

## CREVICULAR DISPERSAL OF MARINE CAVE FAUNAS

by

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### I - INTRODUCTION

In recent years, biological surveys of marine and anchialine caves have resulted in the discovery of many new and unusual troglobitic species (SKET and ILIFFE, 1980 ; ILIFFE et al., 1983, 1984). Anchialine caves have considerably richer and more diverse fauna than their freshwater counterparts primarily because of the much greater number of species inhabiting open water marine habitats as compared with freshwater ones.

Biological collections in anchialine caves often require the use of specialized cave diving techniques as salinity stratification in such caves means that fully marine waters containing the richest fauna are often only are found at considerable depth or penetration into the underwater caves.

### II - CHARACTERISTICS OF MARINE CAVE FAUNAS

A number of exceptional features of the fauna of marine caves have been revealed as a result of current studies.

**First**, marine caves have been found to contain exceedingly ancient relict forms including a number of new higher taxa. The new crustacean class Remipedia (YAGER, 1981) is present in marine caves in the Bahamas, Yucatan and the Canary Islands. Marine caves in Bermuda are inhabited by Mictacea, a new order of peracarid crustacean (BOWMAN and ILIFFE, 1985), and Platycopioida, a new order of copepod (FOSSHAGEN and ILIFFE, 1985).

**Second**, highly anomalous biogeographical distributions have been found for some taxa inhabiting marine caves. This is despite the fact that these organisms are strictly troglobitic and lack planktonic larvae for long distance oceanic dispersal.

A 1.5 km long submerged lava tube cave in the Canary Islands, the Jameos del Agua, contains a considerable variety of troglobitic taxa, many closely related to the fauna of West Atlantic caves (ILIFFE et al., 1984 ; WILKENS et al., 1986). These include Remipedia, with species also present in the Bahamas and Yucatan ; the anthurid isopod *Currasanthura*, with representatives also found in Bermuda and Curacao ; the mysid *Heteromysoides*, also from Cuba ; the thaumatoocyprid ostracod *Danielopolina*, also from Cuba, the Bahamas and Yucatan ; and the amphipod *Speleonicippe*, also from the Turks and Caicos Islands. This amphi-Atlantic distribution is suggestive of an origin for these species in marine caves prior to a not too wide separation of the American and African-European continents during the formation of the Atlantic Ocean about 150 million years ago. Thus, plate tectonics and sea floor spreading may have been the driving mechanism in the dispersal of this Tethyan fauna.

Similarly, the marine cave fauna of the Galapagos Islands is most closely related to that of the Caribbean and West Atlantic, not be Pacific. Among the members of the Galapagos cave fauna are

included the ostracod *Danielopolina*, also with species in Cuba, the Bahamas and Yucatan; the shrimp *Typhlatya*, also from Yucatan, Cuba, the Bahamas, Puerto Rico, the Dominican Republic and Bermuda, and a new genus of pardaliscid amphipod closely related to

*Speleonicippe* from the Turks and Caicos Islands. The fore runners of the Galapagos cave fauna must have entered the Pacific from the Caribbean prior to the closure of the Panama land bridge in the Pliocene.

Much more difficult to explain are several troglobitic taxa with anomalous global distributions. The shrimp genus *Procaris* contains 3 species, all from marine caves - those being in Bermuda in the North Atlantic, Ascension Island in the South Atlantic and Hawaii in the mid Pacific (HART and MANNING, 1986). Equally puzzling is the case of the misophrioid copepod genus *Expansophria* which has only 2 species, those inhabiting caves in Lanzarote in the Canary Islands and Palau in Micronesia - nearly on opposite sides of the earth (BOXSHALL and ILIFFE, 1987). Finally, the subgenus *Liagoceradocus* of the amphipod genus *Hadzia* has cave species on Lanzarote and Hawaii.

A third character of the fauna of shallow water marine caves is their close taxonomic relationship with fauna from bathyal or abyssal depths of the open sea (HART et al., 1985 ; WILKENS et al., 1986). In addition to marine caves, the galatheid crab *Munidopsis* has representatives inhabiting depths to 4000 m. The thaumatocyprid ostracod genus *Danielopolina* contains a deep water species collected in 3400 m depths. Misophrioid copepods include 8 anchialine species and 6 from the deep sea - the latter from depths to 3000 m. Polynoid polychaetes also occur in depths to 3000 m, while the primarily deep sea families Pardaliscidae and Lysianassidae amphipods inhabit depths to 4000 m or more. The peracarid crustacean order Mictacea has a representative collected from 1000 m depths. A new family of shrimp, Agostocaridae, from caves in the Turks and Caicos Islands is most closely related to bresiliids from deep sea hydrothermal vents on the Galapagos Rift (HART and MANNING, 1986).

A fourth character is the presence of marine troglobitic taxa in crevicular groundwater habitats. The evidence for this is both direct and indirect. Five troglobitic species first discovered in the Lanzarote lava tube have recently been found to inhabit crevicular marine groundwaters accessible through wells (WILKENS et al., 1986). Since ancient relict troglobitic taxa have been found in geologically young caves, dispersal from older adjacent habitats is inferred, most likely occurring through the crevicular medium.

Over 60 endemic troglobitic taxa inhabit Bermuda's limestone caves (SKET and ILIFFE, 1980). The island of Bermuda is a mid-ocean volcanic seamount formed about 100 million years ago, but capped today by a layer of Pleistocene and Recent eolian limestones. During periods of Pleistocene glaciation when sea level was 100 m lower than present, all known Bermuda caves, and in fact all limestone, were emergent. At this time, the marine cave fauna of Bermuda must have followed descending sea levels to inhabit crevicular environments in the island's volcanic pedestal (ILIFFE et al., 1983). In a similar vein, the Jameos del Agua lava tube on Lanzarote was formed only 3000 to 5000 years ago in sharp contrast with phylogenetic ages of 100 million years or more for many of the components of its fauna. A colonization of this cave through the crevicular medium is strongly suggested (ILIFFE et al., 1984 ; WILKENS et al., 1986).

To summarize, marine and anchialine caves have been found to be inhabited by relict taxa, some with highly anomalous distributions, some closely related taxonomically to deep water species and some also occurring in the crevicular medium. Questions arise as to how these above observations are related and what can ultimately be concluded as to the origin and modes of dispersal of marine troglobites.

### III - DEEP SEA CAVES

Although to date, all studies of marine caves have been limited to those within normal scuba diving depths, approximately 50 m or less, this by no means indicates that caves and crevicular habitats are limited to the shallow water realm. Indeed, evidence now suggests that submarine caves may exist at virtually any depth within the sea.

Submersible dives on Johnston Atoll in the mid-Pacific have resulted in the discovery of a large limestone cave at 350 m depths (KEATING, 1985). Incredibly, this cave is hydrologically active with what is described as "shimmering water" - water of a different salinity and/or temperature - flowing out of the cave entrance. The presence of stalactites and stalagmites within indicate a subaerial history followed by submergence. Even at such depths within the sea, caves can serve as preferred biological habitats as evidenced by the selective presence of sponges and other

encrusting organisms inside the cave.

Much deeper caves within the ocean also exist and are currently still forming. Lava tubes created by completely submarine eruptions may be a common feature in the deep sea. Tubes a kilometer or more in length have been observed using high resolution side scan sonar at 2700 m depths on the East Pacific Rise (FORNARI et al., 1985). FORNARI has suggested that deep sea lava tubes may be an important means for dispersing molten lava from submarine eruptive sites.

Submersible dives on volcanic seamount slopes and mid-ocean ridges have revealed a highly fractured and fissured rock terrain with large areas of loose rubble and scree. Crevicular habitats in such locations, especially where currents sweep the bottom clear of sediments, thus offer a possible habitat for deep sea fauna.

#### IV - CONCLUSIONS

Based on the preceding data, it is known that :

- (1) Marine troglobitic taxa inhabit and are dispersed through crevicular systems in shallow waters.
- (2) Many shallow water marine troglobites are closely related to deep water forms.
- (3) Caves and crevicular habitats exist in the deep sea.
- (4) Even in deep waters, caves can be a preferred biological habitat for some species.

By extension of this data, it is further concluded that :

- (1) Marine troglobites are most probably not limited to shallow water caves, but are likely to be found in much deeper waters as well.
- (2) Previously unexplained anomalous distributions of marine troglobites on widely separated oceanic islands may arise via trans-oceanic dispersal through deep sea cave and crevicular habitats.

Investigations using deep diving submersibles and remotely operated vehicles (ROVs) to locate, study and collect from deep water caves have already begun in Bermuda. Dives with a Super Phantom ROV during 1987 resulted in the discovery of a 200 km long, sheer underwater cliff face beginning in 90 m depths at the edge of the Bermuda Platform. Although only a small section of this cliff was examined, a number of small holes and possible cave entrances were observed at 100 to 200 m depths.

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#### SUMMARY

Biological surveys of marine and anchialine caves have revealed the presence of many new and diverse cave-limited forms including relict "living fossils". Close taxonomic relationships exist between the faunas inhabiting caves on globally distant and geographically isolated oceanic islands. Since many of these troglobitic species belong to taxa lacking planktonic larvae, traditionally accepted dispersal modes appear unlikely. Many marine troglobites are closely related to deep water species, while others have also been found to inhabit inland phreatic waters of crevices and cracks within the bedrock. Such world-wide biogeographical affinities and observed habitat preferences suggest that island cave faunas may be interconnected and dispersed through populations inhabiting deep water cave or crevice systems on the sides of oceanic seamounts and along mid-ocean ridges.

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