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Origin and Age of the Marine Stygofauna of Lanzarote, Canary Islands

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(With 3 figures)

Abstract

Five species of troglobitic crustaceans, previously known only from the Jameos del Agua marine lava tube in Lanzarote, Canary Islands, have been collected from wells in other, geologically older areas of the island. Most, and possibly all, of the endemic species inhabiting the Jameos del Agua probably entered the cave from adjacent crevicular groundwater habitats. The endemic hypogean fauna of Lanzarote can be divided into 2 groups: (1) relict species with affinities to the cave fauna of other oceanic, primarily Western Atlantic, islands and (2) species with close relatives from the deep sea. The origin of the first group can be correlated to Mesozoic plate tectonics. The species of the second group are probably derived from widely spread deep sea ancestors and may have colonized the crevicular system of Lanzarote at different times.

Introduction

Lanzarote, at the eastern end of the Canary Islands, possesses one of the world's longest lava tubes, the Cueva de los Verdes – Jameos del Agua system, having a total length of more than 8 km (HALLIDAY 1972; WILKENS & PARZEFALL 1974). The seaward-most segment of the tube forms a partially to completely flooded marine cave, about 2 km in length. Water in this section of the cave is of fully marine salinities and is subjected to the tides. Except for some 100 m at the two James del Agua entrances, the cave is in total darkness.

Although the lava tube was formed by eruptions of the volcano Monte Corona during the Holocene, the volcanic history of the island of Lanzarote is much older. The first marine flows began about 40 m. y. ago, with subaerial flows commencing 11 m. y. (ARAÑA & CARRACEDO 1979). The eastern pair of Canary Islands, Lanzarote and Fuerteventura, may have been continuously or periodically connected by land bridges or shallow water straits with Africa between the late Cretaceous and the Mio-Pliocene (ROTHE & SCHMINCKE 1968).

The marine cave biotope in Lanzarote is characterized by a troglobitic fauna with partial or complete absence of body pigment and eyes reduced to varying degrees. To date, 9 endemic species have been described from this biotope. About half of these, such as the crustacean *Morlockia ondinae* VALDECASAS

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which belongs to the class Remipedia (YAGER 1981), show a relict character (Table 1, ILIFFE et al. 1984).

To clarify this seeming contradiction of relict troglobitic species inhabiting a marine cave of recent geologic origin, further studies on the occurrence of such species in different and older areas of Lanzarote were carried out.

Material and methods

Specimens in this study were collected from both active and inactive wells supplying saline groundwaters for salinas (Saltworks). These wells, situated at a maximum distance of about 300 m from the coast, are approximately 1 m in diameter and extend from 2 to 8 m below the land surface. The water is of normal marine salinity (35 ‰) and oscillates with the tides. Seawater penetrates inland from the coast through a 2–3 m thick layer of porous, highly fissured rock that underlies 5 m of rather impermeable cap rock.

A total of 29 wells from 12 salinas were examined, although animals were found in only 13 of these (Fig. 1). Sampling was performed with plankton nets (55 µm) and baited traps. Benthic specimens were also collected. Studies were carried out between 1 and 23 February 1985 and between 16 February and 23 March 1986. All material is deposited in the Zoological Museum Hamburg.

Results

Five of the 9 endemic species present in the Jameos del Agua lava tube were found to inhabit marine groundwaters, accessible through wells, in other parts of the island (Table 1):

Table 1: Composition and collection localities of the endemic stygofauna of Lanzarote, Canary Islands.

		LAVA TUBE	WELLS
Munidopsis polymorpha KOELBEL 1892	Galatheidae, Anomura	X	X
Halosbaena fortunata BOWMAN & ILIFFE 1986	Thermosbaenacea, Crustacea	X	X
Heteromysoides cotti (CALMAN 1932)	Heteromysini, Mysidacea	X	X
Hadzia (Liagoceradocus) acutus (ANDRES 1978)	Hadziidae, Amphipoda	X	X
Danielopolina wilkensi HARTMANN 1985	Thaumatocypridae, Ostracoda	X	X
Morlockia ondinae VALDECASAS 1984	Remipedia, Crustacea	X	
Curassanthura canariensis WÄGELE 1985	Anthuridae, Isopoda	X	
Spelaeonicippe buchi (ANDRES 1974)	Pardaliscidae, Amphipoda	X	
Gesiella jameensis (HARTMANN-SCHROEDER 1974)	Gesiellinae, Polynoidae	X	

1. *Hadzia (Liagoceradocus) acutus* (ANDRES, 1978) (Amphipoda, Crustacea).

This species is common in many wells: Punta Mujeres, Los Cocoteros, Los Charcos, Los Marmoles (Fig. 1).

2. *Heteromysoides cotti* (CALMAN, 1932) (Heteromysini, Mysidacea)

H. cotti was found in only 3 wells, these located about 300 m from the coast: Punta Mujeres, Los Cocoteros, Los Marmoles (Fig. 1). The specimens were collected after several days of baiting. In comparison with individuals collected in the naturally illuminated sections of the Jameos del Agua which were brownish, all specimens from wells were completely depigmented.

3. *Halosbaena fortunata* BOWMAN & ILIFFE, 1986 (Thermosbaenacea, Crustacea)

Two specimens were collected with a plankton net in a well at Los Marmoles (Fig. 1).

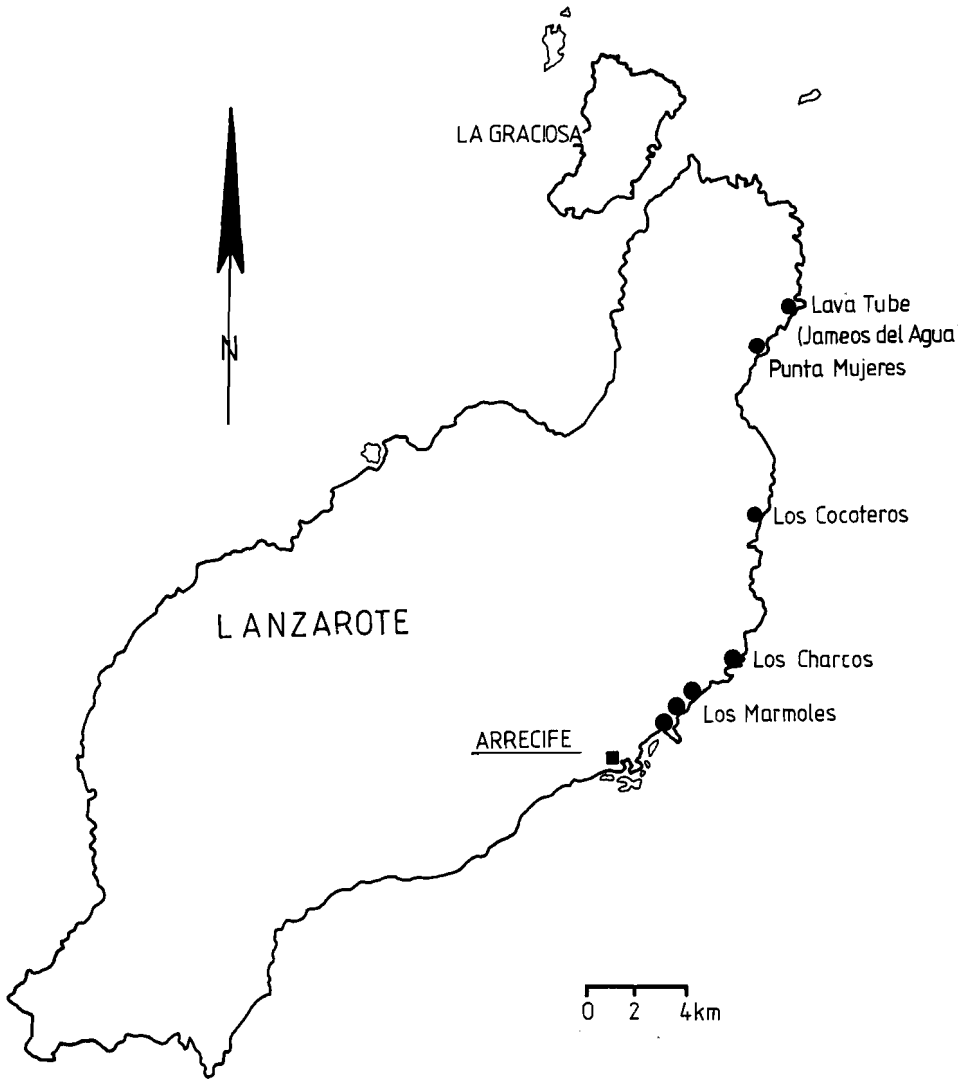

Fig. 1: Distribution of collection sites on Lanzarote.

4. *Munidopsis polymorpha* KOELBEL, 1892 (Galatheidae, Anomura)

One adult was caught in a baited trap left for 2 weeks in a well at Los Cocoteros (Fig. 1), about 300 m from the coast.

5. *Danielopolina wilkensi* HARTMANN, 1985 (Thaumatocyprididae, Ostracoda)

The collection of both adult and larval specimens of *D. wilkensi* from wells at Punta Mujeres and Los Marmoles (Fig. 1) establishes the existence of hypogean populations (G. HARTMANN pers. comm.).

Discussion

These studies show that the marine fauna of the Jameos del Agua lava tube is not restricted to the cave biotope, but is widely distributed in near-coastal

groundwaters of Lanzarote. Present evidence still indicates these species are endemic to the island.

The groundwater biotope consists of sub-sea level sytem of crevices and fissures within the volcanic rock through which wells merely provide convenient access and collecting sites. The Jameos del Agua lava tube, upon its formation, became part of this biotope and was colonized by groundwater fauna.

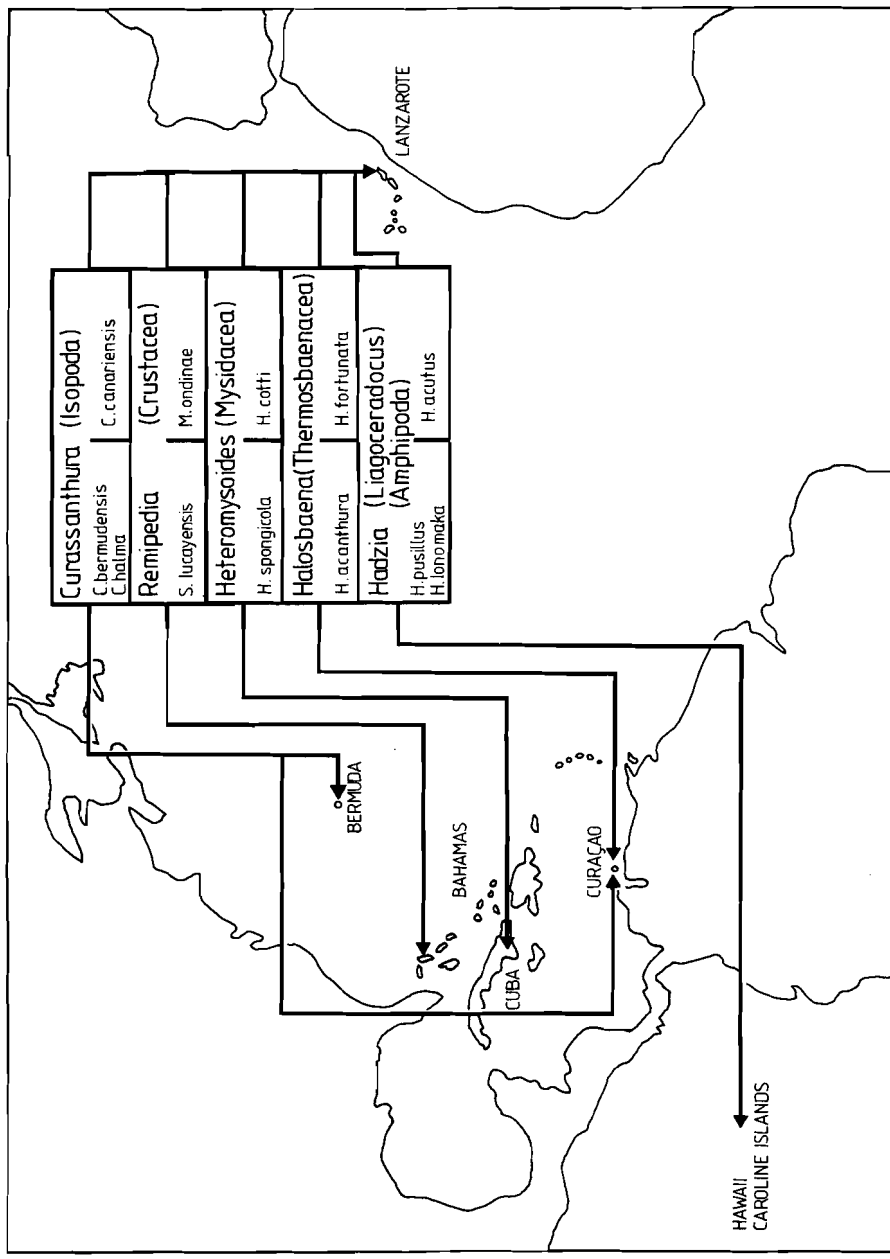

Fig. 2: Endemic species with relations to the cave fauna of primarily Western Atlantic islands.

Interestingly however, since only 5 of the 9 Jameos endemics and no new species were found during the groundwater survey, it appears that the cave habitat yields a more complete representation of this fauna.

The term "crevicular" has been coined by HART et al. (1985) to describe aquatic habitats formed by crevices in and among rocks, in order to delimit it from much smaller sized interstitial spaces. JUBERTHIE (1983) found similar conditions in terrestrial subterranean biotops, naming it the "milieu souterrain superficiel" (MSS).

The endemic marine crevicular fauna of Lanzarote can be divided into two groups (ILIFFE et al. 1984):

1. Relict species with close relations to the cave fauna of other oceanic, primarily western Atlantic, islands (Fig. 2).

a. *Morlockia ondinae* is closely related to *Speleonectes lucayensis* YAGER 1981 and other remipedes from limestone marine caves in the Bahamas and Turks and Caicos Islands.

b. *Heteromysoides cotti* has affinities to the spongicolous *H. spongicola* BACESCU, 1968 from Cuba.

c. *Curassanthura canariensis* WÄGELE 1985 is related to both *C. halma* KENSLEY, 1981 from marine groundwaters in Curaçao and Bonaire and *C. bermudensis* WÄGELE & BRANDT, 1985 from anchialine caves in Bermuda.

d. *Hadzia acutus* is one of 3 members of the subgenus *Liagoceradocus*, the others being 2 Pacific species: *H. pusillus* (BARNARD, 1965) collected from marine algae at Ifaluk Atoll, Caroline Islands and *H. lonomaka* BARNARD, 1977, a blind species from brackish lava ponds on Maui in the Hawaiian Islands. Hadziids in general are an old stock, still distributed over the area of the former Tethys Sea, concentrated in the northern Mediterranean and the West Indies (STOCK 1977).

e. *Halosbaena fortunata*, the first marine thermosbaenacean, has only one congener, *H. acanthura* STOCK 1976, which inhabits coastal groundwaters in Curaçao.

2. Species with relations to taxa inhabiting the deep sea or additionally caves on other oceanic islands (Fig. 3).

a. *Munidopsis polymorpha* is a member of the Galatheidae, most species of which are from the deep sea.

b. *Gesiella jameensis* (HARTMANN-SCHROEDER, 1974) from the mono-specific polynoid subfamily Gesiellinae probably had a deep sea origin.

c. *Danielopolina wilkensi*, from the primarily deep sea family Thaumatocyprididae, is related to *D. orghidani* (DANIELOPOL, 1972) from anchialine caves in Cuba and *D. carolynae* KORNICKER & SOHN, 1976, from 3459 m depth in the South Atlantic.

d. *Spelaeonicippe buchi* (ANDRES, 1974) is related to *S. provo* STOCK & VERMEULEN, 1982 from an anchialine cave in the Caicos Islands, but is also a member of the primarily abyssal family Pardaliscidae.

e. Four new species of misophrioid copepods, all from different genera and 3 of which are new, are now being described by BOXSHALL & ILIFFE from the Jameos del Agua. Misophrioids, which until their discovery from anchialine caves on Bermuda (BOXSHALL & ILIFFE, 1986), were previously considered to be a deep sea taxon. One new Jameos genus of misophrioids has a second new species inhabiting anchialine limestone caves on Palau, Caroline Islands.

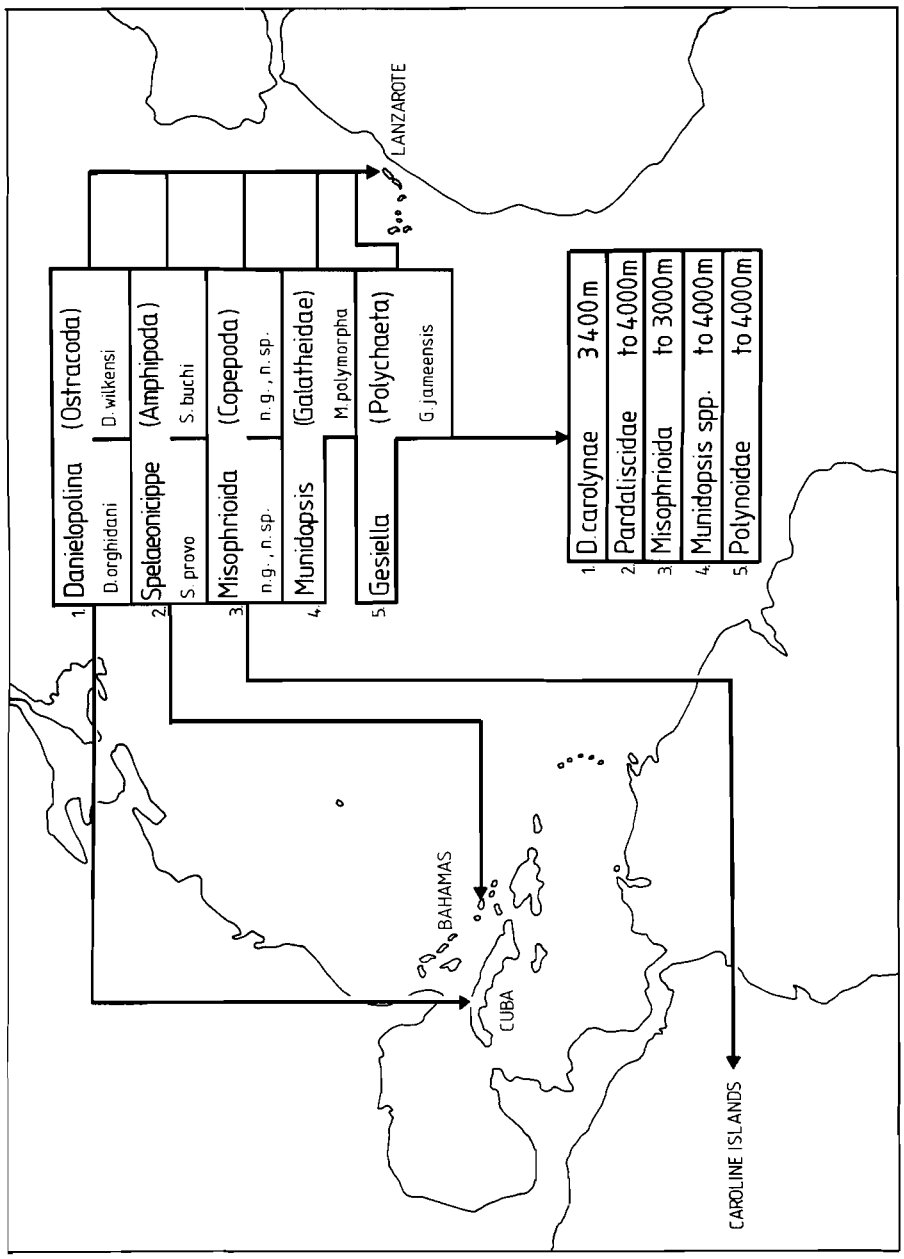

Fig. 3: Endemic species with relations to taxa inhabiting the deep sea or additionally caves on other oceanic islands.

The amphi-Atlantic distribution of species in the first group has been interpreted as resulting from cave colonization during an early stage in the formation of the Atlantic, followed by dispersal by sea floor spreading and continental drift (ILIFFE et al. 1984, HART et al. 1985, WÄGELE 1985). A similar distributional pattern has been observed for cavernicolous Atyidae (Caridea) and Cirolanidae (Isopoda) (MONOD 1972).

Connections to the deep sea, characteristic of the second group of species, may be the result of cave forms originating in this biotope. Many deep sea

species have the ability to colonize marine caves. They already possess the important preadaptations of viviparity and low energy requirements, while both the cave and deep sea biotopes share an absence of light and a lack of wind- or wave-induced water turbulence (RIEDL 1966). An exemplary demonstration of preadaptation is provided by studies of *M. polymorpha* (WILKENS & PARZEFALL 1974, PARZEFALL & WILKENS 1975).

Species with both a deep sea origin and amphi-Atlantic distribution probably developed independently from a widely dispersed ancestor. Cave and deep sea forms are now apparently restricted to their respective biotopes. Until now no evidence supports previous suggestions (WILKENS & PARZEFALL 1974) of a recent deep sea distribution of these forms.

Unfortunately, it is not possible to use the degree of eye reduction as a phylogenetic clock to date the colonization of crevicular habitats in Lanzarote by endemic species. In most cases, the eyes of deep sea-derived species were probably already reduced to some extent before cave colonization (WILKENS 1966).

However, for the speciation process of some forms to arrive at a specific or generic level, a longer time of isolation would be expected. Colonization probably began at different times and in different locations since the formation of Lanzarote. For relict species, a Mesozoic origin is possible.

Final elucidation of these questions awaits further studies from the deep sea around Lanzarote and from other islands within the Canaries. Significant potential for new discoveries exists in the Canaries since islands within the archipelago have varying geologic ages (ROTHE & SCHMINCKE 1968).

Zusammenfassung

Fünf Arten höhlenlebender Crustaceen, die bislang nur aus einem marinen Lavatunnel (Jameos del Agua) auf Lanzarote (Kan. Inseln) bekannt waren, wurden in marinen Brunnen geologisch älterer Regionen der Insel gesammelt. Wahrscheinlich haben alle endemischen Arten der Jameos del Agua den geologisch sehr jungen Lebensraum aus dem angrenzenden grobspaltigen Grundwasserhabitat besiedelt. Die endemische hypogäische Fauna Lanzarotes besteht aus zwei Gruppen: (1) reliktäre Arten mit verwandtschaftlichen Beziehungen zur Höhlenfauna anderer ozeanischer, vor allem westatlantischer Inseln und (2) Formen, die sowohl Beziehungen der vorgenannten Art wie auch zusätzlich zur Tiefsee haben.

Die Entstehung der Arten der ersten Gruppe ist im Zusammenhang mit plattentektonischen Ereignissen zu sehen. Unter ihnen könnten daher Formen sein, die bereits im Mesozoikum ihre cavernicole Evolution begannen. Die zweite Gruppierung besteht aus Arten, die die Besiedlung der Spaltensysteme ausgehend von einem ursprünglich in der Tiefsee weit verbreiteten Vorfahren vollzogen haben. Dies könnte zu unterschiedlichen Zeitpunkten der Existenz Lanzarotes erfolgt sein. Die Fähigkeit hierzu basiert auf der Prädisposition mancher Tiefseeformen für ein Höhlenleben.

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