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First record of a tropical shallow water barnacle *Tetraclita* sp. (Cirripedia: Tetraclitoidea) from the middle Neogene of the Canary islands

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MARTÍN-GONZÁLEZ, E., BUCKERIDGE, J., CASTILLO, C. & GARCÍA-TALAVERA, F. Primera cita de un cirrípedo del género *Tetraclita* en el Neógeno medio de las islas Canarias. *VIERAEA* 40: 97-106.

ABSTRACT: This paper describes the first record of the intertidal, tropical tetraclitoid barnacle *Tetraclita* sp. cf. *T. stalactifera* (Lamarck, 1818) from the middle Neogene of the Canary Islands. The barnacles were recovered as isolated plates from a bioclastic volcanic agglomerate. Associated fauna includes patellid and neritid gastropods, and an oyster bank, which confirm a shallow-water litoral setting. Living *Tetraclita stalactifera* is recorded from tropical waters of the America, South Africa and the Arabian Sea; it is first recorded as fossil from Plio-Pleistocene of Curaçao (Caribbean Sea, Venezuela).
Keywords: *Tetraclita* cf. *stalactifera*, tropical tetraclitoid, intertidal environment, Late Miocene-Early Pliocene.

RESUMEN: Se cita por primera vez la presencia de un cirrípedo tetraclitoideo de aguas someras tropicales, *Tetraclita* sp. cf. *T. stalactifera* (Lamarck, 1818), en los afloramientos del Neógeno medio de las islas Canarias. Los fósiles, únicamente constituidos por placas aisladas, faltando siempre las operculares, se encuentran en niveles de conglomerados bioclásticos con cantos volcánicos. La asociación faunística de estos niveles fosilíferos incluye bancos de ostreidos y gasterópodos pateliformes y nerítidos, lo que confirma un depósito en aguas someras. *Tetraclita stalactifera* se distribuye actualmente en aguas tropicales de Sudamérica, Sudáfrica y Mar de Arabia, y fue citada

como fósil por primera vez en los yacimientos Plio-Pleistocenos de Curaçao (Mar Caribe, Venezuela).
Palabras clave: *Tetraclita* cf. *stalactifera*, tetraclitoido tropical, ambiente intermareal, Mioceno superior-Plioceno inferior.

INTRODUCTION

The Canary archipelago is an island chain of seven main islands, approximately 500 km in length; it lies off the northwest African coast in the North Atlantic, with the easternmost island only 110 km from Morocco. The archipelago is volcanic, originating as either a hotspot (Carracedo *et al*., 1998) or as a unified "hotspot, propagating fracture and uplifted block" model (Anguita & Hernán, 2000).

Fossiliferous deposits found at Fuerteventura, Lanzarote, and Gran Canaria islands have similar fauna assemblages (Meco *et al*., 2007) and are dated as lower Pliocene by K/Ar method of associated lavas (Meco & Stearns, 1981; Coello *et al.*, 1992). Most of these deposits have been attributed to marine transgressions and regressions of glacioeustatic origin.

Although extensively eroded, the deposits crop-out along the coast, dipping gently towards the sea. Post-depositional tectonic uplifting rather than glacioeustatic adjustment, due to increased volcanic materials and tilting is considered the primary cause for the disposition of the strata (Meco *et al.*, 2007).

Rothpletz & Simonelli (1890) listed two barnacles, *Balanus* cf. *perforatus* Bruguiére, 1789 and *Chelonibia hemisphaerica* (Rothpletz & Simonelli, 1890), from Neogene deposits of Gran Canaria island which are no longer present in the Canaries. This paper describes a further tropical barnacle from the Neogene of Canary Islands, following analysis of the collections made for the Fuerteventura Paleontological Catalogue, with important implications paleoecologic and paleobiogeographic. In Canary islands there are currently seventeen barnacles species (González *et al.*, 2012), of which only *Tesserepora atlanticum* Newman & Ross (1977) belongs to the Tetraclitidae family.

MATERIALS AND METHODS

Localitation and geological setting

The Canary archipelago is located between latitudes 27º and 29º N off NW African continent. They are a group of intraplate volcanic islands, the oldest, Lanzarote and Fuerteventura (15 to 23 Ma) being the most eastern. Fuerteventura has the longest and most complete geological history (Coello *et al.*, 1992), and is comprised of four main lithological units: Mesozoic oceanic crust, submarine volcanic complex, complex subaerial Miocene, and sedimentary and volcanic rocks Pliocene-Quaternary (Carracedo *et al.*, 2002).

The fossils described herein were first found at the site of Playa del Valle (Fig. 1), on the west coast of Fuerteventura island (geographic coordinate UTM 28 R 588624 E / 3151212 N), although they are now known from many other outcrops on the island. The Neogene lithologies lie unconformably on breccias, hyaloclastites and pillow-lavas of the

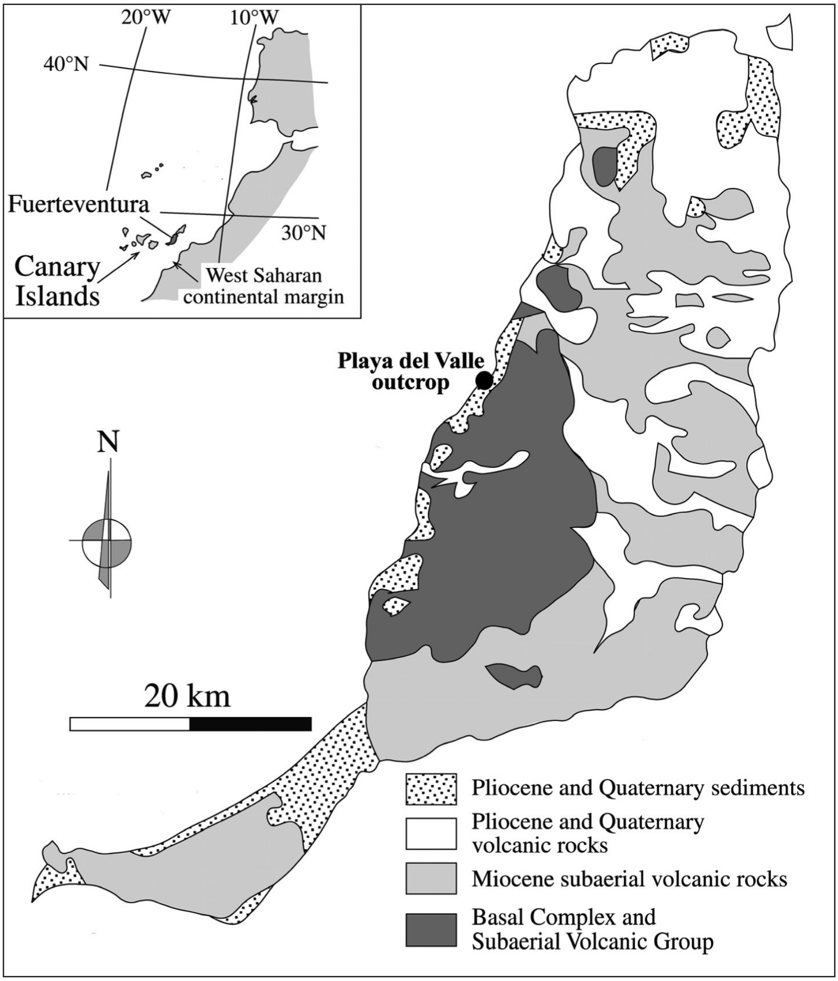

Figure 1.- Schematic geological map of Fuerteventura. The inset shows the location of Playa del Valle outcrop in the island. Map was modified from Gutiérrez *et al.* (2006).

submarine volcanic complex (Gutiérrez *et al.*, 2006), fossilized abrasion platform located between 10 and 50 m above sea level.

The full stratigraphic sequence is a 10-15 m polymictic agglomerate with a sandy matrix (Fig. 2), that begins with a breccia and conglomerate horizon that fills erosional irregularities created in the volcanic substrate. Within this are some more or less continuous, well-cemented bioclastic conglomerates of a pinkish color (N-1 in Fig. 2). Above N-1 is another bioclastic concentration that is up to 0.5 m thick (N-2). These lower sequences are characterized by onlap geometry, it involves a deposit in a context of relative sea-level rise (Martín-González *et al.*, 2001). Above the continuum, a set of clastic breccias and conglomerates, mostly with basaltic and some rounded pebbles, and a matrix-thick medium sand size occurs. This section shows irregular erosion surfaces and contains three fossiliferous levels (N-3, N-4 and N-5). In the middle of the section is a fine sandy bank about 1 m thick. Fossil remains are scattered among the sands and concentrates as small pockets (N-6). Above these sands there is a very cemented bioclastic level comprising large numbers of mollusc shells and small clasts (N-7).

Lava flows (Fig. 1), contemporary with the sands at the base of the sequence at Playa del Valle, have been dated by K-Ar in 5.8 ± 0.5 Ma (Meco & Stearns, 1981) or 5.0 ± 0.3 Ma (Coello *et al.*, 1992). The lava flows above the marine calcarenite, give an age of 3 Ma (Coello *et al.*, 1992), and on the basis of this, we conclude that the unit described herein was deposited between 5.8 and 3 Ma, i.e. latest Messinian to Upper Zanclean.

Palaeontological data

The most abundant fossil at all levels at the site is the neritiid gastropod *Nerita martiniana* Matheron, 1842 which is usually preserved as casts. The limpet *Patella* aff. *am-*

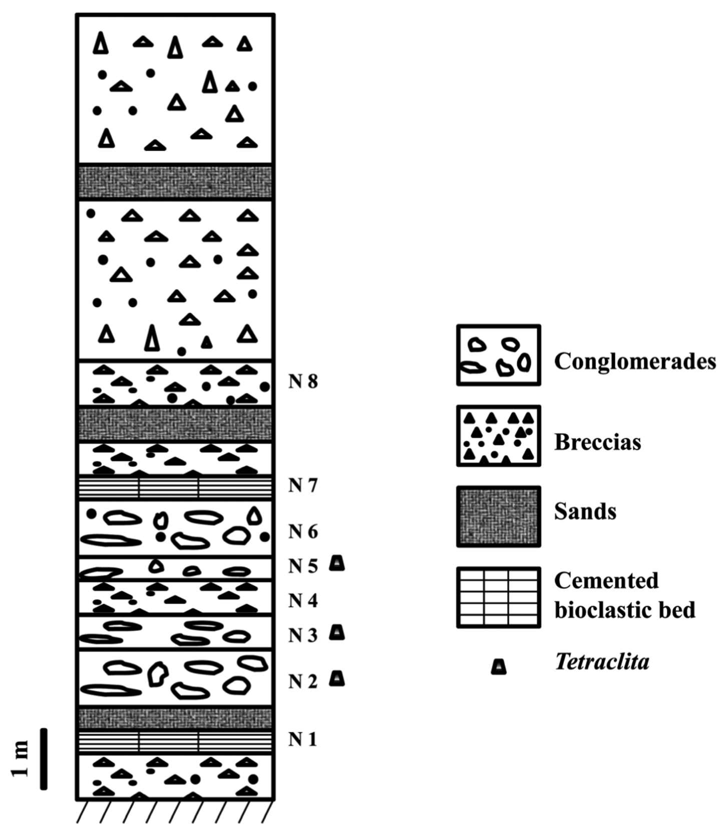

Figure 2.- Stratigraphic column at Playa del Valle outcrop.

broggii Lecointre, 1954, is also abundant, although in most specimens, the apex is generally fragmented, and peripheral ornamentation shows abrasion. The most common bivalve is *Saccostrea* sp. which is often disarticulated and abraded, especially in the umbo area.

Barnacles were found at levels N-3, N-4 and N-5 (Fig. 2), and were primarily scattered in gaps between rounded clasts. Most of them are preserved as disarticulated compartmental plates; they are somewhat abraded and although not *in situ,* are unlikely to have been transported long distance. Unfortunately no opercular plates have yet been recovered.

Studied material are deposited in the collection of paleontology at the Natural Science Museum of Tenerife (Museo de Ciencias Naturales de Tenerife).

SYSTEMATIC PALEONTOLOGY

Phylum ARTHROPODA Latraille, 1829
Class MAXILLOPODA Dahl, 1956
Order SESSILIA Lamarck, 1818
Family **Tetraclitidae** Gruvel, 1903
Genus *Tetraclita* Schumacher, 1817
Tetraclita sp. cf. *T. stalactifera* (Lamarck, 1818)

Description

Shell moderately high conic; comprising carina, rostrum and paired latera; exterior surface eroded to expose fine sharp elongate ridges that in less abraded areas are distinctly bedded; sutures between compartments obliterated; radii extremely narrow or wanting; compartmental wall multi-tubiferous, in juveniles with a single row of rectangular longitudinal pores, but with growth, septa between pores bifurcate to form new pores, that are radially elongate and subtriangular in section; due to branching, pores are smaller and more numerous towards the exterior of the compartment (Fig. 3); interior with sheath extending to more than half the wall height, basal edge of sheath not pendant; opercula unknown; basis absent. Shell pale pink in colour. Maximum reconstructed height 26.4 mm; maximum reconstructed diameter, 32.1 mm; maximum known operculum opening (rostro-carinal) 10.5 mm.

Remarks

This is one of the earliest known occurrences of *Tetraclita*, which is interpreted as having diverged from a *Tesseropora*-like form in the Miocene (Buckeridge, 1983).

The material may be distinguished from the following tubiferous tetraclitoids by the nature and arrangement of the longitudinal pores: *Tesseroplax* Ross (1969) and *Tesseropora* Pilsbry (1916), which possess only a single row of pores; *Newmanella* Ross (1969), which has externally ribbed compartments; *Yamaguchiella* Ross & Perreault (1999), which has two or more rows of pores, but these are regular in shape and size. It clearly differs from *Tetraclitella* Hiro (1939), which is externally ribbed and possesses broad radii. Of all the known species of *Tetraclita*, it is similar to both *T. squamosa* group *rufotincta*) in colour,

Figure 3. Disposition of barnacle shells at the Playa del Valle outcrop: **a**, view of the outcrop, red arrow indicating where photographs b and c were taken; **b**, two *Tetraclita* shells, lacking opercula; both oriented upright; **c,** view showing inverted specimens of *Tetraclita*. The disposition, level of abrasion and articulation of the shells indicates that they have not travelled far, i.e. after death and dislodgement from the substrate, they have most likely fallen into gaps between rocks, where with other shell and lithic fragments, they have been preserved.

but in pore size and disposition more like *T. stalactifera*. The later has a compatible fossil record, being recorded from the Plio-Pleistocene of Curaçao and the Pleistocene of Venezuela (Newman and Ross, 1976); and it is to this taxon that it is currently ascribed. Without opercula, a firmer systematic placement cannot be made.

Both *T. rufotincta* and *T. stalactifera* are tropical intertidal species that are common in surf zones, where they are generally found higher up than *Balanus* Da Costa (1778) and *Amphibalanus* Pitombo (2004). *T. stalactifera* is known from western Atlantic Ocean, Gulf of Mexico and eastern Pacific, so *T. rufotincta* is distributed in the West Indian Ocean . It lives attached to rocks, piers and many other hard substrates where water temperatures range between 20 and 26 ºC (Skinner *et al.*, 2007).

DISCUSSION

The fossil assemblage at the site of Playa del Valle is dominated by molluscs (bivalves and gastropods), barnacles, and accumulations of coralline algae that form small rhodoliths. The most abundant organisms in the outcrop are *Patella* aff. *ambroggii*, *Nerita martiniana* and *Saccostrea* sp. (Gmelin, 1791) all of which are normally abraded and broken fragments. Barnacles are the second most abundant group of organisms although they do not appear to form concentrations. Rather they are scattered among the gaps between pebbles of volcanic agglomerate and bioclasts.

Molluscs and scleractinians corals other neogene canarian deposits indicate palaeoclimatic conditions warmer than the present e.g. *Strombus coronatus* Defrance, 1827, *N. martiniana* and *Siderastrea* (Meco *et al*., 2007). At middle latitudes in the Northern Hemisphere, the Mio-Pliocene is characterized by cooling and a transition from an tropical to temperate climate (Herbert & Schuffert, 1998). This warm climatic regime continued until the cool climate that brought on the development of Pleistocene icesheets 2.7 Ma (Haug *et al.*, 2005). It is likely that ocean circulation changes, caused by the closure of the Panama Channel 4.6 Ma ago (Ravelo *et al.*, 2004), resulted in regional extinction of thermophilic species from the Canary Islands.

The present marine fauna of Canary Islands includes amphiatlantic invertebrates, as several species of *Cymatium* (García-Talavera, 1982), decapod (Quiles *et al.,* 2001), some that are in common with Azores, Madeira and Cape Verde as barnacle *Oxynaspis celata* Darwin, 1851 (Wirtz & Martins, 1993; Wirtz, 2001). The North Equatorial Current, flowing from west to east, is the most likely candidate for dispersal of planktotrophic and lecitotrophic invertebrate larvae along the Atlantic Ocean (Scheltema, 1971; 1995). The tetraclitoid barnacles originated in the Indo-Pacific, but are represented in western Atlantic today by *Tesseropora atlantica* Newman & Ross, 1976 (Newman & Ross, 1977), and recorded as fossil in France, from the Miocene with *T. dumortieri* (Fisher, 1866) and from the Pliocene to *T. sulcata* (Carriol, 1993) (see Carriol, 2008). *T. atlantica* is a non-planktotrophic species, which should minimize the chances of dispersal, however, the distribution in the Atlantic is quite wide (Winkelmann *et al.*, 2010). The larval dispersal of these species provides us with useful insights into contribution of surface ocean currents and oceanographic changes in the region during the during the Pliocene (Allmon *et al.*, 1993).

The presence of the *Tetraclita* genus in the fossil record from the canarian Neogene was extend the family Tetraclitidae paleogeographic distribution to more southern areas of the Atlantic during, at least the Mio-Plioceno. At the same time supports the possibility of the larvae of tropical marine benthic organisms to colonize island away from the continents during interglacial warm periods (Wirtz *et al.*, 2006), in which the oceanographic conditions were different.

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