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Observations on macroborings from the White Limestone Group of Jamaica

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The Middle Eocene to Middle Miocene White Limestone Group contains uncommon, but relatively diverse, macroborings along with moderately diverse, poor to moderately preserved, soft-sediment ichnotaxa. The Troy, Somerset, Moneague and Montpelier formations have yielded macroborings.

Nine ichnogenera represented by twenty-nine ichnospecies are identified. These are *Caulostrepsis taeniola* Clarke, *Clionolithes irregularis* Fenton & Fenton, *Cl. radicans* Clarke, *Conchotrema canna* Price, *Co. tenuis* Teichert, *Conchotrema* isp., *Entobia cateniformis* Bromley & d'Alessandro, *E. gigantea* Bromley & d'Alessandro, *E. megastoma* (Fischer), *E. ovula* Bromley & d'Alessandro, *E. paradoxa* (Fischer), *Entobia* ispp. AA, AB, AC, AD, *Gastrochaenolites anauchen* Wilson & Palmer, *G. cluniformis* Kelly & Bromley, *G. dijugus* Kelly & Bromley, *G. lapidicus* Kelly & Bromley, *G. torpedo* Kelly & Bromley, *Gastrochaenolites* isp., *Maeandropolydora crassa* Bromley & d'Alessandro, *M. decipiens* Voigt, *M. elegans* Bromley & d'Alessandro, *M. sulcans* Voigt, *Oichnus simplex* Bromley, *O. paraboloides* Bromley, *Trypanites* isp. and *Uniglobites glomerata* (Morris).

Most of these structures are preserved in scleractinian corals. Only *E. megastoma* (preserved in crab carapaces) and *E. ovula* (preserved in molluscs) show affinities for a specific host. *Trypanites* isp. is also preserved in hardgrounds. The distribution of bioerosional structures reflects, at least in part, the taphonomic history of the bored substrates. The fossiliferous Moneague and Montpelier formations exhibit the highest diversity of these structures.

KEY WORDS: Jamaica, White Limestone Group, taxonomy, macroborings, trace fossils.

Introduction

Palaeontological research in Jamaica has been conducted since the 1820s, but, despite its well-developed history and numerous subsequent publications (see Wright & Robinson, 1993), systematic ichnologic studies were only initiated in the early 1990s (Pickerill & Donovan, 1991, 1998, 1999; Pickerill *et al.*, 1992, 1993a-c, 1996, 1998a, b, 2002a; Mitchell *et al.*, 1998; Donovan & Blissett, 1998; Pickerill & Mitchell, 1999; Perry, 2000; Donovan *et al.*, 2001; Donovan, 2002). These studies focussed on siliciclastic rock sequences, with the exception of Donovan & Blissett (1998), Perry (2000) and Donovan *et al.* (2001), which discussed the carbonates of the Middle Eocene Yellow Limestone Group and the Middle Miocene to Pleistocene Coastal Group.

The purpose of this contribution is to record, figure and briefly describe systematically the macroborings that, to date, we have observed within the White Limestone Group. This study represents the first, albeit brief, documentation relating to the ichnology of this group. Twelve locations were investigated, labelled a-l in Figures 1 and 2. Additional material, located in the Geology Museum, Department of Geography and Geology, University of the West Indies, Mona (UWIGM), was also examined.

Localities

The Middle Eocene to Middle Miocene White Limestone Group overlies the Middle Eocene Yellow Limestone Group and underlies the Middle Miocene to Pleistocene Coastal Group. It represents 60-65% of the surface outcrop of Jamaica (Mitchell, 2004).

Red Gal Ring (exposure a; Figures 1, 2a) is located in the parish of St. Andrew, 4 km south of Stony Hill town square. It consists of poorly to sparsely fossiliferous micritic limestones of the Troy Formation, and foraminiferal micrites, grainstones, and sparsely fossiliferous micrites and sparry calcitic beds of the Somerset Formation (Mitchell, 2004).

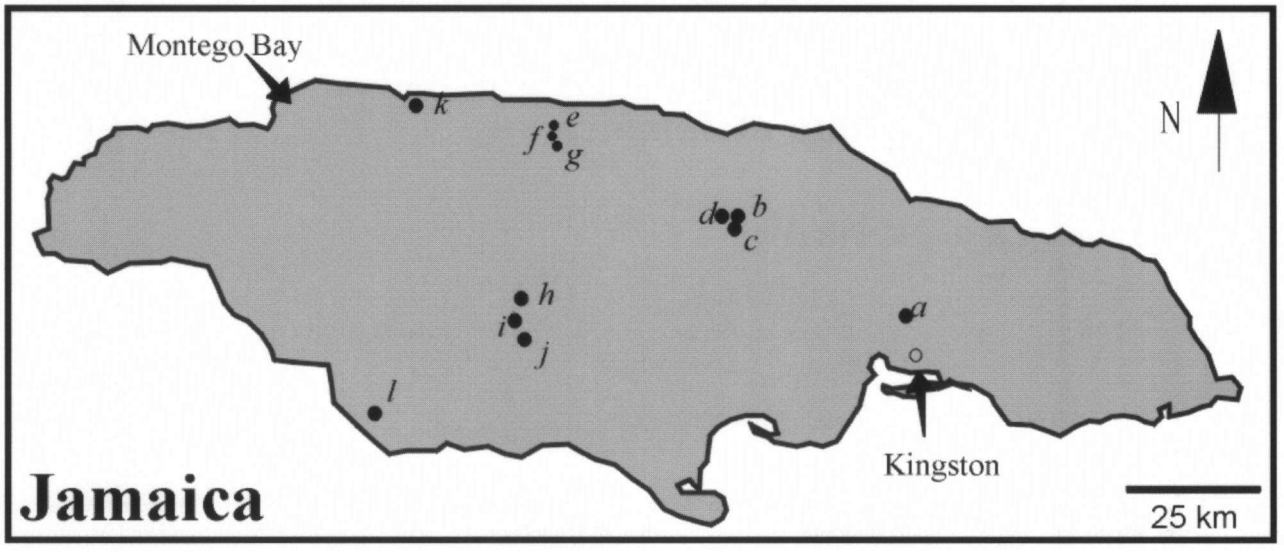


Figure 1. Outline map of Jamaica depicting the location of twelve sites within the White Limestone Group, labelled a-l. The open circle shows the approximate location of the Geology Museum, University of the West Indies.

Exposures b, c and d (Figures 1, 2b) are located in the parish of St. Ann, approximately 4 km north of Schwallenburgh and within mined-out bauxite pits. The Moneague (b), Somerset (c) and Troy formations (d) are represented. At b, the Moneague Formation comprises white, packed fossiliferous micrites, containing abundant corals, along with sparry calcitic packstones possessing moulds and casts of benthic molluscs. The Somerset Formation (c) is represented by massive beds of floatstones-rudstones that lack biogenic structures. The Troy Formation (d) is represented by one of its lithologic variants (Mitchell, 2004) and consists of micrites that contain abundant molluscs.

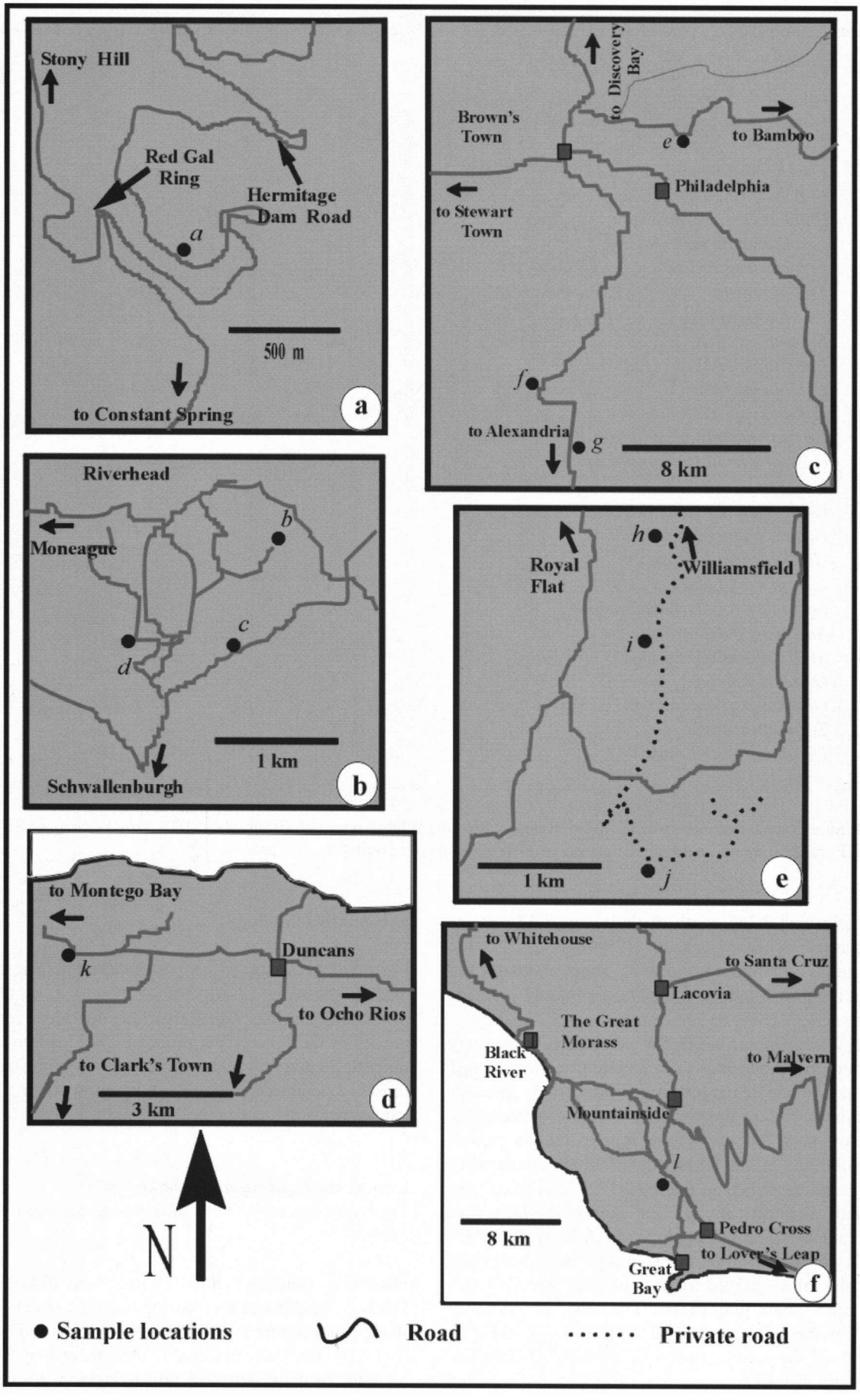
Exposures e, f and g (Figures 1, 2c) are situated in the parish of St. Ann, located approximately 1.5, 4.5 and 7 km, respectively, from Brown's Town along the main road between Brown's Town and Alexandria. All three exposures are within the outcrop of the Moneague Formation. They include well-bedded, fossiliferous, intrasparitic-intramicritic limestones (e); massively bedded, sparry calcitic, sparsely packed bioclastic micrites with an abundance of scleractinian corals, bivalves and foraminifera (f); and, at g, sparsely fossiliferous micrites.

In the parish of Trelawny, approximately 5 km west of the town of Duncans, two distinctive lithologic sequences of the Montpelier Formation (k; Figures 1, 2d) are exposed (Mitchell, 2004). The first lithology consists of 0.5-2.0 m thick beds of fine- to coarse-grained chalks and limestones interbedded with thinly bedded, greyish calcareous mudstones associated with nodular to bedded chert. Chert in joints and fractures is also evident. The second lithology consists of extraclastic, coral-rich rudstones-floatstones with echinoids, crab carapaces, foraminifers, benthic molluscs and nautiloids.

Exposures of the Moneague Formation at h, i and j (Figures 1, 2e) occur on a private haulage road within the WINDALCO (formerly ALCOA mines) mining area, 6 km south of the town of Williamsfield, parish of Manchester. At h, a series of six hardgrounds occur that are laterally discontinuous (Mitchell, 2004), and are interbedded with a range of lithologies varying from unfossiliferous to fossiliferous micrites and foraminiferal wackestones. At i, the sequence is represented by beds 1.0-3.5 m in thickness that consist of molluscan- and algal-rich micrites grading into foraminiferal packstones and, at j, of patches of scleractinian coral-rich rudstones-floatstones.

Figure 2. Detailed road maps of the six areas within which are located the twelve sites labelled a-l in Figure 1. Key: shading = land; blank = Caribbean Sea:

a Red Gal Ring area, north of Kingston, parish of St. Andrew.
b Schwallenburgh bauxite mining area, parish of St. Ann.
c Brown's Town area, parish of St. Ann.
d Duncans area, parish of Trelawny.
e WINDALCO bauxite mine area, parish of Manchester.
f Black River area, parish of St. Elizabeth.


Stony Hill
Red Gal Ring
Hermitage Dam Road
a
500 m
to Constant Spring
a
to Discovery Bay
Brown's Town
e
to Bamboo
Philadelphia
to Stewart Town
f
to Alexandria
g
8 km
c
Riverhead
b
Moneague
c
d
1 km
Schwallenburgh
b
h
Royal Flat
Williamsfield
i
1 km
j
e
to Montego Bay
k
Duncans
to Ocho Rios
to Clark's Town
3 km
d
N
to Whitehouse
to Santa Cruz
Lacovia
The Great Morass
Black River
to Malvern
Mountainside
l
8 km
Pedro Cross
to Lover's Leap
Great Bay
f
● Sample locations
Road
Private road

	TF	SF	MeF	MrF
Caulostrepsis taeniola		X	X	
Clionolithes irregularis				X
Clionolithes radicans				X
Conchotrema canna			X	X
Conchotrema tenuis				X
Conchotrema isp.				X
Entobia cateniformis			X	X
Entobia gigantea			X	X
Entobia megastoma				X
Entobia ovula	X	X	X	X
Entobia paradoxa			X	
Entobia isp. AA			X	X
Entobia isp. AB			X	
Entobia isp. AC		X		
Entobia isp. AD			X	
Gastrochaenolites anauchen			X	
Gastrochaenolites cluniformis			X	
Gastrochaenolites dijugus			X	
Gastrochaenolites lapidicus			X	
Gastrochaenolites torpedo			X	
Gastrochaenolites isp.			X	
Maeandropolydora crassa			X	
Maeandropolydora decipiens			X	
Maeandropolydora elegans			X	
Maeandropolydora sulcans			X	
Oichnus simplex		X	X	X
Oichnus paraboloides		X	X	
Trypanites isp.			X	
Uniglobites glomerata			X	

Table 1. Stratigraphic distribution of the macroborings within the White Limestone Group. Key: TF = Troy Formation; SF = Somerset Formation; MeF = Moneague Formation; MrF = Montpelier Formation; X = present.

At l, located 3 km south of the town of Mountainside, parish of St. Elizabeth (Figures 1, 2f), the Moneague Formation is exposed. There it comprises foraminiferal wackestones that uncommonly contain bivalve shells.

The White Limestone Group contains a moderately diverse to abundant, poor to moderately well-preserved ichnofauna. Nine ichnogenera represented by twenty-nine ichnospecies of bioerosional structures (macroborings) have been identified from four of the six formations within the group. Those identified are tabulated in Table 1 and described in the text. The descriptions are presented alphabetically (cf. Pickerill & Donovan, 1991), rather than in morphological (cf. Uchman, 1995; Schlirf, 2000) or ethological groups (cf. Seilacher, 1964), and are employed for ease of reference. The material, other than that in the UWIGM, is currently housed in the palaeontological collections of the Department of Geology, University of New Brunswick, Fredericton, Canada.

Systematic ichnology

For brevity, discussion on preserved ichnogenera is included following description of their one, or typically more, ichnospecies rather than on individual representatives of the latter. This procedure avoids unnecessary repetition, particularly with respect to comparison of those ichnogenera represented by more than a single ichnospecies.

Ichnogenus *Caulostrepsis* Clarke, 1908
Type ichnospecies — *Caulostrepsis taeniola* Clarke, 1908.

Diagnosis (modified after Bromley & d'Alessandro, 1983) — Single-entrance boring having a pouch- or ear-shape produced by a gallery that is U-shaped. The limbs of the 'U' may be connected by a vane, or may be fused with an oval or flattened pouch lacking a vane. The

width is at least double the thickness at the distal end and becomes noticeably thinner at the apertural end. The cross-sectional shape varies from flat to oval, elliptical or constricted to dumbbell-shaped. In some species, symmetrical rows of deep pits may develop at the apertural end. The aperture may maintain the same cross-sectional shape throughout or may be modified by the development of apertural grooves, normally 2 to 4 in number, radiating out from it.

Caulostrepsis taeniola Clarke, 1908
Figure 3/1

Material — Four specimens: three from locality c (Figure 2b), Somerset Formation, and one, UWIGM 2003.1 (Figure 3/1), from locality h (Figure 2e), Moneague Formation.

Preservation — UWIGM 2003.1 occurs in association with *Entobia ovula* Bromley & d'Alessandro, 1984, in an indeterminate mollusc. The other three specimens are preserved in two indeterminate molluscs.

Description — The figured specimen is a U-shaped boring having cylindrical limbs separated by a vane at its distal end and constricting to an axial depression towards the proximal extremity. The limbs and vane are only pronounced on the side facing the substrate (inward-facing). Only a slight impression of the limbs and vane are preserved on the outward-facing margin. The diameter of the limbs decreases to approximately 0.3 mm at the vertex, but otherwise remains constant at 0.4 mm. The structure, 4 mm in length, is curved close to the vertex and slightly twisted towards the aperture. The aperture is concealed.

Discussion — *Caulostrepsis* differs from the morphologically similar ichnotaxon *Maeandropolydora* Voigt in having no well-developed cylindrical galleries (see below). *Caulostrepsis taeniola* can easily be distinguished from *C. contorta* Bromley & d'Alessandro, 1983, that is sinuous with lobes; from *C. biforans* (Gripp, 1967) and *C. cretacea* (Voigt, 1971), neither of which possess a vane; from *C. avipes* Bromley & d'Alessandro, 1983, that has grooves in its aperture; and from *C. spiralis* Pickerill *et al.*, 2002b, that exhibits a planispiral to torticone geometry.

Ichnogenus *Clionolithes* Clarke, 1908

Type ichnospecies — *Clionolithes radicans* Clarke, 1908.

Diagnosis (modified after Fenton & Fenton, 1932) — Borings, having small tubes radiating from a common centre, which may be single and pronounced, or multiple and indistinct. Tubes may expand into palmate channels, which commonly terminate in minute, radiating or irregularly branching tubes. The tubes may also be errant, coiled, crossing and anastomosing in patterns that almost obscure the centre of radiation.

Clionolithes irregularis Fenton & Fenton, 1932
Figure 3/2

Material — One specimen, UWIGM 2003.2, from locality k (Figure 2d), Montpelier Formation. Preserved in association with *Clinolithes radicans* Clarke, *Conchotrema tenuis* Teichert and *Conchotrema* isp. in an indeterminate scleractinian coral.

Description — Flattened boring having thread-like tubes (less than 0.5 mm in diameter), rarely fused, radiating from several bosses, each less than 0.9 mm in diameter. Individual tubes radiate from these bosses and may or may not be interconnected or branched. A minimum of five tubes, typically more, emerge from the bosses, with the tubes normally exhibiting up to third order branches while radiating in various directions. Numerous protruding spikes, that can be considered apertures, irregularly emerge from the majority of tubes. Although the bosses are more or less flattened, they possess an irregular ovoid- to knob-like shape. The ichnospecies forms a dense mesh-like network occupying an area of approximately 5 x 5 mm.

Clionolithes radicans Clarke, 1908
Figure 3/3

Material — One specimen, on UWIGM 2003.2, from locality k (Figure 2d), Montpelier Formation. Preserved in association with *Clinolithes irregularis* Fenton & Fenton, *Conchotrema tenuis* Teichert and *Conchotrema* isp. in an indeterminate coral.

Description — Poorly preserved stellate boring comprising a single pronounced raised central boss, with two pairs of radiating tubes of unequal length that extend between 1-3 mm, oriented at approximately 90° from each other. The tubes are cylindrical in shape and have a diameter of approximately 0.13 mm.

Discussion — *Clionolithes* ispp. are very distinct from *Conchotrema* ispp., which comprise fine, anastomosing tubes having repeated branching. In contrast, the tubes of *Clinolithes* radiate from a common centre, which may be multiple and indistinct as in *Clionolithes irregularis*, or single and pronounced as in *Clionolithes radicans* (Fenton & Fenton, 1932).

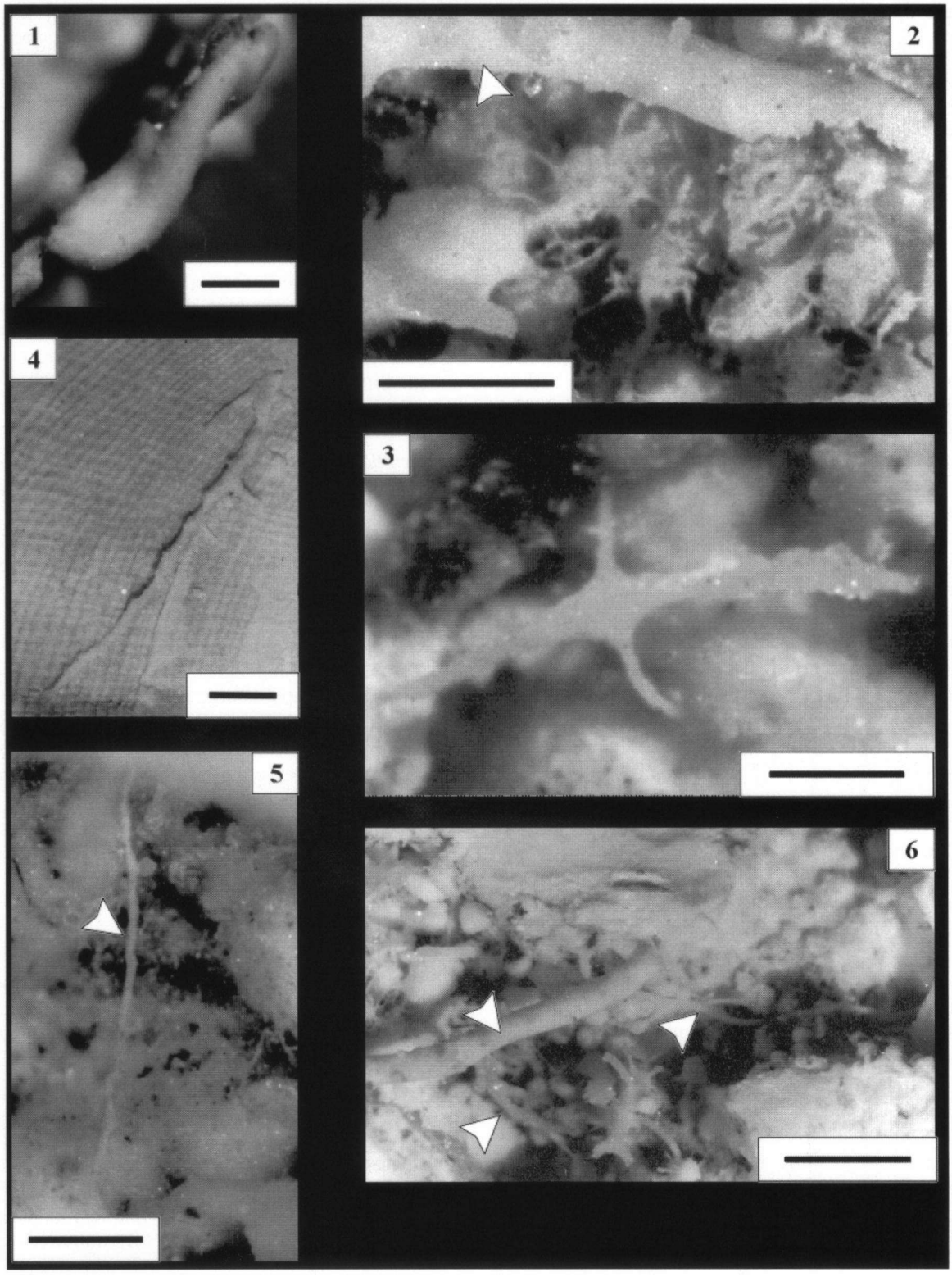


Figure 3.

1 - xenomorphic *Caulostrepsis taeniola* (Clarke, 1908), UWIGM 2003.1, preserved in association with *Entobia ovula* Bromley & d'Alessandro, 1984, in the mould of an indeterminate molluscan specimen. Scale bar represents 1 mm; Moneague Formation.
2 - stenomorphic *Clionolithes irregularis* Fenton & Fenton, 1932, UWIGM 2003.2, in association with *Conchotrema* isp. (arrowed) and an *Entobia* isp. in an indeterminate coral specimen. Scale bar represents 2 mm; Montpelier Formation.
3 - stenomorphic *Clionolithes radicans* Clarke, 1908, UWIGM 2003.2, in association with an indeterminate *Entobia* isp. Scale

bar represents 0.5 mm; Montpelier Formation.

4 - stenomorphic *Conchotrema canna* (Price, 1916), UWIGM 2003.3, in the mould of an indeterminate bivalve. Scale bar represents 2 mm; Moneague Formation.

5 - xenomorphic *Conchotrema tenuis* Teichert, 1945, UWIGM 2003.2 (arrowed), in association with an indeterminate *Entobia* isp. in an indeterminate coral specimen. Scale bar represents 0.5 mm; Montpelier Formation.

6 - stenomorphic *Conchotrema* isp., UWIGM 2003.2, in an indeterminate coral specimen. Lower and right arrowheads indicate first order branching, and upper left arrowhead indicates main branch. Scale bar represents 4 mm; Montpelier Formation.

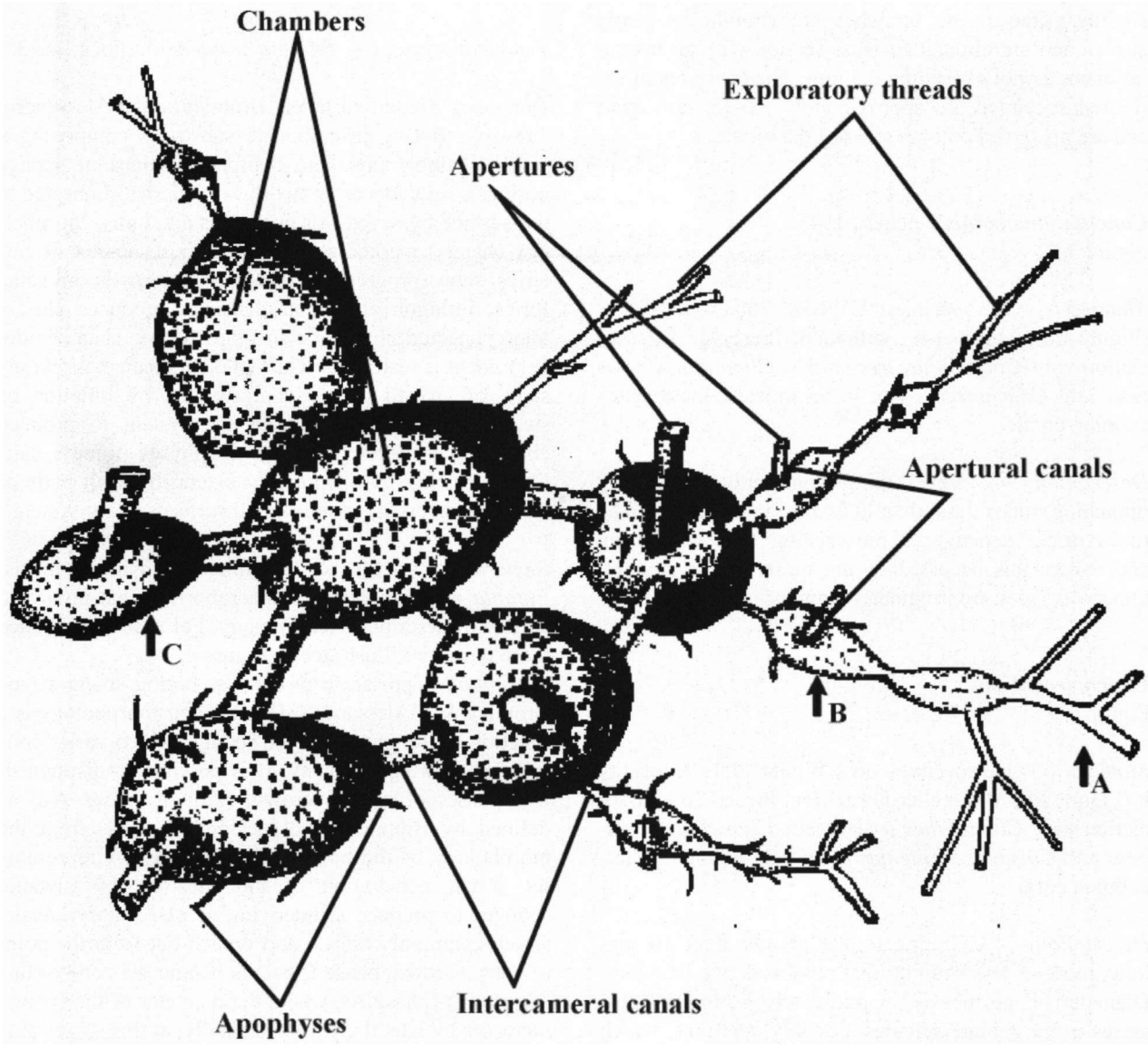


Figure 4. Schematic line drawing showing major components of an *Entobia* boring, including phases A (unshaded), B (lightly stippled) and C (heavily stippled), and the nomenclature utilised with respect to sponge borings (based on Bromley & d'Alessandro, 1984, fig. 2). Not drawn to scale.

Ichnogenus *Conchotrema* Teichert, 1945

Type ichnospecies — *Conchotrema canna* (Price, 1916).

Diagnosis (modified after Bromley & d'Alessandro, 1987) — Thin tubular boring networks showing irregularly repeated branching and anastomosing in all directions. Rarely more than a few millimetres between branches, but density of ramification varies. Boring diameter typically ranges between 0.10 and 0.25 mm. Course almost straight to sinuous or contorted. Apertures are numerous.

Conchotrema canna (Price, 1916)
Figure 3/4

Material — Four specimens, all Moneague Formation: one specimen, UWIGM 2003.3 (Figure 3/4), locality k (Figure 2d); three specimens, locality f (Figure 2c). Preserved in the moulds of two indeterminate bivalves.

Description — The specimens comprise slender tubules, rarely branched, with sporadically developed small-scale protrusions (apertures) on both sides. The tubules are slightly sinuous; the branches are straight to gently curved and are circular in cross-section with an irregular diameter not exceeding 0.5 mm. The apertures of the figured specimen are approximately 1.0-1.5 mm apart and are preserved on both sides of the tubule.

Conchotrema tenuis Teichert, 1945
Figure 3/5

Material — One specimen, UWIGM 2003.2, locality k (Figure 2d), Montpelier Formation. Preserved in association with *Clionolithes irregularis*, *Clionolithes radicans* and *Conchotrema* isp. in an indeterminate scleractinian coral.

Description — Very thin, commonly irregularly branching tubes less than 0.5 mm in diameter. The tubes rarely penetrate a pre-existing entobian boring and, where this occurs, they are more or less straight. Otherwise, they are irregularly sinuous.

Conchotrema isp.
Figure 3/6

Material — One specimen on UWIGM 2003.2, locality k (Figure 2d), Montpelier Formation. Preserved in association with *Clionolithes irregularis, Clionolithes radicans* and *Conchotrema tenuis* in an indeterminate scleractinian coral.

Description — Cylindrical tube greater than 10 mm long, more or less straight, that possesses two branches. Diameter of the tube is approximately 1 mm and possesses a few minute spicules, possibly apertures, which are cylindrical in cross-section. Slight swelling occurs at the branching sites. The latter are less than half the diameter of the main branch, are a maximum of 12 mm in length, and are curved to wavy, forked or themselves irregularly branched. The distal ends of the secondary branches are not seen. Third order branching occurs sporadically.

Discussion — Bromley & d'Alessandro (1987) placed the ichnogenus *Clinolithes* of Price (1916, 1918) in synonymy with *Conchotrema*, *Conchotrema canna* becoming the type ichnospecies. However, this did not affect the availability of *Clionolithes*. *Conchotrema* isp. differs from the nominal ichnospecies of *C. canna* and *C. tenuis* by possessing a main trunk from which secondary branches radiate. However, given that it is only known from a single specimen, we are reluctant to name it as a new ichnotaxon.

Ichnogenus *Entobia* Bronn, 1837

Type ichnospecies — *Entobia cretacea* Portlock, 1843.

Diagnosis (modified after Bromley & d'Alessandro, 1984) — Boring in carbonate substrates comprising a single chamber (swollen, fusiform portions of sponge borings), networks or boxworks of galleries connected to the surface by several or numerous apertures. Morphology changes markedly with ontogeny. Diameter of galleries show progressive increase in growth; in some forms, inflation at regular distances produces closely interconnected chambers; in other forms, chamber development is restricted; while in others, cameration (any stage of growth that is characterized by inflation or swelling of discrete parts of the system to produce chambers) is developed. Fine apophyses (minute hair-like extensions that commonly extend from all parts of the sponge boring) arise from all surfaces of the system.

Remarks — As can be determined from its diagnosis, *Entobia* ispp. are complex macroborings that involve a variety of descriptive terminology. For ease of reference these terms are illustrated in Figure 4.

Entobia ispp. are a product of boring sponges (see Bromley & d'Alessandro, 1984). Their morphology is a function of the growth of the sponge, which varies continuously during ontogeny. It is possible to distinguish five phases of sponge growth (growth phases A-E as defined by Bromley & d'Alessandro, 1984) from the morphology of the boring. Growth phase A represents the initial penetration of the substrate by juvenile sponges to produce slender, linear, exploratory canals, which commonly radiate and branch out from the point of entry. Growth phase B occurs behind the zone of linear growth (phase A), where the diameter of the sponge increases by lateral growth. Normally, at this stage camerate forms begin to swell to develop chambers, whereas non-camerate forms assume a characteristic antler-like shape. Growth phase C is commonly represented by large areas of the boring having characteristic traits such as chamber size and intercameral canals (subcylindrical canals that interconnect chambers). At this stage, the radiating form of the system may still be obvious, but many sponge borings progress no further. Growth phase D is characterised by the continuation of lateral growth by the sponges, which inflates the chambers or branches until little intervening substrate survives. In some camerate forms, fusion of neighbouring chambers occurs and large compound cavities are produced.

Growth phase E is represented where there is a continuation of lateral growth until extensive fusion has obliterated most of the characteristic traits of the form to produce either a single or few large cavities or a non-camerate tunnel system of large size. These definitions are accepted and are adopted in the description of the material from the White Limestone Group.

In order to avoid confusion with the previously defined growth phase terminology A-E of Bromley & d'Alessandro (1987, 1989), we describe those specimens that precluded ichnospecific assignment, essentially because of incomplete or poor preservation, informally as *Entobia* ispp. AA-AD.

Entobia cateniformis Bromley & d'Alessandro, 1984
Figure 5/1

Material — Two specimens, one, UWIGM 2003.4A, from locality h (Figure 2e), Moneague Formation; the other from locality k (Figure 2d), Montpelier Formation.

Preservation — UWIGM 2003.4A is preserved in an indeterminate scleractinian coral; the specimen from the Montpelier Formation is preserved in an indeterminate gastropod.

Description — Phase A of UWIGM 2003.4A is represented by well-developed, branched, exploratory threads, 0.08 mm in diameter. The threads lie at an angle to the larger, 0.2 mm diameter, canals into which they conjoin. Phase B is marked by branched, elongate chambers connected by constrictions with a length slightly greater than 1 mm. Apertural canals originate from these elongate chambers, but are generally indiscernible. Phase C is poorly developed, but fusion on a single elongate chamber of phase B appears to have been initiated (arrowed in Figure 5/1). Phase D not observed.

Entobia gigantea Bromley & d'Alessandro, 1989
Figure 5/2

Material — Two specimens: UWIGM 2003.5, locality k (Figure 2d), Montpelier Formation; one specimen, locality f (Figure 2c), Moneague Formation. Both specimens are preserved in indeterminate scleractinian corals.

Description — The samples exhibit phases A-D, with phase E only sporadically and weakly developed. Phase A consists of long, straight to slightly curved exploratory canals or threads that branch irregularly, and of variable diameter (0.25-1.0 mm) and length (5-20 mm). The thread-like branches and several of the exploratory canals swell at the distal extremities to produce globular, chamber-like, structures. Phase B is represented by chambers connected to threads, which are globular with several being elongated. The intercameral canals, characteristic of phase C, coalesce to form larger canals, up to 5 mm in diameter, where the globular chambers begin to fuse. At the fusion sites, phase D is sporadically preserved where larger irregularly shaped chambers, maximum dimensions 15 x 5 mm, resembling warts with protrusions, are developed. On the largest chambers of the figured specimen (Figure 5/2) the protrusions have conical bases with short, thread-like apophyses that are randomly distributed on this chamber's surface. Phase E is partially observed on one of the large chambers in the figured specimen, the latter being partially smooth.

Entobia megastoma (Fischer, 1868)
Figure 5/3

Material — Seven specimens, locality k (Figure 2d), Montpelier Formation, including UWIGM 2003.6 (Figure 5/3). All preserved in moulds of decapod crustacean carapaces.

Description — Non-camerate forms comprising subcylindrical, commonly tubular gallery systems that vary in diameter (0.1-0.6 mm), with swellings at nodal points. Apertural canals are subcylindrical and taper distally. Larger galleries comprise numerous apertural canals. The entobians are organized in an irregular boxwork system and are preserved as natural casts within internal moulds of crab carapaces. Phases A and B are not obvious. Phase C is comprised of few apertural canals and narrow galleries, while in phase D the density of the apertural canals and the relative size of the galleries increase. Both phases C and D lack exploratory threads.

Entobia ovula Bromley & d'Alessandro, 1984
Figure 5/4

Material — Seven specimens: one specimen, locality d (Figure 2b), Troy Formation; two specimens, locality i (Figure 2e), Moneague Formation, including UWIGM 2003.7 (Figure 5/4); one specimen, locality b (Figure 2b), Moneague Formation; one specimen, locality k (Figure 2d), Montpelier Formation; one specimen, locality h (Figure 2e), Moneague Formation; one specimen, locality c (Figure 2b), Somerset Formation. All preserved in indeterminate molluscan shells.

Description — Camerate entobians comprising spherical to ovoid chambers, averaging approximately 2 mm in diameter, with up to five very short intercameral canals commonly reduced to constrictions.

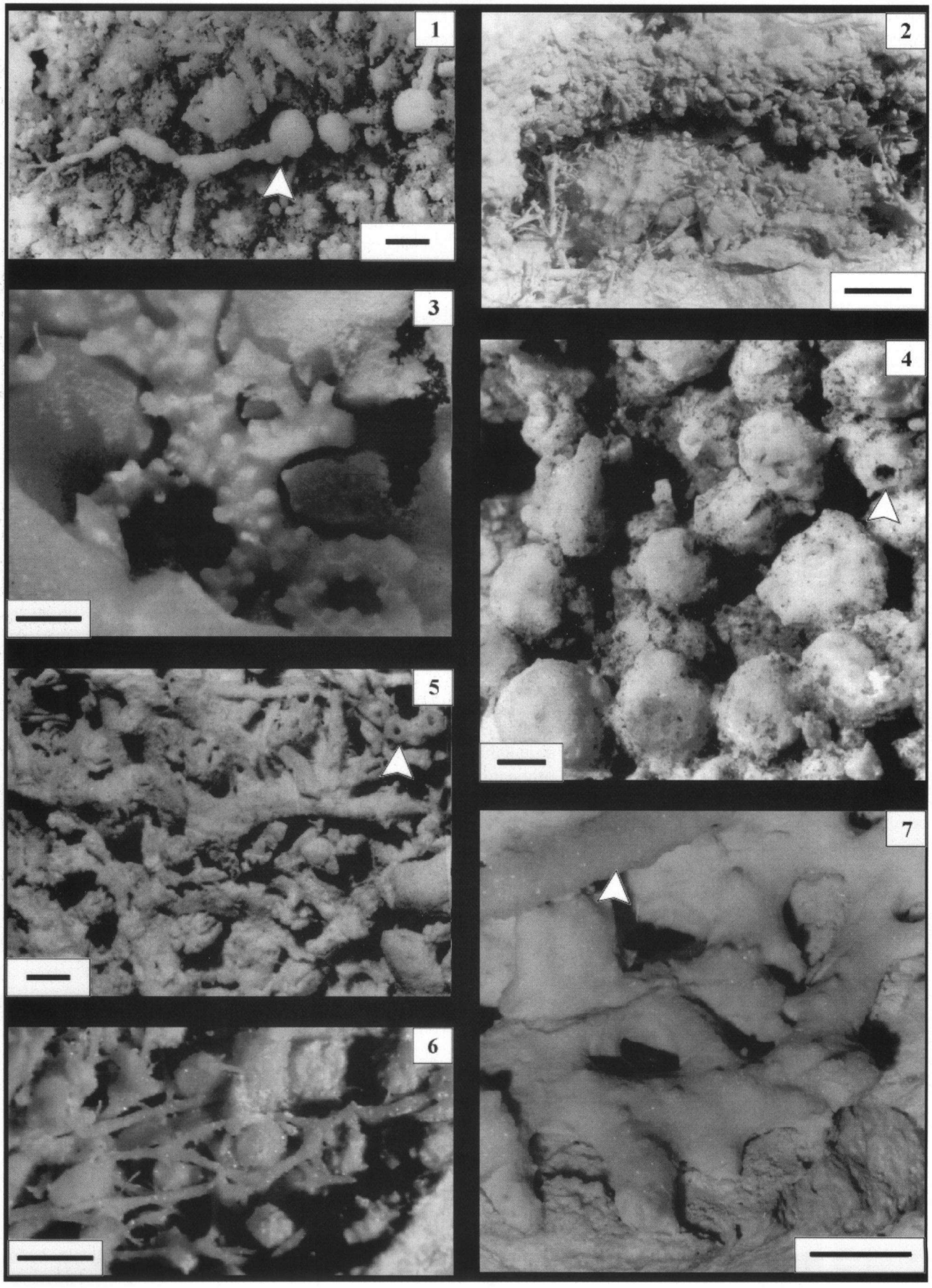

1
2
3
4
5
6
7

Figure 5.

1 - stenomorphic *Entobia cateniformis* Bromley & d'Alessandro, 1984, UWIGM 2003.4A, in an indeterminate coral specimen; note fusion of chamber with intercameral canals (arrowed). Scale bar represents 1 mm; Moneague Formation.
2 - stenomorphic *Entobia gigantea* Bromley & d'Alessandro, 1989, UWIGM 2003.5, in an indeterminate coral specimen. Scale bar represents 10 mm; Montpelier Formation.
3 - stenomorphic *Entobia megastoma* (Fischer, 1868), UWIGM 2003.6, in an indeterminate decapod crustacean carapace. Scale bar represents 0.5 mm; Montpelier Formation.
4 - stenomorphic *Entobia ovula* Bromley & D'Alessandro, 1984, UWIGM 2003.7, in an indeterminate molluscan shell. Note aperture opening near the upper right hand corner (arrowed). Scale bar represents 1 mm; Moneague Formation.
5 - stenomorphic *Entobia paradoxa* (Fischer, 1868), UWIGM 2003.8, in an indeterminate coral specimen. Note the three-fused chambers with exposed apertures (arrowed). Scale bar represents 1 mm; Moneague Formation.
6 - stenomorphic *Entobia* isp. AA, UWIGM 2003.9, in an indeterminate coral specimen. Scale bar represents 2 mm; Montpelier Formation.
7 - stenomorphic *Entobia* isp. AB, UWIGM 2003.10A, in the outer whorl (arrowed) of aff. *Strombus* sp. Scale bar represents 5 mm; Moneague Formation.

The apertures are small and circular, averaging 0.3 mm in diameter; where apertural canals are preserved they taper distally. Phases A and B are not normally present. Where preserved, chambers are comprised of thin apophyses and arranged in straight lines, considered a result of stenomorphism with respect to their host material; they mimic the curvature of their restricted area of shell walls. Phase D consists of irregularly ovoid chambers in very close proximity, but each is clearly distinguishable.

Entobia paradoxa (Fischer, 1868)
Figure 5/5

Material — One specimen, UWIGM 2003.8, locality f (Figure 2c), Moneague Formation. Preserved in an indeterminate scleractinian coral.

Description — A camerate entobian with two tiers arranged vertically and having most of its phases preserved. Phase A is represented by long, generally branched, forked exploratory threads that vary in diameter from 0.3-0.9 mm. These are connected to phase B chambers that are generally elongate, amoeboid in shape and cover a maximum area of 2.0 x 4.0 mm. The chambers are connected by a number of short intercameral canals, which in some places are reduced to constrictions. Phase C is marked by changes in the shape of the chambers, which range from globose to crudely triangular to star-like. Late phase C or phase D is represented by the amalgamation of chambers into irregularly shaped, flattened, much-branched galleries having variable diameters, up to 3 mm. This gives the entobian a mesh-like appearance. Fusion of chambers also occurs such that the resulting compound chamber appears to have multiple apertures. Short apophyses and ovoid to sub-circular apertures are present in all phases.

Entobia isp. AA
Figure 5/6

Material — Three specimens: two specimens, locality k (Figure 2d), Montpelier Formation, including UWIGM 2003.9 (Figure 5/6); one specimen, locality f (Figure 2c), Moneague Formation. Preserved in indeterminate scleractinian corals.

Description — The figured specimen, a camerate entobian, comprises a long (2 mm) intercameral canal that branches. At the proximal end, the branches from the intercameral canals terminate in crudely palmate-shaped exploratory threads. The canals progress into chambers, approximately 1 mm in diameter, which are smooth, rounded and without apophyses. Apertures not observed. At several junctions, chambers change shape to become more or less globose to elongate and the intercameral canals radiating from these chambers increase to at least three. Intercameral canals constrict as the boring begins to cluster.

Entobia isp. AB
Figure 5/7

Material — One specimen, UWIGM 2003.10A, locality g (Figure 2c), Moneague Formation, preserved in a shell of aff. *Strombus* sp.

Description — A non-camerate cast of an entobian that forms an irregular network of flattened galleries. The galleries vary in width from 1-6 mm, except where fusion is evident, where they attain a width of 8 mm. These galleries branch at various angles, with up to seven extending from any one junction. Two styles of protuberance emerge from the galleries: spinose, up to 1 mm in height and diameter; or large, irregularly cylindrical, up to 9 mm at the base and generally extending from the junction of the galleries into the substrate.

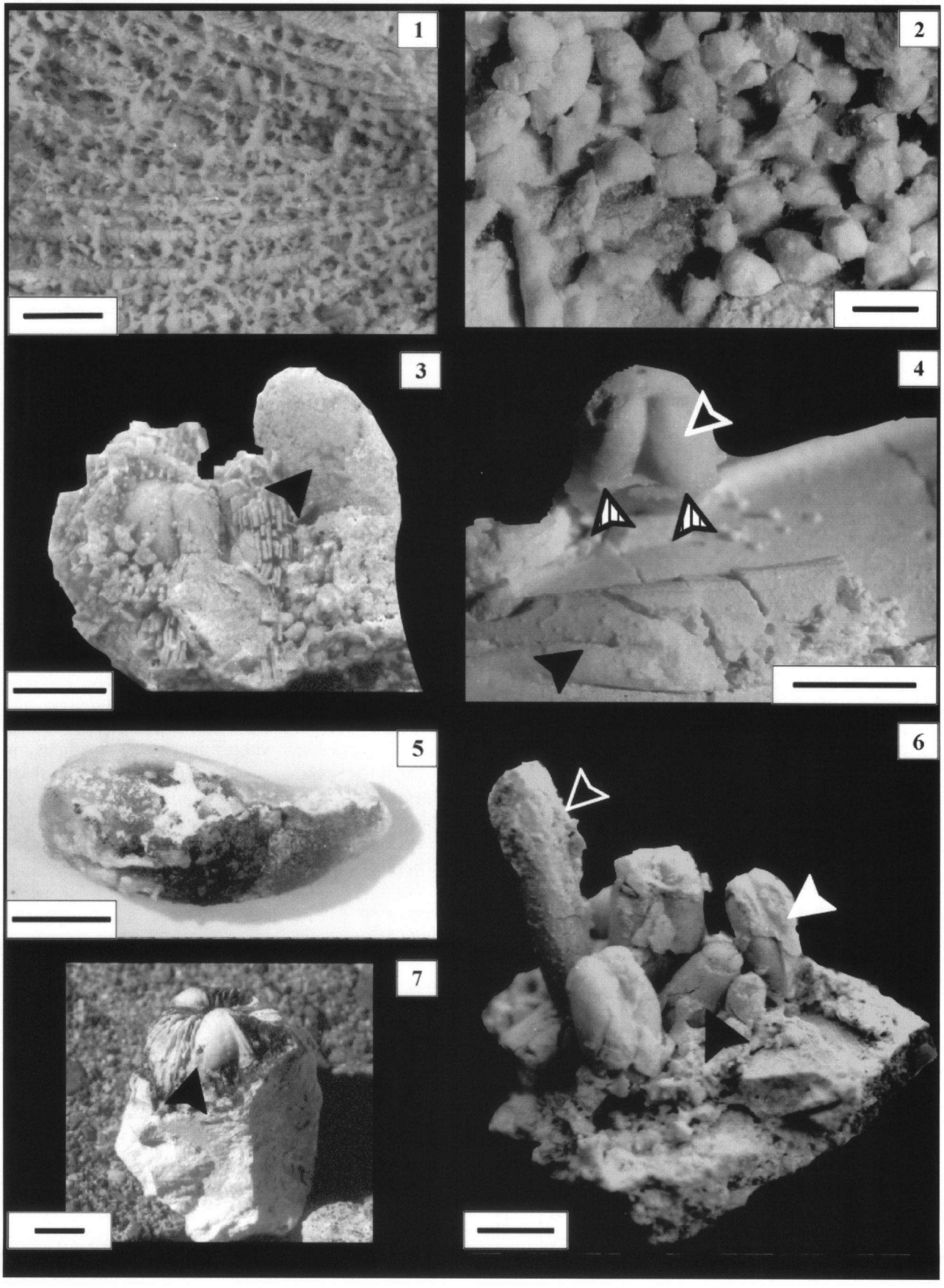

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Figure 6.

1 - extensive stenomorphic *Entobia* isp. AC, UWIGM 2003.11, in an indeterminate molluscan shell. Scale bar represents 5 mm; Somerset Formation.
2 - stenomorphic *Entobia* isp. AD, UWIGM 2003.12, in aff. *Strombus* sp. Scale bar represents 2 mm; Moneague Formation.
3 - *Gastrochaenolites anauchen* Wilson & Palmer, 1998, UWIGM 2003.13 (arrowed), in an indeterminate coral specimen. Scale bar represents 10 mm; Moneague Formation.
4 - *Gastrochaenolites cluniformis* Kelly & Bromley, 1984, UWIGM 2003.16C (black arrowhead with white outline), in association with xenomorphic *Trypanites* isp. (hatched arrowhead). In the foreground *Gastrochaenolites dijugus* Kelly & Bromley, 1984 (black arrowhead), preserved in the shell of aff. *Strombus* sp. Scale bar represents 5 mm; Moneague Formation.
5 - *Gastrochaenolites lapidicus* Kelly & Bromley, 1984, UWIGM 2003.15, fortuitously released from a bivalve substrate in an attempt to collect its host. Scale bar represents 2.5 mm; Moneague Formation.
6 - *Gastrochaenolites torpedo* Kelly & Bromley, 1984, UWIGM 2003.16A (black arrowhead), preserved in association with *Gastrochaenolites cluniformis* Kelly & Bromley, 1984 (white arrowhead), and *Gastrochaenolites dijugus* Kelly & Bromley, 1984 (arrowhead with white outline). Scale bar represents 5 mm; Moneague Formation.
7 - *Gastrochaenolites* isp., UWIGM 2003.17 (arrowed), in an indeterminate coral. Scale bar represents 5 mm; Moneague Formation.

Protuberances are irregularly distributed along the galleries.

Entobia isp. AC
Figure 6/1

Material — One specimen, UWIGM 2003.11, locality a (Figure 2a), Somerset Formation, preserved in an indeterminate molluscan shell.

Description — A camerate cast of an entobian that forms a complex network preserved in two to three tiers. The single aperture chambers have a maximum diameter of 0.6 mm, are sub-rounded to elongate with few or no apophyses. The chambers are connected such that they appear like a string of beads branching in various directions. The intercameral canals are generally reduced to constrictions; where this is not the case, fusion of the chambers gives the entobian a non-camerate appearance.

Entobia isp. AD
Figure 6/2

Material — One specimen, UWIGM 2003.12, locality g (Figure 2c), Moneague Formation, preserved in the gastropod *Strombus* sp.

Description — A relatively dense camerate entobian without exploratory threads, preserved in poorly defined tiers. The chambers, 1-2 mm in diameter, ovoid to elongate amoeboid in shape, are arranged sub-linearly and interconnected by very short intercameral canals. Intercameral canals commonly constricted. No apertures present and few apophyses are observed.

Discussion — Ichnotaxonomic assignment of ichnospecies of *Entobia* ispp. is based, to a large degree, on the presence and connectivity or otherwise of growth phases (Bromley & d'Alessandro, 1984). Because of the rarity and poor preservation of most of the material documented herein, we are unable to assign all of it with confidence. However, *E. cateniformis* is characterized by elongate chambers and an open branching system that render this ichnospecies distinct from other *Entobia* ispp. The Jamaican specimens of *E. gigantea* do not entirely conform to Bromley & d'Alessandro's (1989) original description, that specified chambers "measure 83 x 82 x 23 mm" (*sic*), but they do resemble specimens figured by Bromley & Asgaard (1993) in both size and morphology. *Entobia gigantea* differs from *Uniglobites glomerata* Pleydell & Jones, 1988, morphologically the closest resembling ichnotaxon, but which is single chambered and does not exhibit cameration. *Entobia gigantea* also differs from *Entobia magna* Bromley & d'Alessandro, 1989, morphologically the most similar ichnospecies of *Entobia*, in that the latter maintains its camerate characteristics throughout all phases A-E.

Entobia megastoma, as described above, is differentiated from *E. mammillata* Bromley & d'Alessandro, 1984, as the latter is camerate in phase B, partially in phase C to totally non-camerate in phase E, and has tubercles, which may be fused. *Entobia megastoma* can also be differentiated from *E. paradoxa*, as the juvenile stage (phase A) in the former is not present and the resemblance can only occur in this phase. The density of the nodal points in *E. megastoma* could be a result of the restriction placed on the boring organism by the morphology of the substrate.

Entobia ovula is morphologically similar to *E. laquea* Bromley & d'Alessandro, 1984, and *E. cretacea* Portlock, 1843. It differs from *E. laquea*, in which phase A exists into late stages, and from *E. cretacea*, which always shows clearly developed intercameral canals.

Entobia isp. AA resembles *Entobia retiformis* (Stephenson, 1952) except for its lack of apertures. *Entobia*

isp. AB is present in the same substrate as *Entobia* isp. AD, but they are preserved as separate systems. *Entobia* isp. AB resembles the gerontic and or late phase E stage of *E. megastoma* (non-camerate), *E. mammillata* and *E. paradoxa* (both camerate). *Entobia* isp. AD resembles *E. ovula*, but lacks the distinctive apertural openings. *Entobia* isp. AC lacks exploratory threads as well as clear phase divisions making it difficult to compare with other *Entobia* ispp.

Ichnogenus *Gastrochaenolites* Leymerie, 1842

Type ichnospecies — *Gastrochaenolites lapidicus* Kelly & Bromley, 1984.

Diagnosis (modified after Kelly & Bromley, 1984; Edinger & Risk, 1994) — Clavate borings in lithic substrates. The apertural regions are narrower than the main chambers and may be circular, oval or dumb-bell shaped. The apertures may be separated from the main chambers by a neck region that may be flared. The main chambers may vary from subspherical to elongate, having a parabolic to round truncated base and circular to oval cross-section, modified in some forms by a longitudinal ridge of grooves to produce an almond- or heart-shaped section. A series of fine arc-shaped laminations parallel to the sides and the base of the boreholes may also be present.

Gastrochaenolites anauchen Wilson & Palmer, 1998
Figure 6/3

Material — Five specimens: three specimens, locality g (Figure 2c), Moneague Formation, including UWIGM 2003.13 (Figure 6/3); two specimens, locality j (Figure 2e), Moneague Formation. All preserved in indeterminate scleractinian corals.

Description — Apertures appear circular with approximate diameters of 3 mm. From the apertures, the specimens gradually widen in all directions until they achieve diameters, albeit with the substrate preserved on the majority of their circumferences, of 8-10 mm and lengths between 18-20 mm. No neck regions were observed.

Gastrochaenolites cluniformis Kelly & Bromley, 1984
Figure 6/4, 6

Material — Four specimens, all from the Moneague Formation: three specimens, locality h (Figure 2e), including UWIGM 2003.16C (Figure 6/6); one specimen, UWIGM 2003.14A (Figure 6/4), locality g (Figure 2c).

Preservation — UWIGM 2003.14A is preserved as a cast in association with *Trypanites* isp. and *G. dijugus* within an internal mould of the gastropod *Strombus* sp. Other specimens are preserved in an indeterminate scleractinian coral in association with *G. dijugus* and *G. torpedo*.

Description — Asymmetrical, crudely club-shaped and, in one example, oblate borings. They are bilobate at the base and circular to ovate at the apertures. Observed lengths, although truncated or buried in the substrate, vary between 10-15 mm, while their diameters vary from 6-8 mm. The basal portion of each boring possesses a pronounced central furrow and gives each a buttock-like appearance. The furrows narrow and become undefined as they approach the neck regions.

Gastrochaenolites dijugus Kelly & Bromley, 1984
Figure 6/4, 6

Material — Three specimens, all Moneague Formation; UWIGM 2003.14B (Figure 6/4), locality g (Figure 2c); two specimens, locality h (Figure 2e), including UWIGM 2003.16B (Figure 6/6).

Preservation — UWIGM 2003.14B is preserved in association with *Trypanites* isp. and *G. cluniformis* within a shell of the gastropod *Strombus* sp. Other specimens are preserved in an indeterminate scleractinian coral in association with *G. cluniformis* and *G. torpedo*.

Description — The three specimens are fragmentary, smooth and unlined. The neck regions, observed in two of the better-preserved specimens, have two opposite facing furrows that are approximately parallel and become less clearly defined as they approach the main chamber. Bases are unobserved. The length of the preserved specimens ranges between 20-30 mm and width between 4-9 mm.

Gastrochaenolites lapidicus Kelly & Bromley, 1984
Figure 6/5

Material — UWIGM 2003.15, locality g (Figure 2c), Moneague Formation, preserved in an indeterminate bivalve.

Description — Smooth boring comprising a main chamber, 2 mm in diameter at its widest section, and a narrow neck, 1 mm in diameter. The main chamber is parabolic and has a length of approximately 4 mm.

Gastrochaenolites torpedo Kelly & Bromley, 1984
Figure 6/6

Material — Two specimens, UWIGM 2003.16A (Figure 6/6; both figured), locality h (Figure 2e), Moneague Formation, preserved in association with *G. cluniformis* and *G. dijugus* within an indeterminate scleractinian coral.

Description — Smooth specimens with an elongated or stretched club-shaped configuration. Their lengths, although incomplete, are 15 and 16 mm, and they are 4 and 6 mm in diameter, respectively, at their widest section. The widest section of each specimen is located midway between the base and the aperture. The apertures are circular with diameters of 2 mm.

Gastrochaenolites isp.
Figure 6/7

Material — Two specimens, including UWIGM 2003.17 (Figure 6/7), locality i (Figure 2e), Moneague Formation, preserved in an indeterminate scleractinian coral.

Description — Two partially exposed borings within an indeterminate corallite. Exposed bases are globular and neck regions are not exposed. Diameter of the bases average 5 mm.

Discussion — *Gastrochaenolites anauchen* differs from *G. lapidicus* in having no neck region and from *G. turbinatus* Kelly & Bromley, 1984, that is comprised of an evenly tapered main trunk that merges with the neck. Further, *G. anauchen* has its greatest diameter above the base. *Gastrochaenolites cluniformis* and *G. cor* Bromley & d'Alessandro, 1987, are both bilobate, but the furrow (= ridge) of the latter lies within the longer axis of the cross-section, while in the former it is along the shorter axis (Bromley & d'Alessandro, 1987). *Gastrochaenolites dijugus* differs from *G. ampullatus* Kelly & Bromley, 1984, its morphologically most similar ichnospecies, in that the latter is flared at the neck region and contains two diverging tubes that lead to two apertures (Kelly & Bromley, 1984). Further, *G. dijugus* is conjoined by ridges or furrows depending on the preservation. *Gastrochaenolites lapidicus*, with its obvious neck region, can be distinguished from *G. anauchen*, its closest morphologic analogue, in which this feature is absent. Although linings were not observed, *G. torpedo* differs from *G. lapidicus* by exhibiting a more elongated tube. *Gastrochaenolites* isp., although possessing a globular base, shows no affinity to previously defined ichnospecies exhibiting globular bases, namely *G. cluniformis*, *G. ornatus* Kelly & Bromley, 1984, and *G. torpedo*. Ichnospeciation was not possible as the neck regions were concealed.

Ichnogenus *Maeandropolydora* Voigt, 1965

Type ichnospecies — *Maeandropolydora decipiens* Voigt, 1965.

Diagnosis (after Bromley & d'Alessandro, 1983) — Long, cylindrical galleries having two or more apertures, running through the substrate sinuously or in irregular contortions. Galleries may run parallel in contact with each other in pairs, with or without fusion. Loose or tight loops may occur; the limbs of these may be connected by a vane or form a pouch.

Maeandropolydora crassa Bromley & d'Alessandro, 1987
Figure 7/1

Material — One specimen, UWIGM 2003.18, locality j (Figure 2e), Moneague Formation, preserved in an indeterminate scleractinian coral.

Description — Abundantly branched, cylindrical-like tubes, 1 mm in diameter, that are straight or irregularly curved, and are arranged such that they form a complex 3-dimensional boxwork system. Individual tubes within the boxwork system are sugary in texture. At one extremity (lower right in Figure 7/1) the cylindrical-like tubes are totally fused. Apertures are not obviously preserved and, where suspected to be so, their interpretation as such is equivocal.

Maeandropolydora decipiens Voigt, 1965
Figure 7/2

Material — One specimen, UWIGM 2003.19A, locality j (Figure 2e), Moneague Formation, preserved in association with *M. elegans* in a molluscan shell.

Description — A long (10 mm), branched, slightly sinuous to curved, cylindrical boring, approximately 0.04 mm in diameter, possessing a prominent ear-like pouch towards one extremity (arrowed in black in Figure 7/2). The gallery at the opposite extremity terminates blindly.

Maeandropolydora elegans Bromley & d'Alessandro, 1983
Figure 7/2, 4

Material — One specimen, UWIGM 2003.19B, locality j (Figure 2e), Moneague Formation, preserved in association with *M. decipiens* in an indeterminate molluscan shell.

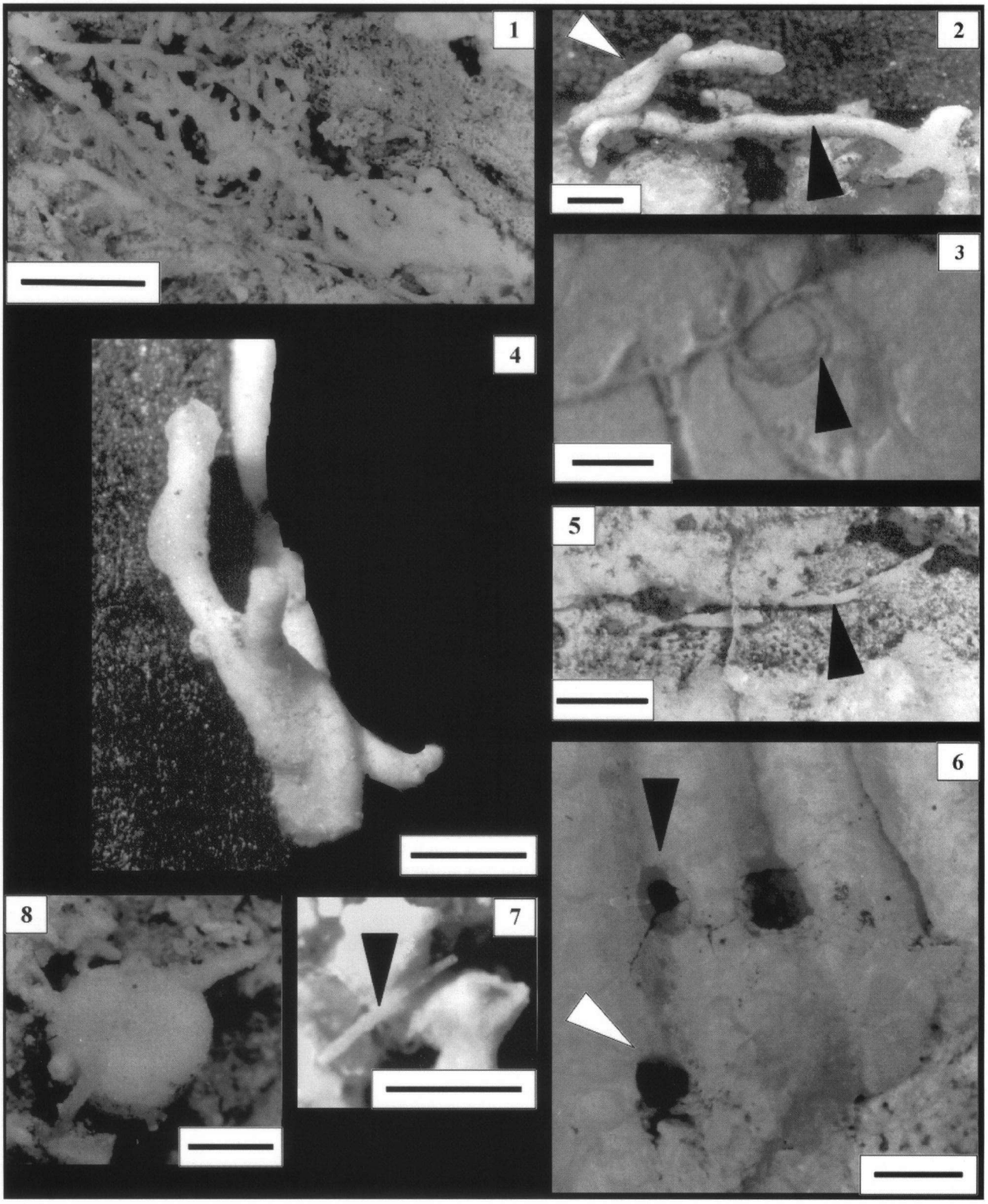
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Figure 7.

1 - *Maeandropolydora crassa* Bromley & D'Alessandro, 1987, UWIGM 2003.18, in an indeterminate coral specimen. Scale bar represents 5 mm; Moneague Formation.
2, 4 - *Maeandropolydora decipiens* Voigt, 1965, UWIGM 2003.19A (2, black arrow), in an indeterminate molluscan shell in association with *M. elegans* Bromley & d'Alessandro, 1983 (white arrow); enlargement (4) of *M. elegans*. Scale bars represent 1 mm; Moneague Formation.
3, 5 - *Maeandropolydora sulcans* Voigt, 1965; UWIGM 2003.10B (3, arrowed), partial preservation in aff. *Strombus* sp.; UWIGM 2003.20, partial preservation (5) in an indeterminate coral specimen. Scale bars represent 2 mm; Moneague Formation.
6 - *Oichnus simplex* Bromley, 1981, UWIGM 2003.21A (white arrowhead), and *O. paraboloides* Bromley, 1981, UWIGM 2003.21B (dark arrowhead), in the shell of an indeterminate gastropod. Scale bar represents 1 mm; Moneague Formation.
7 - idiomorphic *Trypanites* isp., UWIGM 2003.10C (arrowed), in association with *Entobia* isp. AB and AD (cf. Figures 5/6; 6/1, respectively). Scale bar represents 0.5 mm; Moneague Formation.
8 - stenomorphic *Uniglobites glomerata* (Morris, 1851), UWIGM 2003.4B, preserved in an indeterminate coral. Scale bar represents 1 mm; Moneague Formation.

Description — A partially preserved, thin cylindrical tube that consists of a contorted, U-shaped loop. Diameter of tube is approximately 0.04 mm. The tube diverges toward its apertural extremities and its distal equivalent is in close contact, but is separated by a depression or furrow. A slight bulge is observed on one side of the tube.

Maeandropolydora sulcans Voigt, 1965
Figure 7/3, 5

Material — Two specimens, both Moneague Formation: UWIGM 2003.10B (Figure 7/3), locality g (Figure 2c); UWIGM 2003.20 (Figure 7/5), locality j (Figure 2e).

Preservation — UWIGM 2003.20 is preserved in an indeterminate scleractinian coral; UWIGM 2003.10B is preserved in a gastropod aff. *Strombus* sp.

Description — Coarse, looped or straight borings of cylindrical cross-section, varying in length from 4 mm (UWIGM 2003.20) to 8 mm (UWIGM 2003.10B). Borings comprise galleries that are slightly contorted and both exhibit variable diameters of between 0.1-0.3 mm.

Discussion — *Maeandropolydora crassa* comprises repetitively branching, numerous blind branches and lacks prominent pouches; these morphological features distinguish it from other *Maeandropolydora* ispp. It is closest morphologically to *M. sulcans*, which also lacks pouches and exhibits non-repetitive branching. *Maeandropolydora decipiens* shows the closest affinities to *M. elegans* due to the lack of pouches and the presence of hairpin loops in the latter (Bromley & d'Alessandro, 1987).

Oichnus Bromley, 1981

Type ichnospecies — *Oichnus simplex* Bromley, 1981.

Diagnosis (after Donovan & Pickerill, 2002, p. 87) — Small, circular, subcircular, oval or rhomboidal holes or pits of biogenic origin in hard substrates, commonly perpendicular to subperpendicular to substrate surface. Excavation may pass directly through substrate as a penetration, most commonly where the substrate is a thin shell, or may end within the substrate as a shallow to moderately deep depression or short, subcylindrical pit, commonly with a depth:width ratio of smaller or equal 1, with or without a central boss.

Oichnus paraboloides Bromley, 1981
Figure 7/6

Material — Four specimens: three specimens, including UWIGM 2003.21B (Figure 7/6), locality l (Figure 2f), Moneague Formation; one specimen, locality c (Figure 2b), Somerset Formation. All specimens are preserved in molluscs.

Description — These borings fully penetrate their respective hosts and have the appearance of inverted, truncated cones. The figured specimen has an outer diameter of 1 mm tapering to an inner diameter of 0.5 mm. Etch marks are present at the rim of the figured specimen.

Oichnus simplex Bromley, 1981
Figure 7/6

Material — Twenty specimens: one specimen, locality j (Figure 2e), Moneague Formation; ten specimens, including UWIGM 2003.21A (Figure 7/6), locality l (Figure 2f), Moneague Formation; seven specimens, locality c (Figure 2b), Somerset Formation; two specimens, locality k (Figure 2d), Montpelier Formation. All specimens are preserved in indeterminate molluscs.

Description — Circular to slightly oval vertically oriented borings that sporadically penetrate their respective host. The figured specimen, circular in cross-section, is completely penetrative. Diameter of the figured specimen is 1.0 mm.

Discussion — Pickerill & Donovan (1998) regarded *Tremichnus* Brett, 1985, as a junior synonym of *Oichnus*, a conclusion reiterated by Nielsen & Nielsen (2001) and followed herein. *Oichnus simplex* and *O. paraboloides* are the most widespread and commonly reported ichnospecies in the White Limestone Group, and can be easily distinguished from other members of this ichnogenus. *Oichnus ovalis* Bromley, 1993, possesses a rhomboid external opening; *O. coronatus* Nielsen & Nielsen, 2001, has an external opening surrounded by a granular halo; *O. asperus* Nielsen & Nielsen, 2001, possesses regular to irregular elongate to oval openings; *O. gradatus* Nielsen & Nielsen, 2001, exhibits an abrupt change in diameter from wide externally to narrow internally; and *O. excavatus* Donovan & Jagt, 2002, is characterized by a central boss (see also Blissett & Pickerill, 2003). All these attributes are clearly absent in the material documented herein.

Ichnogenus *Trypanites* Mägdefrau, 1932

Type ichnospecies — *Trypanites weisei* Mägdefrau, 1932.

Diagnosis (modified after Bromley, 1972; Bromley & d'Alessandro, 1987) — Single entrance, cylindrical or sub-cylindrical, unbranched boring in lithic or biogenic substrates having circular cross-section throughout length. The axes of the boring may be straight, curved or irregular.

Trypanites isp.
Figures 6/4; 7/7

Material – Forty-three specimens, all from the Moneague Formation: 40 specimens (plus numerous examples that were not collected), locality h (Figure 2e); three specimens, locality g (Figure 2c), including UWIGM 2003.14A (Figure 6/4) and 2003.10C (Figure 7/7).

Preservation — All specimens from locality h are located within a series of hardgrounds. The three examples from locality g are preserved in association with *G. cluniformis* and *Entobia* isp. within a shell of the gastropod *Strombus* sp.

Description — Smooth, more or less cylindrical, unbranched, straight-gently curved borings each with a constant diameter. Diameter and length vary ranging, respectively, between 0.1-5.0 mm and from 1-50 mm. The figured specimens are cylindrical, unbranched and straight with a diameter of 0.1 mm and length of approximately 1.0 mm.

Discussion — Bromley & d'Alessandro (1987) noted that the three ichnospecies of *Trypanites*, namely *T. weisei* (that is perpendicular to the substrate), *T. solitarius* (von Hagenow, 1840) (that runs closely beneath the surface) and *T. fimbriatus* (Stephenson, 1952) (that is club-shaped and can either be perpendicular or parallel to the substrate) were distinguished on unsatisfactory characteristics, but that the insufficient material available to them prevented a decision on the validity of the ichnospecies. The material available for this study did not allow determination below the level of ichnogenus, as orientation was indeterminate.

Ichnogenus *Uniglobites* Pleydell & Jones, 1988

Type ichnospecies — *Uniglobites glomerata* (Morris, 1851).

Diagnosis (after Pleydell & Jones, 1988) — Single-chambered borings in lithic substrates, connected to substrate surface by one or more apertures or apertural canals; chamber spherical to irregularly elongate, with elongation parallel to substrate surface; progressive increase in size of chamber and fusion of apertural canals may occur during ontogeny.

Uniglobites glomerata (Morris, 1851)
Figure 7/8

Material — One specimen, UWIGM 2003.4B, locality h (Figure 2e), Moneague Formation, preserved in association with *Entobia cateniformis* within an indeterminate scleractinian coral.

Description — Single-chambered, non-camerate boring with at least three apertural canals and one aperture. The chamber is spherical, a maximum of 2 mm in diameter.

Discussion — *Uniglobites glomerata* is differentiated from *Entobia* ispp. in that the former, monoichnospecific ichnotaxon is single chambered and non-camerate. This is the first record of *Uniglobites* in Jamaica.

Conclusions

The majority of macroborings documented herein occur in association with macrofaunal elements, notably ben-

thic molluscs and scleractinian corals (Table 1). The general absence of bioerosional structures within the Troy Formation may be a result of its dolomitic lithology; that is, dolomitization most likely destroyed bored substrates. At localities where dolomitization is not pronounced, host fossils, although more or less unaltered, are fragmentary, hence making identification of ichnotaxa impossible.

The Somerset Formation is fossiliferous; however, faunas are fragmentary and only a few ichnospecies, namely *Caulostrepsis taeniola*, *Entobia ovula*, *Oichnus simplex*, *O. paraboloides* and *Entobia* isp. AB were identifiable. The Moneague Formation is the most extensively exposed formation on the island, and incorporates a variety of lithologies containing well-preserved body fossils and included ichnofossils. The Montpelier Formation consists locally of allochthonous fossiliferous scleractinian-rich limestone with a well-preserved ichnofauna.

The producers of these bioerosional structures cannot be identified because the majority of them were soft-bodied or weakly mineralised (*e.g.*, clionid sponges; Bromley & d'Alessandro, 1989). Where soft-bodied animals were not the producing organisms (*e.g.*, *Gastrochaenolites*, *Oichnus*, usually a product of boring bivalves and gastropods, respectively), no shells were observed within or in close association with the borings. The substrates in which these ichnofossils occur are generally recognisable only at a high taxonomic level, but do include various scleractinian coral species, various benthic molluscs (*e.g.*, strombids), decapod crustaceans (crab carapaces) and hardgrounds.

Our initial observations suggest that the borings documented herein exhibit affinities for both specific and variable hosts. For example, *E. megastoma* is restricted to crab carapaces; *E. ovula*, *C. canna*, *Entobia* isp. AB, *Entobia* isp. AC, *Entobia* isp. AD, and *Oichnus* ispp. are restricted to bivalves; and most of the remaining borings occur in corals (*e.g.*, *Cl. irregularis*, *Cl. radicans*, *Co. tenuis*, *Conchotrema* isp., *E. gigantea*, *E. cateniformis*, *E. retiformis*, *Entobia* isp. AA, *G. anauchen*, *Gastrochaenolites* isp., *M. crassa*, *M. sulcans*, and *U. glomerata*).

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