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## Cave Fauna of Bermuda

*key words:* speleobiology, ecology, zoogeography, coastal caves, brackish water

### Abstract

Sea-level pools are found in most of Bermuda's known caves. Although the terrestrial fauna of the caves is sparse, a rich aquatic fauna inhabits the pools. While many of the marine cave animals are more or less regular immigrants from open littoral habitats, a number of new species have been discovered, including blind and probably subterranean ones. Zoogeographical connections exist between Bermuda's cave fauna and those of the West Indies and the Mediterranean.

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### 1. Introduction

The Bermuda Islands consist of Pleistocene and Recent marine and colian limestones capping a mid-ocean, volcanic seamount. The seamount was formed by two volcanic eruptions: the first, coincident with the formation of the surrounding sea floor, about 110 million years ago, and the second, which deposited a substantial portion of the volcanics, 33 million years ago (REYNOLDS & AUMENTO, 1974). The oldest carbonates probably date back to the Nebraskan Pleistocene (SCHENK, 1973). Calcarenite layers in rolling hills extend from 79 m in elevation down to the top of the weathered basalts at an average depth of 75 m below present sea level. Additional

information on the geology of Bermuda is available in several reports (LAND *et al.*, 1967; LAND & MACKENZIE, 1970; UPCHURCH, 1970; MACKENZIE & VACHER, 1975). Bermuda is situated about 1000 km east of the North American Coast and has never been part of a continental land mass.

The Bermuda calcarenites have been exposed to fairly intense karstification. There are about 100–200 known caves; most of them some tens of meters long. Many of the caves contain tidal salt water pools which extend, as evidenced by diving, at least as deep as 24 m below sea level. The age of the oldest caves, those located in the Walsingham Limestone Formation, is probably early Pleistocene (FORNEY, 1973; HARMON, 1974; PALMER *et al.*, 1977; ILIFFE, 1978; MYLROIE, in press).

The geographical isolation of Bermuda over its entire geological history, coupled with the fact that only marine-derived fauna are available for colonization of subterranean habitats, makes these karst islands an ideal simplified system for investigations of the taxonomy, ecology, colonization, evolution and zoogeography of cave fauna. The observations reported here are the results of a short-term investigation, preceding a planned, larger scale faunal survey of the caves. In spite of the preliminary nature of the data, we feel that the significant observations made so far justify their publication at this time.

## 2. Terrestrial Habitats

### 2.1. *Physical characteristics*

The air-filled portions of Bermudian caves are characterized by fissure entrances and irregular chambers floored with large breakdown blocks or surface derived soils. Large parts of the cave walls, ceilings and floors are covered by dripstone formations. Despite the absence of permanent streams in any of the caves, all parts of the interiors are kept moderately wet by drip waters. Although temperature conditions in Bermuda's caves have not yet been studied, they are probably close to the annual mean average air temperature of 21 °C.

### 2.2. *Food Input and Energetics*

The dry parts of Bermuda's caves appear to contain very little organic matter. The clay deposits are of uniform color. Even near breakdown where cracks to the surface may occur, there is little or no organic debris. There are no animals in the caves which could serve as carriers of food, since Bermuda lacks cave-inhabiting bats (VAN GELDER & WINGATE, 1961), crickets or other ecologically similar animals. Some organic matter may enter the caves as part of the surface derived soils.

In several of the former commercially operated or better known caves, wooden debris carried in by man is found close to pathways. However, such material is of recent origin and thus has no significance in the history of true cave fauna.

Temperatures in Bermuda's caves are higher than those in the faunistically rich European caves. Since metabolic rate increases with temperature and since food supplies are low in the terrestrial parts of Bermuda's caves, the locally unfavorable ratio of food stock to metabolic rate may account for the scarcity of terrestrial fauna.

### 2.3. Fauna

Currently eight animal species have been found in the terrestrial habitats of Bermuda's caves (Table 1). The animals are distributed very sparsely in the caves, although there are aggregations of some, mainly *Orthomorpha* and *Schizomus*, in the rotten wood brought in by man. Flies and cockroaches were collected from baited pit-falls in even the most remote parts of the caves. It is very significant that no adult cockroaches have been found within the caves; only juveniles of less than 10 mm in length.

Table 1. Terrestrial cave fauna of Bermuda

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<i>Schizomus portoricensis</i> CHAMBERLIN (Schizomida)
<i>Miktoniscus</i> sp. (Isopoda, Trichoniscidae)
<i>Lithobius peregrinus</i> LATZ. (Chilopoda)
<i>Orthomorpha gracilis</i> C. L. KOCH (Diplopoda, Paradoxosomatidae)
<i>Spirostrophus naresi</i> POCOCK (Diplopoda, Pachybolidae)
<i>Hanseniella</i> sp. (Symphyla)
<i>Periplaneta americana</i> L. (Blattaria)
Phoridae g.sp. (Diptera)

### 2.4. Origin of Terrestrial Fauna

The isopod, *Miktoniscus*, is represented in our material by only one female specimen, so that its exact taxonomic position is unclear. All other animals can be considered as edaphic (soil inhabiting) rather than subterranean. The distribution patterns of all specimens identified to species show that they possess some biological peculiarities which enable them to form an aggressive dispersion; at least some of them are synanthropic. *Orthomorpha* is widely distributed in the tropics and subtropics as well as in synanthropic habitats, even in temperate zones. *Spirostrophus* has a disperse distribution in South America, Indopacific islands and the Antilles (MAURIES, pers. comm.). *Schizomus portoricensis* has a wide distribution throughout Central America, including the West Indies, on the surface as well as in caves (ROWLAND & REDDELL, 1977). As found by ROWLAND and REDDELL, only the surface population in the nuclear parts of this area are bisexual. It is obvious that the parthogenetic abilities of some females enabled the species to invade such a large area, including many islands and unfavorable habitats such as caves. All of the approximately one dozen specimens of *Schizomus* found in Bermuda's caves are female.

The above data indicates that the terrestrial habitats in Bermuda's caves were originally an empty niche which has become inhabited by common edaphic animals in very recent times. At least some of these species have been brought to Bermuda by man.

## 3. Aquatic Habitats

### 3.1 Hydrographical and hydrological conditions

Most Bermudian caves have large, formerly air-filled portions, now drowned by seawater; sometimes with a thin brackish layer at the surface. The phreatic zone underlying karstic areas of Bermuda consists of slowly moving or stagnant water, while the thickness of the fresh viz. brackish layer must depend on local and/or temporary meteorological and geomorphological conditions. Very different conditions are believ-

ed to have existed during periods of Pleistocene glaciation. Cave formation occurred during lower stands of sea level (to  $-100$  m) when most of the top of the Bermuda platform was above sea level and the exposed land area was up to 13 times as large as it is today. During those times, much greater quantities of fresh subterranean waters were present, significantly increasing the rate of limestone dissolution.

Special conditions exist on the isthmus between Castle Harbour and Harrington Sound, where most of Bermuda's known caves are found. About 50% of the tidal water exchange of Harrington Sound has been calculated to occur through underground passages and sediments (MORRIS *et al.*, 1977). These calculations are indirectly confirmed by the hydrological conditions in the caves as well as by the visible subterranean water exchange from caves along the coast of Castle Harbour. Thus, in such areas of Bermuda, an intensive transport of subterranean waters takes place.

Table 2. Salinity (S) and temperature (T) profiles from sea level pools of Bermudian caves during May 1979 (single measurements).

Depth	Admiral's Cave		Walsingham Cave		Walsingham Sink Cave		Roadside Cave		Bat Cave		Shop Cave	
	S (‰)	T (°C)	S (‰)	T (°C)	S (‰)	T (°C)	S (‰)	T (°C)	S (‰)	T (°C)	S (‰)	T (°C)
Surface	3.6		30.8		31.7		32.5		10.2		13.3	
		19.5		15.3		17.3		19.9		—		20.2
— 10 cm	8.8		30.8		31.8		32.6		11.6		15.1	
		19.0		15.3		17.2		20.1		—		20.0
— 50 cm	21.8		32.5		33.1		32.5		15.6		19.0	
		20.4		16.2		18.0		20.2		—		20.7
— 100 cm	25.9		35.8		35.4		33.0		21.6		23.8	
		20.8		17.8		19.5		20.5		—		20.7

Some preliminary measurements of salinity and temperature have been made in the cave water column to depths of 1 m (Table 2). In caves in the Walsingham area, located in the northern part of the isthmus between Castle Harbour and Harrington Sound, the water at the surface of the pools is only slightly diluted and reaches normal marine salinity (35–36 ‰) at  $-1$  m. In addition to the caves, some open anchialine pools of collapse origin also exist in the Walsingham area. Obviously, this is an extremely karstified area with strong underground tidal currents and thus rapid water exchange.

Much lower surface salinities were found in the pools of some caves adjacent to the Walsingham area, where even at  $-1$  m, the salinity was only 20–26‰. The extremely low chlorinity (0.30 ‰) of Freshwater Cave is achieved indirectly through the air, as the pool is situated about 7 m above sea level.

The temperature data from a single series of measurements do not provide much information. The oxygen content of the cave waters have not yet been measured. Based on observations of the caves along the Yugoslavian Coast (SKET, 1977), dissolved oxygen concentrations can be presumed to be high in the caves in the Walsingham area, but somewhat lower in the caves with stagnant water bodies. The input of food in most caves is primarily derived from the sea itself, although open anchialine pools may provide an additional source of food for the submerged caves. However, we have yet to measure the organic content of the cave waters or their sedimentary deposits. The lack of anoxic conditions, even in stagnant pools, indicates that, unlike what has been observed in Yugoslavian coastal caves (SKET, 1977), the input of organic matter is relatively low.

### 3.2. Collection of aquatic cave fauna

Collections in most of the caves were made using a longhandled dip net from the surface, which did not allow us to get animals from depths greater than about 1 m. Some attempts with the phreatological (Cvetkov) net were not very successful, as the walls of the cave pools are extremely rough. In Walsingham Cave, we did collect some specimens from depths down to 8 m using SCUBA. Thus, the faunistic data for Walsingham Cave are of a somewhat different character and value. Principal caves sampled in the area between Castle Harbour and Harrington Sound are shown in Figure 1, while a list of the animals collected from cave pools is presented in Table 3.

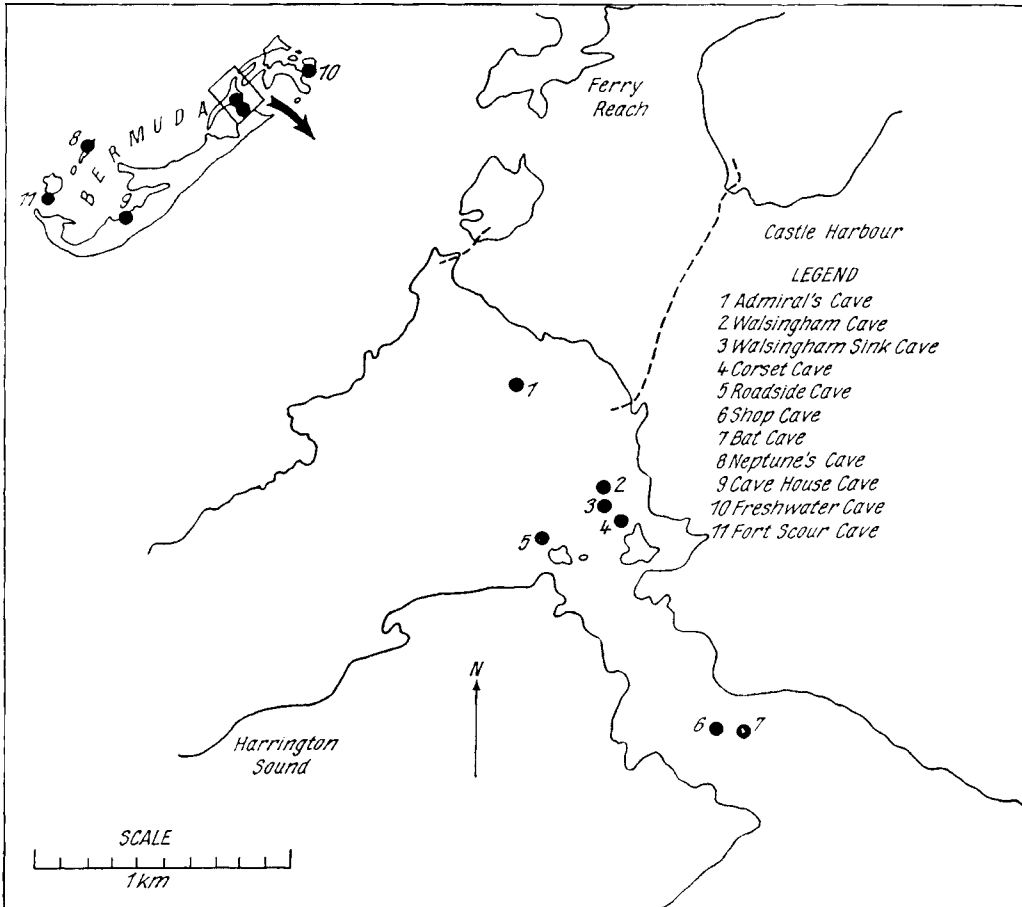


Figure 1. Location of biologically prospected (in 1978/1979) caves in Bermuda.

### 3.3. Ecological conditions versus fauna in some characteristic caves

Walsingham Cave, situated 150 m from the coast, contains a long pool of water near the entrance that is partially exposed to daylight. Surface salinities in the pool reach 30 ‰. Even in dark sections of the cave, we found some littoral animals, including the starfish *Coscinasterias*, seemingly bleached out, and serpulids. Through a 60 m long underwater passage, one reaches a large, completely dark and partially air-

Table 3. Aquatic cave fauna of Bermuda

## Walsingham Caves (Walsingham, Walsingham Sink, Corset, and Roadside Caves)

Foraminiferida	Mysidacea
<i>Triloculina</i> sp.	Mysidae g.sp.
<i>Guttulina</i> cf. <i>problema</i> ORBIGNY	Cumacea
Ciliata – g.sp.	<i>Nannastacus</i> sp.
Spongiaria	Cumacea g.sp.
cf. <i>Sycon</i> sp.	Tanaidacea
Turbellaria – g.sp.	<i>Apeudes bermudeus</i> BĂCESCU (described from this material as sp.n.)
Cnidaria – g.sp.	Isopoda
Kamptozoa – g.sp.	<i>Atlantasilus carernicolus</i> sp.n., gen.n., fam.n.
Nemertinea	(to be described by SKET)
cf. <i>Gorgonorhynchus</i> sp.	cf. <i>Janira</i> sp. (blind; manca)
Gastropoda	<i>Limnoria</i> sp.
<i>Caecum heladum</i> OLSSON et HARBISON	Amphipoda
<i>Caecum tornatum</i> VERILL et BUSH	<i>Cocoharpinia iliffei</i> G. KARAMAN
<i>Caecum</i> sp. A	(described from this material as sp.n., gen.n.)
<i>Caecum</i> sp. B	<i>Idunella sketi</i> G. KARAMAN (described from this material as sp.n.)
<i>Acteocina</i> sp.	<i>Gitanopsis petulans</i> G. KARAMAN
Polycheata	(described from this material as sp.n.)
<i>Laonice cirrata</i> SARS	<i>Bogidiella martini</i> ssp.n.
Polychaeta g.sp. (postlarva)	(to be described by SKET)
Serpulidae g.sp.	<i>Pseudoniphargus</i> cf. <i>adriaticus</i> S. KARAMAN
<i>Mesonerilla</i> sp.n. (STERER)	cf. <i>Eriopisa</i> sp.n. (to be described by SKET)
Copepoda	<i>Ingolfiella</i> sp.n. (to be described by SKET)
<i>Ridgewayia marki</i> EASTERLY	Echinodermata
<i>Pseudocyclops</i> sp.n.A (BOWMAN, pers. comm.)	<i>Chiridota rotifera</i> PORTALES
<i>Calanopia americana</i> DAHL	<i>Coscinasterias tenuispina</i> L.
<i>Calanoida</i> g.sp.	Ophiuroidea g.sp.
<i>Paramphiascella robinsoni</i> A. SCOTT	Tunicata
Laophontidae g.sp.	<i>Ecteinascidia conklini minuta</i> BERILL
Ostracoda	Pisces – g.sp.
<i>Bairdia</i> (s.l.) sp.n. ? (HARTMANN, pers. comm.)	
<i>Polycope</i> sp.	
<i>Propontocypris</i> sp.	
Myodocopida g.sp.	
Decapoda – g.sp. (larvae)	
Caves adjacent to Walsingham (Admiral's, Shop and Bat Caves)	Neptune's Cave
Copepoda	Polychaeta – g.sp.
<i>Eurycyclops</i> sp.n.	Copepoda
(to be described by PETKOVSKI)	<i>Pseudocyclops</i> sp.n.
Amphipoda	(to be described by BOWMAN)
<i>Pseudoniphargus</i> cf. <i>adriaticus</i> S. KARAMAN	<i>Calanopia americana</i> DAHL
	<i>Paramphiascella robinsoni</i> A. SCOTT
Cave House Cave	Freshwater Cave
Gastropoda	Copepoda
<i>Caecum plicatum</i> CARPENTER	Cyclopidae g.sp.
<i>Caecum tornatum</i> VERILL et BUSH	Ostracoda
<i>Caecum</i> sp. B	<i>Cypridopsis</i> sp.
	<i>Cyclocypris</i> sp.
	Ostracoda g.sp.
	Diptera
	Chironomidae g.sp. (larvae)

filled room. There are abundant specimens of Serpulidae, *Ecteinascidia* and other sedentary animals attached to the drowned stalactites, but free-living animals on the rocky substratum are scarce. The bottom is covered by a thick deposit of fine clay, inhabited by rather rich populations of *Apseudes* and *Cocoharpinia*. *Ridgewayia* seems to occur in good numbers in open waters of the cave.

Walsingham Sink Cave has a seawater pool located near the entrance, but still in almost total darkness. The gradually sloping walls of the pool have accumulations of surface-derived earth and detritus. The surface salinity is 31‰. As we did not collect from deeper than 1 m, it is difficult to say whether the great variety of marine animals found in Walsingham Cave are present here. The numbers of animals collected was not large, but a variety of species not known from other caves were found: some *Caecum* spp., Harpacticoida, some Isopoda and Amphipoda. The isopod, *Atlantasellus*, is found regularly here as isolated specimens, while most amphipods were found only once. It seems probable that the parts of the bottom reached by our sampling method are not their normal habitat.

Several pools in Admiral's Cave are situated far from the entrance and seemingly far from the underground tidal currents, as the salinity is comparatively low (3.6‰ at the surface). Shallow portions of the pools are floored by dripstone and small slabs of breakdown with only very little detritus. The fauna is very scarce and poor, only *Pseudoniphargus* and *Eurycyclops* were caught there.

Cave House Cave is situated only 35 m inland, but in an area where the water exchange probably is not very intensive. The shallow bottom of the pool is covered by a very pure, fine clay. Only a few specimens of some *Caecum* spp. have been found.

Freshwater Cave is a special case in the Bermudian karst as it contains a large pool of freshwater. There is considerable organic debris, mostly rotten wood, in the pool. The fauna is not diverse, but is comparatively dense. It consists of some oculated Ostracoda and the larvae of Chironomidae.

No animals were found in Fort Scaur Cave, probably due to its isolated location in an area of poor water exchange.

### 3.4. Communities

Perhaps it is too early at our state of knowledge of the Bermudian cave fauna to speak about communities, but it seems likely that true cavernicole communities in the sense of European and North American continental karst do not occur. Impoverished types of littoral communities, including plankton, have developed in caves near the main subterranean tidal currents. The subterranean amphipods occasionally found in Walsingham Sink Cave seem to be immigrants from another habitat, perhaps the interstitial, rather than members of a local community. Only *Pseudoniphargus* and perhaps *Eurycyclops*, which are characteristic of the low salinity cave waters, appear to represent a kind of fauna of their own.

### 3.5. Ecological and zoogeographical characteristics

Many of the animals found in Bermudian cave waters (e.g. Spongiaria, Echinodermata, Tunicata, Pisces) are more or less euryoecious inhabitants of the littoral zone which are undemanding enough to be able to sustain themselves under the unfavorable cave conditions (e.g. lack of light, smaller food supplies). We shall not discuss this group of animals.

There is a significant number of species which are now known only from the Bermudian caves: however, many of them may not be restricted to such habitats. It

is very probable that we shall find some of these new species outside caves, searching in corresponding places (e.g. muddy bottom for *Apseudes bermudeus* and *Cocoharpinia*, and interstitial waters for some amphipods). Before these investigations are carried out, it is very difficult to speak about the habitat limitations or origin of the cave fauna. Only for *Caecum* spp. can we be certain that they occur in interstitial conditions outside the caves. In spite of being new species, our *Polycope*, *Bogidiella*, *Eriopisa* and *Ingolfiella* have the body form of their relatives inhabiting interstitial waters. However our new *Atlantasellus*, *Cocoharpinia*, *Idunella* and *Gitanopsis* do not seem to be interstitial animals because of their shape; unfortunately comparisons with their relatives fail to tell us much about their origins.

Some animals show obvious connections with the Atlantic Coast of the Americas. *Caecum heladum* is found in Florida, while *C. plicatum* inhabits Florida and the West Indies (ABBOTT, 1974). *Bogidiella* sp. from Bermuda is a subspecies of *B. martini*, described by STOCK (1978) from the antillean island St. Martin.

Less expected were some striking zoogeographical connections of Bermuda to the east. *Caecum tornatum*, presumably endemic to Bermuda, is apparently identical or at least closely related to *C. elegantissimum* from the Canary Islands (VELKOVRIH, pers. comm.). The new *Eurycyclops* sp. from Bermuda is most closely related to *E. mediterraneus* (KIEFER) from Balears (PETKOVSKI, pers. comm.). A species group under the genus *Pseudoniphargus* is widely distributed in the Mediterranean and western Atlantic (Azores and Madeira). It is a quite ubiquitous subterranean animal, living in caves and interstitial waters, at marine salinities and in fresh water. Bermuda is the third oceanic island known to be inhabited by *Pseudoniphargus* and the western most point of its distribution. It has never been found in eastern North America or the West Indies, which are speleobiologically better prospected.

#### 4. Discussion and Conclusions

Terrestrial habitats are inhabited by some edaphic animals, several of them probably introduced by man within the last few centuries. We suppose that the mild oceanic climatic conditions in the recent geological past coupled with the low competition pressure in the surface habitats of these isolated and sparsely populated islands and with the comparatively short existence of cavernicolous habitats (of Pleistocene age) have not favored the evolution of troglobites. The terrestrial cave fauna has 'adapted' to the poverty of food sources, due in part to the absence of the usual food carriers, by maintaining very sparse populations rather than by evolutionary change.

The aquatic habitats (excluding Freshwater Cave) are rather diverse, extending from marine salinities to very diluted ones, and from intensive water exchange (by tidal currents) to nearly stagnant conditions. Thus, the Bermudian caves can be characterized as a combination of marine caves and coastal caves (sensu SKET, in press). For both types, the possibility of food input from the sea is enormously high in Bermuda.

Many animals in the cave waters are more or less regular immigrants from open littoral habitats. However, a number of new species have been discovered, including blind and probably subterranean ones. There are some surprising points regarding the composition of this fauna. First, no shrimps (Decapoda Natantia), common in anchialine environments of many oceanic islands (HOLTHUIS, 1973), were found in Bermuda. Second, in spite of Bermuda's close proximity to the oceanic depths, no species known as abyssal have been found. This is especially surprising since abyssal elements form the major part of the lava tube fauna of the Canary Islands (WILKENS and PARZEFALL,

1974). However, some of our new species (e.g. *Atlantassellus*) could in the future be recognized as abyssal. Lastly, it is surprising that no animal reported previously from the interstitial habitats of Bermuda (by COULL, 1970; OTT, 1977; KARLING, 1978) has been found in the caves. Here it must be emphasized that the interstitial amphipods of Bermuda have not been investigated. It is nearly certain that at least some of the cave-dwelling amphipods (*Bogidiella*, *Ingolfiella*, *Eriopisa* and *Pseudoniphargus*) are living also, or even primarily, in interstitial habitats.

Bermuda's cave fauna shows some zoogeographic connections to the West Indies and some to the Mediterranean, but no elements of those which are especially characteristic for both of them (e.g. *Hadzia* s.l., *Spelaeomysis*) have been found. Although there is some evidence relating to the geographical origins of the cave fauna, it is much more difficult to explain how or when these animals or their ancestors reached Bermuda's shallow waters. There are four theories that could possibly explain the transoceanic distribution of marine cave fauna.

First, STERRER (1973) has proposed plate tectonics as a mechanism for the dispersal of interstitial sand fauna. However, since Bermuda has never been part of a continental plate, a direct role of plate tectonics in the origin of Bermuda's cave fauna can be ruled out.

Second, STOCK (1977) and many others have attempted to explain distributional patterns by 'stranding' of species on the shoreline of a receding fossil sea. As a small and young oceanic island, Bermuda would not have experienced significant changes in coastline during such geologic episodes. Also in other areas any changes in coastline due to tectonic or glacial events would have been so gradual that even localized 'stranding' would have been unlikely.

Third, it has been suggested that coastal interstitial species may be interconnected by abyssal ones (WEBB, pers. comm. in STERRER, 1973). Available data regarding changes in meiofauna composition with depth and substrate indicate that such interconnections are unlikely (STERRER, 1973). Additionally, no abyssal species have yet been identified from Bermuda's caves.

Fourth, GERLACH (1977) reports observations of interstitial animals found drifting in the open ocean on small quantities of substratum, such as a coconut. Stronger amphipods may even be distributed by birds (SEGERSTRÅLE, 1954). Although the number of individuals transported by such mechanisms may be very small, it is difficult to determine how many immigrants arriving under what conditions and in what sequence would result in a successful colonization. The chances of short-range transport by such 'coconut-spreading' or bird transfer is viewed as good, while those chances for long-range dispersal by the same mechanisms are infinitely small (STERRER, 1973). Bermuda's present position, about one month's drift time in the Gulf Stream from Florida, can explain the existence of some Caribbean fauna. However, as far as Old-World faunal elements are concerned, only shortly after its initial formation (about 110 million years ago) would Bermuda have been close enough to Africa for such dispersal mechanisms to be functional. This was long before the existence of Bermuda's shallow water carbonate habitats (maximum age about 1 million years) and thus would have required a prolonged subsistence of the species outside the cave habitat. Consequently, it is far from clear what zoogeographical connections existed or what dispersal processes were operative in producing Bermuda's cave fauna.

Once species had reached Bermuda, it was still necessary for them to invade the cave systems for cave colonization to be successful. Subterranean tidal currents provide an excellent means of introducing surface species into the caves. Planktonic animals and larvae are regularly distributed through subterranean channels by tidal currents as is evidenced by the presence of gastropods in anchialine Walsingham Pond (GOULD,

1968). The caves with the richest faunas also had major tidal currents moving through them.

Climatic changes during the Pleistocene may have played a significant part in the formation of the Bermudian cave fauna. Today, Bermuda is situated near the winter oceanic isotherm of 20°C and, as such, has the northernmost coral reef ecosystem in the Atlantic Ocean. During periods of Pleistocene glaciation, lower water temperatures probably caused the extinction of many tropical species (BRIGGS, 1966, 1974). Bermuda's cave habitats, lacking the extremes of temperature, may have served as a refuge for some temperature sensitive species.

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## 6. Summary

The limestone caves of the mid-ocean islands of Bermuda comprise an ideal simplified system for studies of the taxonomy, ecology, colonization, evolution and zoogeography of cave fauna. Sea level pools, extending as deep as –24 m. are found in most of Bermuda's 100–200 known caves. Although the terrestrial fauna of the caves is sparse, a rich marine fauna inhabits cave pools hundreds of meters from the coast. While many of the marine cave animals are more or less regular immigrants from open littoral habitats, a number of new species have been discovered, including blind and probably subterranean representatives. The absence from the caves of shrimps and abyssal fauna, as well as any previously reported interstitial species, is surprising. Zoogeographic connections exist between Bermuda's cave fauna and those of the West Indies and the Mediterranean.

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