At the very bottom of the chamber a small hole leads into the most impressive Lower Chamber. The copious flowstone assumes many forms - huge stalagmite bosses, curtains, pillars, flows and stalactites. On the right a short climb down leads to a boulder choke which can be penetrated for 30 feet before becoming impassable. (Plate 1, figs. 2 and 3).

Too Far Stream Cave, Mouth River, Length 280 feet, Map Ref. 351 544.

At the far end of Good Hope Cave Two, one emerges into Far Enough Glade and continuing northwards through the obvious gap into Guinea Grass Glade, and beyond another more spacious grassy glade is reached. The cave is situated in the latter glade opposite the point of entry where a small stream sinks beneath a low cliff.

A hole leads to a drop into a narrow vadose trench which can be followed to the left. After 30 feet a larger phreatic roof tube can be entered above the trench, but this is soon choked at either end. The vadose trench continues for 180 feet round several sharp bends until it closes down and becomes too tight immediately after a small inlet enters on the left.

Old Man's Gully, Breeze Hole, Depth 140 feet, Map Ref. 338 479.

At the end of the road towards Breeze Hole a footpath can be followed until a small path turns downhill to the right towards Breeze Hole. Just before this is reached a large depression is passed on the north of the path, and Old Man's Gully is located at the bottom of this depression.

A large shaft gives a single pitch of 140 feet against the wall to a boulder choked floor.

STILL WATERS CAVE, Whitehall, Length 11800 feet. Map Ref. 287 477 (fig.9)

The cave is located at the sink of the Tyne River near Accompong. Although the Tyne River is very small in the dry season (it can hardly even be called a river) it responds very rapidly to rain. Due notice should therefore be taken of the weather conditions and pattern at the time of year before going underground as the entrance and several parts of the streamway are low and aqueous.

During the expedition, 11800 feet of passage were explored, and the following brief description should be read with the survey. (Fig. 9).

A few yards inside the entrance are two ducks or sumps, (Plate 2, figs. 1 and 2). Between the two, the more obvious passage is a large, normally dry, flood level on the left - Gillette Passage.

Gillette Passage. This can be followed along a walking size passage (Plate 2, fig. 3) to the start of a short low canal, and then continues on through a series of low canals and short climbs to a large sump pool - the Deep. In the first section, four passages on the right lead into the Tardis Series, and just before the Deep, a passage on the left leads to the Lair of Grendel and the downstream cave.

The Grey Flood. Flowing into the far side of the Deep is a river, known as the Grey Flood. The large stream passage continues through deep pools until a junction is reached - the Parting of the Ways. To the left here is the Mersey Way - another downstream continuation of the Grey Flood. Upstream from the Parting of the Ways leads via a short section of large streamway to a complex massive rockfall with a large aven overhead - the Kaled Dome.

There are two routes through the boulder complex of the Kaled Dome. To the right in the stream leads to a large pool with the aven above and a large dry passage leading straight on into Tardis Series. The other route leads over boulders to the left to a pool where Forbidden Swamp Series enters the Kaled Dome. Both routes continue to rejoin the Grey Flood. Upstream leads in a high narrow streamway to another rock fall - the Pillars of Hercules. The stream can be followed to the right to an inlet - Sesame Passage, or to the left under a boulder arch to the upstream continuation of the Grey Flood. On the other side of the boulder pile one can descend to yet another section of streamway - the start of Forbidden Swamp Series.

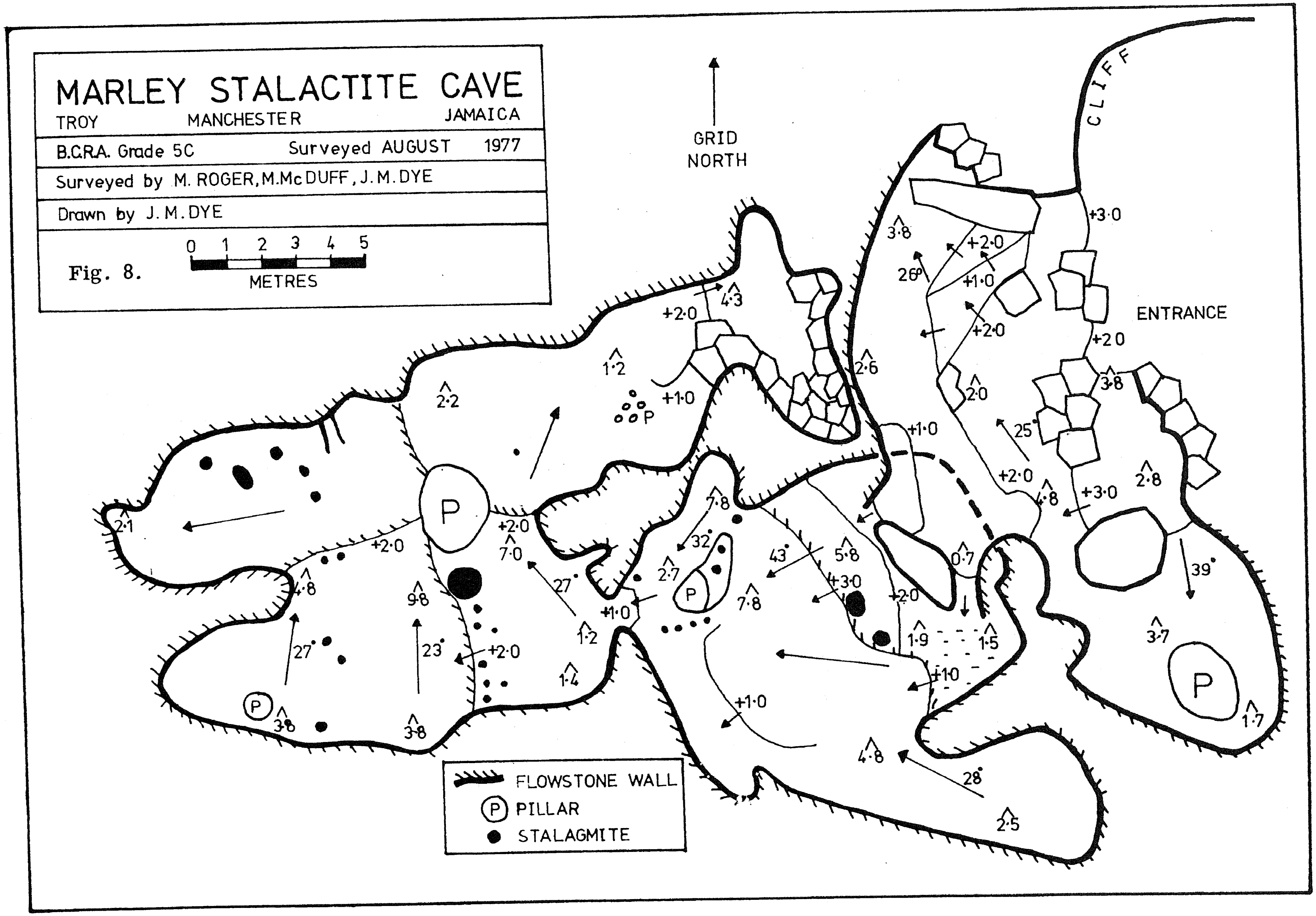
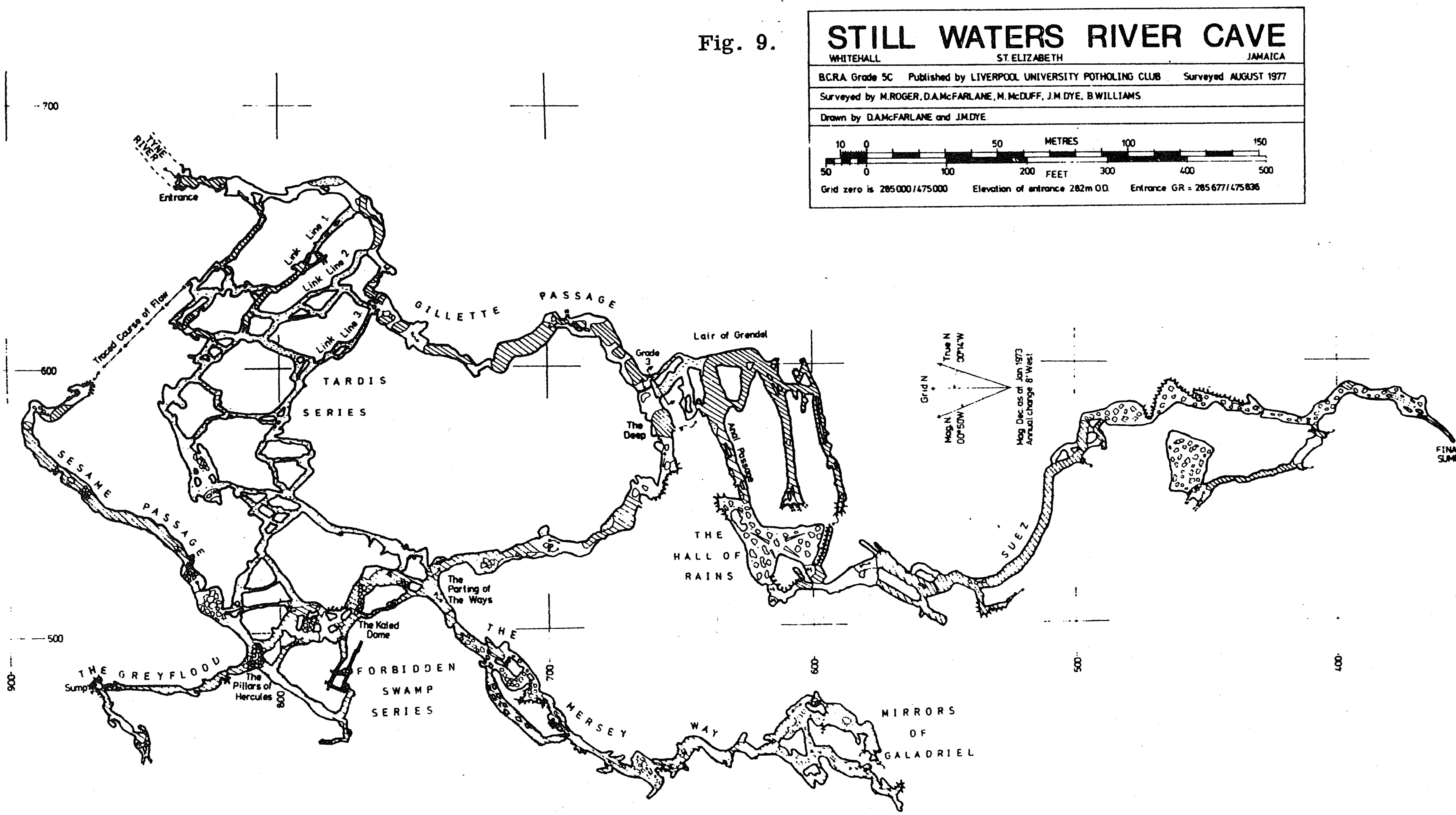

MARLEY STALACTITE CAVE
TROY MANCHESTER JAMAICA
B.C.R.A. Grade 5C Surveyed AUGUST 1977
Surveyed by M. ROGER, M.Mc DUFF, J.M. DYE
Drawn by J.M. DYE
0 1 2 3 4 5
METRES
GRID NORTH
CLIFF
ENTRANCE
FLOWSTONE WALL
P PILLAR
STALAGMITE

Fig. 8.

Fig. 9.



STILL WATERS RIVER CAVE
WHITEHALL
ST. ELIZABETH
JAMAICA
B.C.R.A. Grade 5C
Published by LIVERPOOL UNIVERSITY POTHOLING CLUB
Surveyed AUGUST 1977
Surveyed by M.ROGER, D.A.McFARLANE, M.McDUFF, J.M.DYE, B.WILLIAMS.
Drawn by D.A.McFARLANE and J.M.DYE.
METRES
FEET
Grid zero is 285000/475000
Elevation of entrance 282m O.D.
Entrance GR = 285677/475836
TYNE RIVER
Entrance
Link Line 1
Link Line 2
Link Line 3
Traced Course of Flow
GILLETTE PASSAGE
TARDIS SERIES
SESAME PASSAGE
Grade 3
The Deep
Lair of Grendel
Anal Passage
THE HALL OF RAINS
SUEZ
FINAL SUMP
True N
Grid N
Mag N
Mag Dec as at Jan 1973
Annual change 8' West
The Parting of The Ways
The Kaled Dome
FORBIDDEN SWAMP SERIES
THE GREYFLOOD
Sump
The Pillars of Hercules
THE MERSEY WAY
MIRRORS OF GALADRIEL

Upstream in the Grey Flood leads through deep water past a couple of low sections to a swim with about six inches airspace. Just beyond this the stream appears to rise from amongst massive blocks on the right. A low section leads to a further continuation to the left to a boulder choke.

The Tardis Series is a complex series of passages connecting between the Grey Flood and the entrance area. Most are dry walking passages or crawls, but these are relieved by some long and deep pools. Sesame Passage is a very aqueous upstream route ending in a flooded boulder pile.

Mersey Way. From the Parting of the Ways the Mersey Way leads on down a short section of streamway to a rockfall. Straight ahead over the boulders leads down to a low canal and duck before the streamway gathers height until another rockfall is met. More streamway and a third choke lead to a junction, and the left returns to the streamway and a couple of lakes - the Mirrors of Galadriel. To the right, a bouldery passage leads along a section of streamway through a couple of ducks until progress is blocked by calcited boulders, where the streamway can be heard beyond.

The Lair of Grendel and the downstream cave. Just up Gillette Passage from the Deep a crawl leads off to the right into the Lair of Grendel. The crawl emerges into a large canal passage and beyond a low wet muddy crawl leads on to a large chamber - the Hall of Rains. Straight ahead through the Hall leads to a climb down into a rift taking the river. A climb onto boulders at the far end of the rift takes one out of the river. From this pool a short upstream passage can be followed to a boulder choke - this is the downstream end of the boulder choke encountered at the end of the river in the Lair of Grendel. The main canal passage straight ahead continues downstream, as Suez.

Suez consists of a long section of canal passage with a couple of active oxbows on the right and two high level dry oxbows on the left. The river eventually runs into a sump at the start of a series of boulder chambers. Up over the boulders leads to a short high level passage on the right which ends in a static canal and sump. Down between the boulders the stream can be rejoined flowing into a deep sump between massive collapsed boulders. No way can be found beyond this point.

KARREN MORPHOLOGIES IN CONTRASTING KARST AREAS

The aim of the study was to see if the shape of karren as expressed by the width, depth, length ratios differed significantly between the Troy, Portland Ridge and Hellshire Hills areas, and to establish the cause of any variations that might be found.

Descriptions of areas.

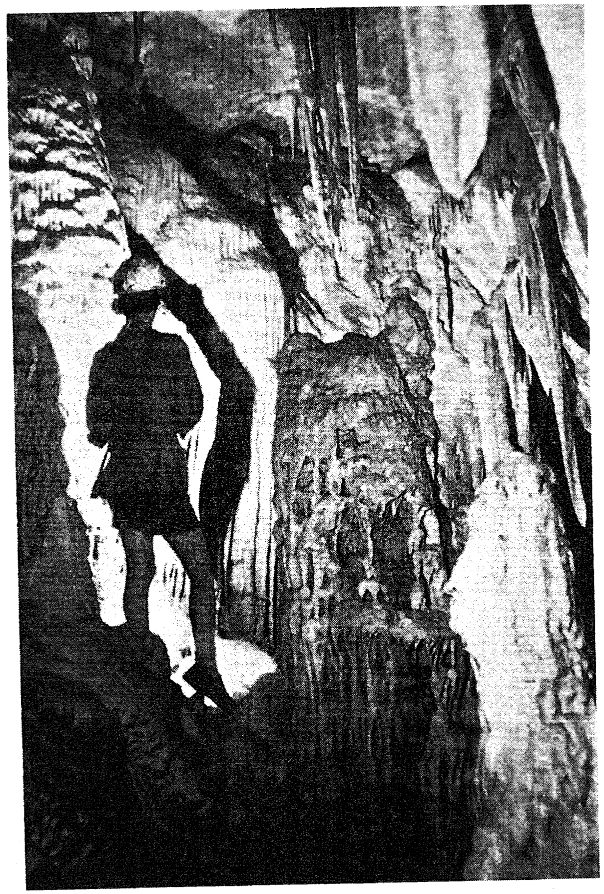
The selection of the three areas was designed to give three contrasting environments of study. The Troy area is situated in the Cockpit Country, an area of classic cockpit karst, supporting dense wet forest under a mean annual rainfall of over 250 cm. Mean monthly temperatures range from 24 - 28° C, and thus precipitation probably exceeds evapotranspiration in most months of the year. The soil cover is generally discontinuous though plant litter forms a fairly extensive cover. The sample area was underlain by the Troy Limestone, a dolomitised micrite.

The Portland Ridge area is one of subdued relief, relative to the Cockpit Country. Rainfall is in the region of 80 cm. per year with mean monthly temperatures from 27 - 29° C. Portland Ridge is covered in a thick scrub of xerophytic plants such as cacti and thorn scrub producing a discontinuous and generally thin canopy. Soil cover is sparse; the surface consists of case-hardened Newport Limestone, a micrite which has weathered to razor-sharp irregular surfaces. Evapotranspiration exceeds precipitation in most months of the year and it should be noted that on the extensive unshaded rock surfaces temperatures will often exceed 40° C.

The Hellshire Hills show similar environmental conditions to the Portland Ridge, differing only in the more extreme nature of the environment. The vegetation is very sparse and soil is almost non-existent; rainfall is in the region of 40 - 50 cm. which, coupled with the high temperatures and permeable nature of the bedrock, produces a desert scrub-like landscape. The area consists of Newport Limestone which has weathered to a case-hardened, razor sharp karren form. The study area was located at around 10 m. O.D., where the effect of marine-boring organisms may have been important in the higher sea levels of the mid-Flandrian.

PLATE 1.

1. York Shaft.



2. Speleothems in Marley Stalactite Cave.

3. Surveying in Marley Stalactite Cave.

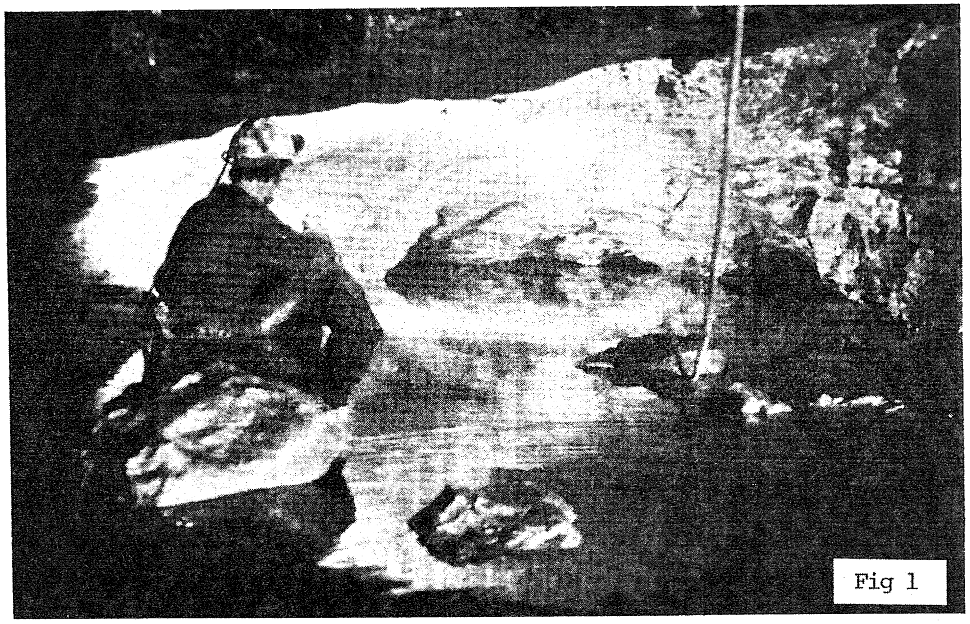


Fig 1

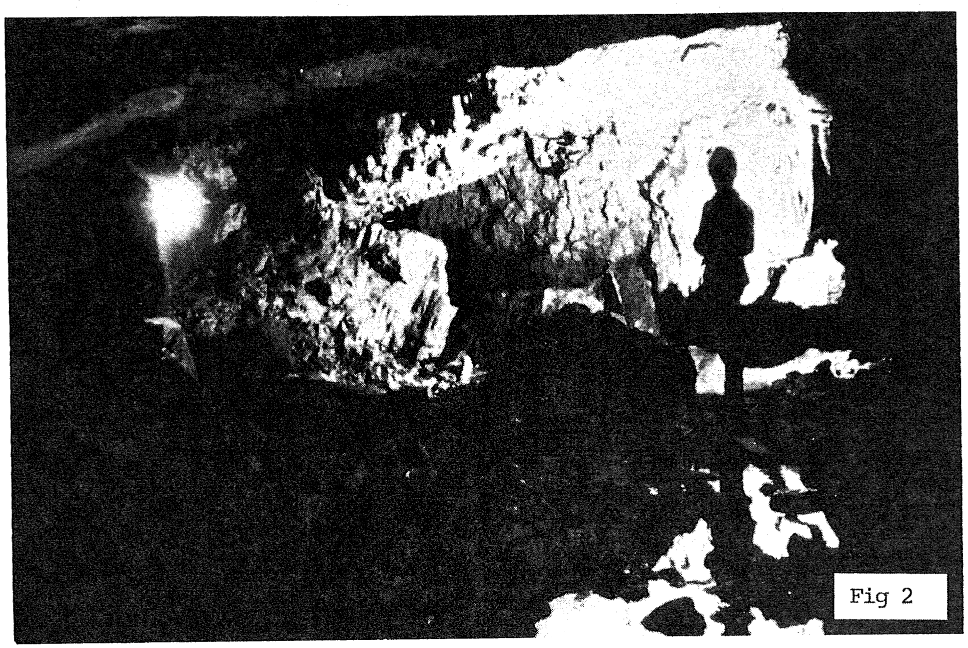


Fig 2

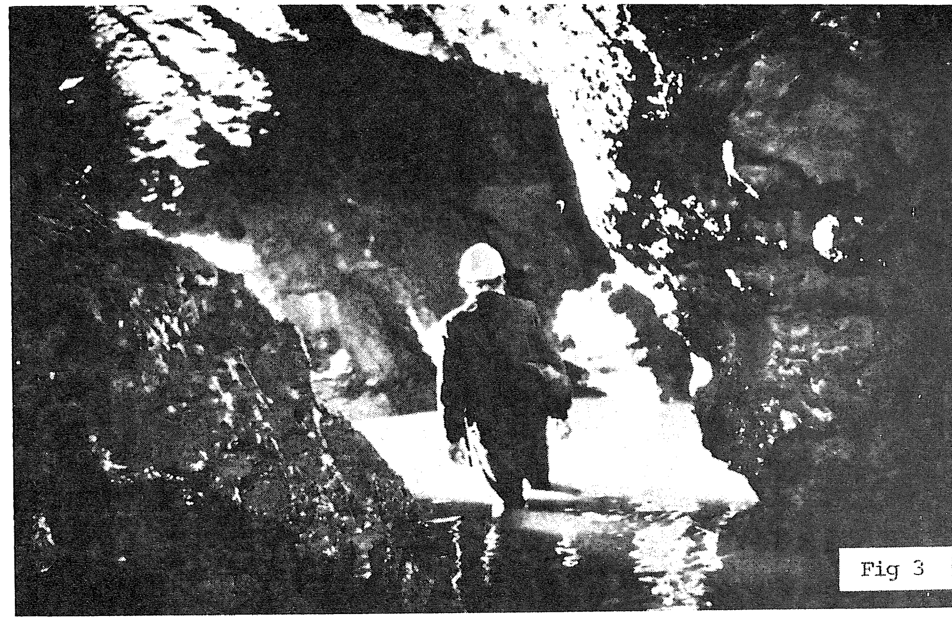


Fig 3

PLATE 2. STILL WATERS CAVE JAMAIC

Fig 1. Sump/duck in Entrance series.

Fig 2. Beyond the Entrance sump/duck.

Fig 3. Flood levels in the Entrance series.

Method of Study

One-metre quadrats were set up and within each quadrat the depth of 10 randomly sampled solution pits was measured. A photograph was taken of each quadrat so that length and width measurements could be made later. For each quadrat the following variables were noted:

1. Slope of the surface.
2. Aspect of the slope.
3. Lithology.
4. Dip of Bedrock.
5. Frequency of jointing.
6. Soil cover (%).
7. Vegetation cover (%).
8. Orientation of karren.

The position of each quadrat was selected to give a reasonable representation of the range of environmental variables found within each area. It should be noted that logistics imposed by accessibility, density of vegetation (in the Cockpit Country Area each quadrat had to be cleared by machete) and intensity of mosquito infestation influenced the location of quadrat location. In the Troy area 21 quadrats were evaluated, in the Portland Ridge area 14, and in the Hellshire Hills area 20.

In each area the following parameters of each karren feature were utilized:

1. Depth.
2. Length of the long axis (L).
3. Width of the widest part at right angles to long axis (W).
4. The width-length ratio ($\frac{L}{W}$).
5. Orientation of the long axis of each pit.
6. Orientation of axis about the direction of slope (aspect).

Using this data certain statistical tests were carried out by computer analysis, using package programmes on the University of Liverpool computer facilities. The object of the statistical tests was to see if any significant variation in karren form occurred between the areas, and what, if any, environmental factor was responsible for variations in depth and the $\frac{L}{W}$ ratio within each area.

Comparison of Areas.

Portland Ridge showed a highest mean depth of 8.18 cm, with Troy and Hellshire Hills with mean depths of 7.71 and 6.43 cm. respectively. The range of depth valves was also highest in Portland area - 74.2 cm. compared with 39.8 and 37.6 cm. for Troy and Hellshire. A Kruskall-Wallis Analysis of Variance for all sample depths reveaked no significant difference between the karren depth data of the three areas.

Troy shows the smallest mean width value of 2.30 cm., with Portland at 3.37 cm. and Hellshire the highest value of 4.10 cm. Kruskall-Wallis analysis showed that there is no significant difference between Troy and Portland, and a significant difference between Troy and Hellshire, with respect to karren width data.

Troy has the outstanding mean length of 23.05 cm., while Portland and Hellshire have much lower mean lengths of 5.97 and 6.30 cm. respectively. Kruskall-Wallis analysis showed no significant difference between Portland and Hellshire while the length data from Troy was significantly different.

The mean width/length ratios for Hellshire and Portland show the karren to be sub-circular; Hellshire with a mean ratio of 1.61 has the most circular form followed by Portland with a mean ratio of 1.99. The Troy karren however, have a markedly linear form of mean ratio 30.38.

Spearman-Rank analysis of site environmental factors showed poor correlation of factors on individual sites except that there does exist a strongly positive correlation between lithology and width-length ratio, (r = 0.8447, Sig. level = .001). The joint frequency also has positive correlation with width-length ratio (r = 0.6388, Sig. level = .001).

The orientation of karren was plotted for each area to see if slope orientation exercised a strong control on the orientation of karren. None of the areas shows preferred orientations in a downslope direction. Troy area however, shows two orientation maxima, the first from 0^{o} - 9^{o}, the second from 80^{o} - 99^{o}. It is possible that these preferred orientations are determined by the direction of jointing of the bedrock.

Summary of Results and Conclusion.

The relief of karren as expressed by the depth parameter, does not particularly vary between the three areas. The form of karren as expressed by the width-length ratio, does show a difference between the areas, particularly at Troy, where the karren are of a linear nature, unlike the dominantly sub-circular karren of Portland and Hellshire. If length of karren can be equated with stage of development then Troy shows well-developed karren, whilst the other areas have more immature features. The width data showed only slight differences between each area, and in themselves are not regarded as indicative of any particular factor.

The site factors investigated have little or no influence on karren depth, form, or orientation. It can thus be postulated that the differences in karren form and development are dependant upon climatological or lithological factors.

The Troy area experiences much higher rainfall than Portland Ridge or the Hellshire Hills. The excess of rain over evapotranspiration, coupled with the acid nature of the leached soils and organic matter, produces faster rates of solution. The more arid areas of Portland Ridge and Hellshire, where evapotranspiration exceeds rainfall, have lower rates of solution. It is thus possible that the different rates of solution produce the different karren forms. Furthermore the effects of rain-pitting under the intense rainstorms experienced on an unprotected surface might favour the development of sub-circular rather than linear features.

The variation in lithology is probably the most important factor. The Newport Limestone occurs at Portland and Hellshire, between which there are the smallest differences in form. Troy, with Troy Limestone, exhibits not only the largest range of form, but is also significantly different from the other two areas. The cause of these differences in form may be of a structural nature, e.g. the nature and frequency of jointing, or of a mineralogical nature. The micro-structure of an initially exposed limestone surface will have an immediate effect in the initial stages of solution of the surface. Weaknesses in the crystalline structure may favour the concentration of solution favouring the production of linear karren.

Another factor to take into account is the possible effect of marine-boring organisms in the Hellshire Hills area. A higher sea-level in the past would have submerged most of the Hellshire Hills sample area. Marine-boring organisms (Trudgill, 1972) produce sub-circular pits, within which solution is concentrated. Since the rate of solution in the Hellshire Hills is relatively low, the effect of boring mechanisms would tend to last over long periods.

To conclude, it is probable that no one particular factor is responsible for the form of karren produced in a particular area, but rather a combination of factors. This study has established that the site factors investigated have, surprisingly, no influence on karren form. Climate, in terms of precipitation, and lithology can be seen to be the dominant controls, but the relative importance of these two factors remains to be investigated.

THE CHIROPTERA COLLECTION

During the course of the expedition, efforts were made to undertake a programme of collection and observation of cavernicolous bats. The collection was designed to assist the British Museum (Natural History) in the establishment of a representative sample of Jamaican bats, and the Museum's assistance in the provision of equipment, references, and facilities is gratefull acknowledged.

Chiroptera were collected from three important roosts, Oxford Cave (G.R.332 475), Wallingford Roadside Cave (326 465) and Windsor Cave (326 528). Collection in St. Clair Cave (518 454) and Swansea Cave (497 484) was interrupted by the discovery of Still Waters Cave which absorbed the efforts of the whole team. In addition, the expedition biologist, B. Williams, was incapacitated for a week during an epidemic of Dengue fever, and a second visit to Windsor Cave was prevented by local hostilities.

Methods.

In all cases the bats were taken in mist nets set up near the cave entrances. It should be noted, however, that the use of these nets is illegal in many countries, and their acquisition by the local populace is in any case extremely undesirable, so that discretion should be used and the nets must never be left unattended. It was found that live bats left in the nets for more than a few moments become hopelessly entangled in the fine mesh and that it was therefore preferable to kill the specimens in situ as they were caught. This was conveniently and humanely achieved by means of a direct intra-cardiac injection of Euthatal (sodium pentabarbitol) which could be administered swiftly and resulted in extremely rapid death.

Although rabies is unknown in Jamaica, its prevalence in Central America and Trinidad was considered adequate reason for expedition members to avail themselves of the new rabies vaccine. In addition, thick gloves were always used whilst handling the live animals.

Captures were reduced by bats veering away from cavers' electric headlamps and so missing the mist nets. Future workers might try masking headlamps with a red filter as bats are probably unable to see red light.

Once killed, the bats were removed from the net and placed in individual polythene bags for transportation back to the laboratory. After examination for ectoparasites, each specimen was individually identified with a label attached to the leg, and had its mouth stuffed with cotton-wool to facilitate examination of the teeth and palate at a later date. Subsequent preservation was by immersion for 48 hours in 90% ethanol followed by permanent transfer to 70% ethanol.

Identification was most kindly carried out by Mr. J. E. Hill of the British Museum, where the collection is now lodged.

Results.

Fifty-four specimens of seven species of bat were collected. These and their distribution were as follows:

	Species	Number of specimens
Wallingford Roadside Cave	*Tadarida molossa*	11
Windsor Cave	*Pteronotus parnellii parnellii*	3
	Macrotus waterhousii jamaicensis	1
Oxford Cave	*P. fuliginosus fuliginosus*	17
	Mormoops blainvilli	10
	Monophyllus redmani	6
	P. macleayii grisea	1
	P. parnellii parnellii	4

Fig. 10 summarises the morphological data collected from the specimens before preservation.

Discussion. Very little has been published on the ecology, or even the status, of Jamaican bats. Indeed, the sole paper on the ecological aspects is that by Goodwin (1970) and it is the current author's opinion that this paper is both inadequate and misleading in its coverage of the subject for the following reasons:

Firstly, Goodwin recorded *Pteronotus fuliginosus fuliginosus* only from St. Clair Cave, even though he spent sufficient time collecting at Oxford Cave to be able to give a species list, population estimate, and behavioural data. In our experience, *P. fuliginosus fuliginosus* was the commonest species we collected from Oxford Cave. Secondly, Goodwin missed *P. macleayii grisea* which we collected from Oxford Cave, and also *Macrotus waterhousii jamaicensis* which we recorded from Windsor Cave. Although Goodwin did not visit Wallingford Roadside Cave (very obvious and only a few miles down the road from Oxford Cave) he did not record *Tadarida molossa* anywhere on the Island. Koopman and Williams (1951) have suggested from their own studies of fossil material that *T.molossa* may prefer roosting sites not frequented by other species, and our collection of living specimens tends to support this, there being no other species associated with Wallingford Roadside Cave.

Secondly, it may be that Goodwin's omissions may arise from his collecting technique. During our own work, it was noticed that in a mixed species colony, as at Oxford Cave, the bats leaving the roost at any one time do not represent a random sample of the total population. This was particularly well shown at Oxford Cave, where it was found that for fifteen minutes after the emergence of the first bat, only male *Pteronotus fuliginosus fuliginosus* were caught. In the subsequent five minutes female *P. fulinginosus fuliginosus*, and *P. parnellii parnellii* began to emerge, and the last specimen to be collected was *Macrotus waterhousii jamaicensis*. It therefore seems reasonable to conclude that any collection which does not include samples at short intervals throughout the whole period of activity of the bats is likely to produce a highly biased picture both of species and of sex ratios. The period of activity extends throughout the night, making such observations a long task.

Thirdly, with the thoroughness of his collections in doubt, a number of Goodwin's behavioural observations may be viewed with scepticism.

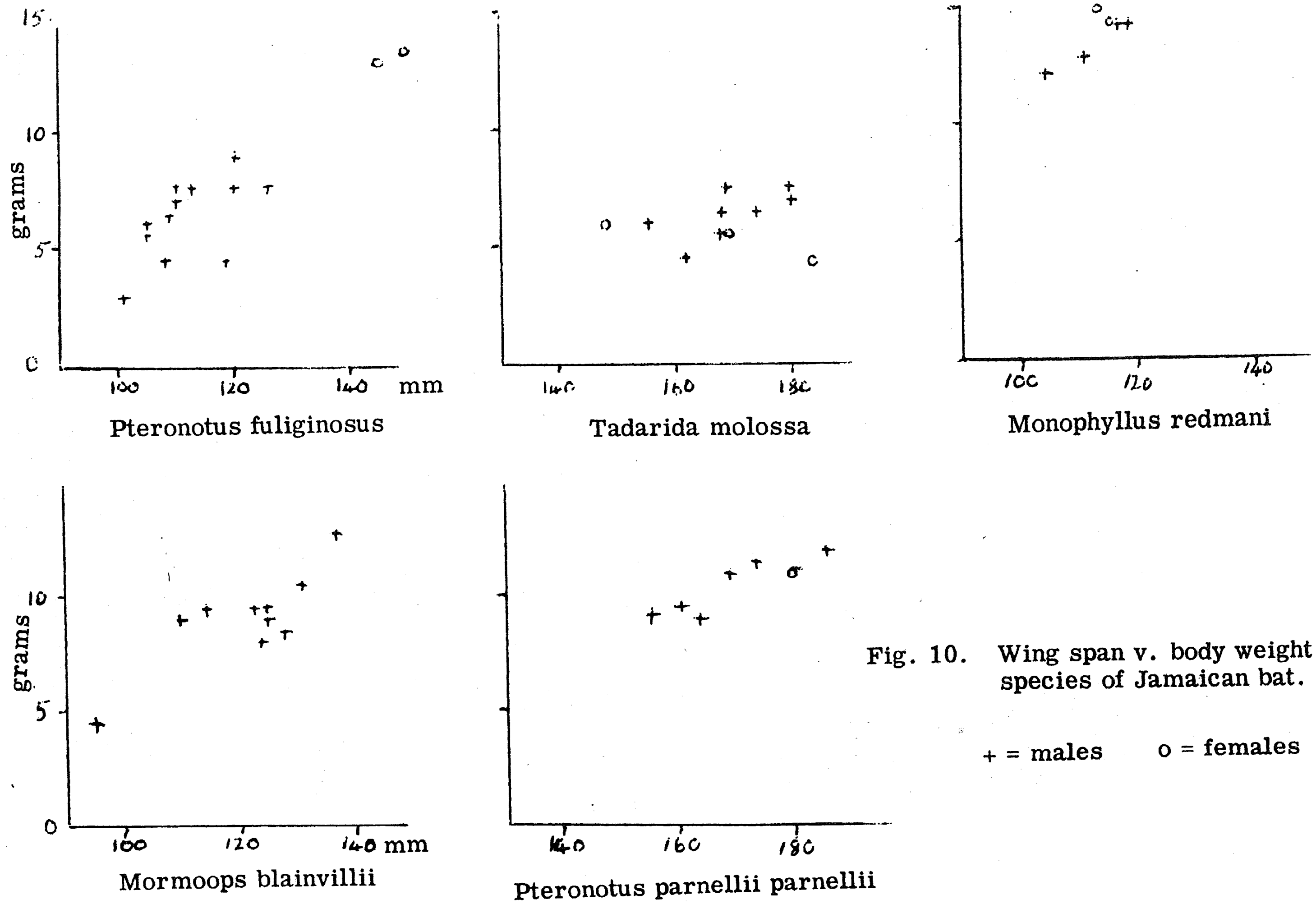


Fig. 10. Wing span v. body weight for five species of Jamaican bat.

+ = males o = females

We found all the bat colonies we visited to be very sensitive to disturbance, and human approach caused great activity amongst the bats, many retreating into the depths of the caves well ahead of the advancing biologist. Further, many of the species proved extremely difficult to identify even in the hand, and impossible when forty feet up in the roof, so that it is difficult to see how valid observations on roosting behaviour could be obtained. Also, in Oxford Cave, specialized climbing techniques not available to Goodwin enabled us to scale the huge aven frequented by a large proportion of the bat fauna. Even so it proved impossible to estimate the number of bats present accurately, so that it is difficult to see how Goodwin could confidently quote not only total population size, but also numbers of each species.

An effort was made by the author to test a new technique for estimating numbers in a bat roost. The principle was to take photographs at right angles to the cave entrance at regular intervals throughout the evening exodus, and having calculated the speed of movement of the bats from the length of the blur on a long exposure photograph and the number of animals on each of a series of flash photographs, to extrapolate an estimate of population size. The technique requires a fast, high resolution black and white film and powerful electronic flash, neither of which was available to us at the time. Nevertheless trials at Oxford Cave were encouraging.

In conclusion, it must be said that although there is an urgent need for a proper study of Jamaican bat ecology, indiscriminate collecting and disturbance must be avoided. During our own work, we attempted to restrict the size of our samples to the specific quota of each species requested by the British Museum in advance of the expedition. This policy was hampered, however, by the extreme difficulty involved in identifying many Jamaican species without first killing and returning them to the laboratory. The author has therefore undertaken a preliminary study of Jamaican bat hairs, with a view to enabling future workers merely to return hairs to the laboratory and release the bats unharmed. The results of this work will be published elsewhere.

The key provided with this report is that compiled for the expedition by Mr. J. E. Hill of the British Museum, without whom none of this work could have been attempted.

A KEY TO THE BATS OF JAMAICA:

1.	Tail thick, long and extending for about one half its length beyond well developed tail membrane.	MOLOSSIDAE
	Tail, if present, not extending much beyond tail membrane.	2.
2.	Muzzle with definite chin or nose leaves.	3.
	Muzzle without definite terminal foliations.	5.
3.	Chin with flat dermal plates provided with numerous papillae, no nose leaf.	MORMOOPIDAE
4.	Prominent nose leaf, its vertical part lanceolate, no plates on chin.	PHYLLOSTOMATIDAE
5.	Two phalanges on third finger.	NATALIDAE
	Three phalanges on third finger.	6.
6.	Tail partly enclosed in tail membrane, free portion emerging dorsally from its centre.	NOCTILIONIDAE
	Tail entirely enclosed in tail membrane or extending very slightly beyond its posterior edge.	VESPERTILIONIDAE

NOCTILIONIDAE

Noctilio leporinus mastivus only Jamaican representative.

MORMOOPIDAE

1.	Ears noticeably separated, but may be connected by a low, inconspicuous ridge.	*Pteronotus (= Chilonycteris)*
	Ears united on the rostrum by a prominent band.	*Moormoops blainvillei*

Pteronotus (=Chilonycteris)

1.	Length of forearm exceeding 50 mm.	*P.parnellii parnellii*
	Length of forearm less than 50 mm.	2.
2.	Length of forearm 41-46 mm.	*P.macleayi grisea*
	Length of forearm 37-40 mm.	*P.fuliginosus fuliginosus*

PHYLLOSTOMATIDAE

1. Noseleaf rudimentary, without distinct upright process, tail present. — Phyllonycterinae
   Noseleaf well-developed, tail absent if noseleaf rudimentary. — 2.
2. Tongue very long, upper surface of lower lip divided centrally by a deep groove, head long, narrow. — Glossophaginae
   Tongue normal, upper surface of lower lip not grooved, head short, blunt. — 3.
3. Tail membrane a very narrow band along legs and posterior body; calcars indistinct or absent. — Sturnirinae
   Tail membrane moderate to well developed. — 4.
4. Upper molars normal, with W-pattern. — Phyllostomatinae
   Upper molars abnormal, W-pattern lacking, obscured or distorted. — 5.
5. Upper molars narrow, trenchant. — Carolliinae
   Upper molars short, wide, the cusps rising from a broad, flattened crushing surface. — Stenodermatinae

Phyllostomatinae

1. Length of forearm 49-55 mm. — *Macrotus waterhousii jamaicensis*
   Length of forearm exceeding 100 mm. — *Vampyrum spectrum*

Carolliinae

Carollia perspicillatum the only Jamaican representative.

Sturnirinae

Sturnira lilium the only Jamaican representative.

Stenodermatinae

1. Length of forearm less than 45 mm.. — *Ariteus flavescens*
   Length of forearm 56-66 mm. — *Artibeus jamaicensis jamaicensis*

Phyllonycterinae

1. Second and third lower molars without distinct cusps. — *Phyllonycteris (-Reithronycteris) aphylla*
   Second and third lower molars dinstinctly cusped. — *Erophylla sezekorni syops*

Glossophaginae

1. Tail short, not extending beyond tail membrane, upper premolars in contact, filling space between canine and first molar, lower incisors well developed. — *Glossophaga soricina antillarum*
   Tail long, extending a little beyond tail membrane, a gap between premolars and between these and the adjacent teeth, lower incisors minute or absent. — *Monophyllus redmani*

NATALIDAE

Chilonatalus micropus the only Jamaican representative.

VESPERTILIONIDAE

1. Upper incisors 2-2 — *Eptesicus*
   Upper incisors 1-1 — *Lasiurus degelidus*

Eptesicus

1. Length of forearm less than 45 mm. — *E. lynni*
   Length of forearm exceeding 46 mm. — *E. fuscus hispaniolae*

These are difficult to separate externally and discrimination by length of forearm is probably purely arbitrary. *Eptesicus lynni* has a smaller skull than *E. fuscus*.

MOLOSSIDAE

1. Palate deeply emarginate between incisors. — *Tadarida*
   Palate without a deep emargination between incisors. — 2.
2. Length of upper incisor along cingulum equal to its height; one pair lower incisors. — *Molossus milleri*
   Lengh of upper incisor along cingulum less than its height; two pairs lower incisors. — *Eumops glaucinus*

Tadarida

Length of forearm 36-46 mm. — *T. murina*
Length of forearm 58-64 mm. — *T. molossa*

The character used to separate *Tadarida* from *Molossus* and *Eumops* is rather difficult but externally there are no good diagnostic features. It is easy to confuse *Tadarida murina* with *Molossus milleri* which has a forearm length of about 40 mm. or *T.molossa* with *Eumops glaucinus* in which the forearm length is about 58-61 mm.

Koopman however, separates Tadarida from *Molossus* and *Eumops* as follows:

a. Upper lip wrinkled, antitragus of ear not constricted at base. — *Tadarida*
   1. Small size, ears hardly meeting at midline. — *T. murina*
   2. Large size, ears united at base. — *T. molossa*

b. Upper lip smooth or slightly warty.
   1. Large size, nose snoutlike, antitragus of ear flaplike and not constricted at base. — *Eumops*
   2. Small size, nose not snoutlike, antitragus of ear lobate and constricted at base. — *Molossus*

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