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Blanchard Cave 2: A historical period Audubon's shearwater (*Puffinus lherminieri*) nesting site in Marie-Galante (Guadeloupe islands, FWI)

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ABSTRACT

In this paper we present a natural deposit in Marie-Galante island (French West Indies), Blanchard 2, where historical-period Audubon's shearwater remains dominate the vertebrate assemblage. We combined a study of sediment geometry, a taphonomic analysis of molluscs, crustaceans and vertebrate remains, and direct radiocarbon dating on bird bone to demonstrate that the cave was used as a nesting ground during the island's colonial period. This approach also allows the discussion of the causes leading to the desertion of the site by birds. Finally, we investigate hypotheses regarding the dynamics of Audubon's shearwater nesting during prehistoric and historical times and the impact of anthropogenic phenomenon on these birds.

1. Introduction

Oceanic islands are known to be fragile environments where indigenous biotas are strongly vulnerable to human-induced modifications (van der Geer et al., 2010). This remark is especially valid for Caribbean islands which are home to numerous wild animal species threatened with extinction or which have already disappeared (Myers et al., 2000).

This area presents the worldwide highest extinction rate in the world of its endemic non-flying mammals, greater than 95% following Dávalos and Turvey (2012). Indigenous Squamates and bats also have very high extinction rates depending of the island (e. g. 60% to 70% on Marie-Galante Island: -Bailon et al., 2015; Stoetzel et al., 2016-). Concerning birds, many extinct species have been described (Turvey, 2009) and the description of the past Caribbean avian diversity is still ongoing (e.g. Gala and Lenoble, 2015; Takano and Steadman, 2015; Steadman and Takano, 2016). During the last decade several studies have highlighted the preponderant role of Man in these numerous extinction events (Steadman et al., 2005; Bailon et al., 2015; Soto-Centeno and Steadman, 2015; Stoetzel et al., 2016) and the minor role of natural modifications of the environment in these processes. However, much work has still to be done to determine the exact timing of extinctions and the exact relation between extinctions and human behaviours or historical event.

Amongst extinct species, marine bird species have seen an important reduction in their numbers (Lowrie et al., 2012). The Audubon's shearwater (*Puffinus lherminieri*), a small, land-nesting bird, is currently considered one of the most threatened, particularly due to the introduction of mammal species, such as the black rat, which feed on its eggs and hatchlings. In fact, these rodents have been shown to heavily impact marine bird colonies (Atkinson, 1985; Towns et al., 2006; Jones et al., 2008). Indeed, the extent to which black rat predation can impact breeding colonies of Audubon's shearwater was recently revealed following an attempt to eradicate the rodent from the islets of Saint-Anne, Martinique (Pascal et al., 2004).

Today, Audubon's shearwater nesting grounds are for the most part located on small coastal islets (Birdlife International, 2014; Lowrie et al., 2012; Bright et al., 2014). However, the discovery of Audubon's shearwater bones in archaeological or paleontological contexts on Caribbean islands where this bird is no longer present, such as Mona, Anguilla, Antigua and Barbuda (Wing et al., 1968; Pregill et al., 1994; Nieves-Rivera et al., 1995), suggests a reduction in nesting areas as a consequence of European colonisation, especially due to the intentional or accidental introduction of exogenous mammals such as the rat or

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mongoose. This, however, does not exclude the possibility of an earlier human impact.

In fact, the human exploitation of nesting ground marine birds is described as having almost immediately followed the settling of the first European colonists in the region in the early 17th century. For example, historical accounts mention that sterns on the islets of Les Saintes were heavily exploited by Europeans (Breton, 1647: 32) and that marine birds formed part of the subsistence strategies of indigenous populations (Du Tertre, 1667: 274–275; Breton, 1665: 164). However, the use of marine birds is likely to date to considerably earlier. For instance, the disappearance of Black-capped petrel from Martinique was advanced by Wetmore (1952) on the basis of the discovery of a bone of this species in pre-Columbian middens of the Ceramic age period (ca. -300 BCE to 1500 CE). A much earlier human impact on native bird populations is even possible. Indeed, excavations at a preceramic site on Dog Island (Anguilla), one of the most important nesting grounds in the Caribbean (Hodge et al., 2008), led Crock (2005) to suggest that human predation on birds dates to the earliest occupation of the archipelago, some 5000 y BP.

The question is even more pertinent for the Aubudon's shearwater, one of the most frequent marine birds found in Amerindian middens (Grouard, 2001; Wing, 2001), several of which amongst the oldest known in the archipelago (Hofman et al., 2006).

In addition to Amerindian middens, Aubudon's shearwater remains have also been documented from caves and rock shelters (e.g. Pregill et al., 1994; Morgan, 1994; Nieves-Rivera et al., 1995). Nevertheless, these sites often lack chronological resolution and the agents responsible for the deposits (human and/or animal predation or nesting sites) more often than not remain difficult to determine. As a result, the historical biogeography of this species proves difficult to document.

Numerous studies have however provided criteria for determining the agent responsible for the accumulation of bird bones in fossil contexts. While the identification of butchery marks remains the most reliable evidence for human exploitation (Laroulandie, 2000, 2001, 2005; Vigne et al., 1991), the relative proportions of certain anatomical parts can provide arguments concerning the origin of avian material in both archaeological and natural contexts (Baales, 1992; Bovy, 2002; Bochenski, 2005; Ericson, 1987; Livingston, 1989). Besides, in a few rare cases, it has been possible to demonstrate that bird bone accumulations result from the use of caves as nesting sites, where numerous complete remains of both young and adult individuals occur in the context of a near total absence of evidence for either animal or human predation (Laroulandie, 2000, 2010; Mourer-Chauviré, 1975, 1983).

Here we discuss evidence from a site in Guadeloupe, Blanchard 2, where historic-period Audubon's shearwater remains dominate the vertebrate assemblage. Sedimentological data, a direct date on faunal material, and an analysis of mollusc, crustacean and vertebrate remains combined with a taphonomic approach indicates the site to have been a nesting ground during the island's colonial period. This taphonomic approach also allows the causes leading to the abandonment of the site as a nesting ground to be discussed, and by extension, investigate hypotheses concerning the dynamics of Audubon's shearwater nesting as a response to the region's prehistoric and historic settlement.

2. Site background

Blanchard 2 (15°52′55.82″N, 61°14′2.27″W, 10 m NGF) is a small crevice cave formed in the rhodolith limestone of Pliocene age (Lenoble et al., 2009). The cave opens onto the Capesterre cliff, not far from Blanchard 1. The site lies a few metres above the Petite Anse coastal plain in a dry deciduous forest on the southern part of Marie-Galante (Fig. 1) (Rousteau et al., 1994). Discovered in 2007, vertebrate and malacological material, together with a pierced, lozenge-shaped conch shell button and an unworked conch shell identified on the surface near the entrance alongside a flint flake recovered further within the cave suggested an Amerindian occupation. Moreover, the site is located in an area rich in sites of both cultural and natural importance. Several dozen metres to the west on the same cliff face can be found the rock shelters of Cadet. Cadet 3 rock shelter contains Late Glacial to Holocene fossil deposits (Stouvenot et al., 2014), and Cadet 2 rock sheleter, an Amerindian funerary cave also contains natural deposits and documents the islands final Pleistocene vertebrates (Courtaud, 2011; Bochaton et al., 2015). A test pit practised under the porch of the nearby Blanchard 1 site also produced an Amerindian burial (Stouvenot, 2005; Grouard et al., 2014), while the zone deeper within the cave contains substantial Pleistocene fossil deposits (Lenoble et al., 2009; Goetz et al., 2014; Bailon et al., 2015; Stoetzel et al., 2016). Amerindian settlements are also known from the vicinity of the cave, including the Saladoid and Troumassoid site of Tourlourous (Colas et al., 2002) located a little more than a kilometre to the northeast on the same plain, and the Troumassoid site of Petite Anse, a few hundred metres from Blanchard 2 on the littoral belt of the Anse (Lenoble et al., 2012; Casagrande, 2013).

Blanchard 2 comprises a main corridor that follows the cliff line and from which several smaller, lower chambers can be accessed (Fig. 2). This configuration is typical of crevice caves that form following slope failure (Halliday, 2004). The cave has two entrances, the first, however, is impractical due to rock fall. The more accessible eastern entrance, although low (~1 m) is 8 m wide, allowing access to a slope leading to an 8 m long and 2 to 2.5 m wide corridor filled with rock fall. This north-south corridor runs approximately 15 m and cuts several pre-existing cavities that are too low to enter (0.3 to 0.5 m). It is likely that these smaller, interconnected chambers continue for several metres in the rock mass.

3. Material and methods

Following a comprehensive topographic survey of the cave's surface, a half-square metre test pit (test pit 1) was excavated towards the front of the central chamber in the northern section of the cave (Fig. 2). Excavations consisted of eleven 5-cm-thick spits that followed the geometry of the deposit. The excavated sediment was dry-sieved using a 2.8 mm mesh in order to recover all osseous materials. Additionally, bones were collected from the surface of the cave's eastern entrance. The stratigraphic analysis combined pedological (colour, texture and structure) and sedimentological criteria (bedding, clast type and orientation) complemented by a consideration of the geometry of the stratigraphic units and the nature of the contact between layers. A second 0.5 m by 0.5 m test pit (test pit 2) was dug to no deeper than 0.2 m on the slope overlying the site in order to control for the possible introduction of faunal material into the site.

Mollusc and crustacean remains were identified at the *Institut national de recherches archéologiques préventives* (Inrap) of Guadeloupe by S. Serrand. Vertebrate remains were determined to taxa with reference to the Comparative Anatomy collections held by the *Muséum national d'Histoire naturelle* in Paris (MNHN) and the PACEA laboratory at the University of Bordeaux. A fair portion of the bird remains could not be identified due to their heavily fragmented state, the presence of young individuals presenting no clear diagnostic traits and numerous problems in identifying bones of small Passeriformes. This non-identifiable material was therefore grouped in four size classes: small passerines (class 1, e.g. *Loxigilla noctis*), specimens similar in size to pigeons (class 2, e.g. *Zenaida aurita*) or Audubon's shearwater (class 3, e.g. *Puffinus lherminieri*) and those equal to or larger than herons (class 4, *Nyctanassa violacea*). All of the vertebrate remains were counted by spit (number of identified specimen, NISP) in order to avoid overestimating the minimum number of individuals (MNI) [O'Connor, 2008]. On the other hand, the MNI could be estimated for the less-fragmented mollusc and crustacean remains.

All faunal material was examined under a binocular loupe at between × 10 and × 40 magnification in order to identify mechanical, biological or chemical surface alterations. Age of death for the birds