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Multi-analytical approach to zooarchaeological assemblages elucidates Late Holocene coastal lifeways in southwest Madagascar

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ABSTRACT

The impact of resource exploitation by ancient human communities on Madagascar's environment is an area of intense debate. A fundamental question in the archaeology of Madagascar is the extent to which arrival of settlers, introduction of non-native plants and animals, and subsequent human exploitation of island biota, which catalyzed declines in biodiversity and significantly degraded environmental conditions. Fine-grained datasets, including zooarchaeological, archaeobotanical and other ecological evidence, are needed to assess the relationship between human resource exploitation and environmental change. On Madagascar, the resolution of zooarchaeological datasets is often reduced by poor preservation of faunal remains, making precise taxonomic identifications difficult, and few projects to-date have comprehensively assessed zooarchaeological data. Here, we present zooarchaeological data from three coastal villages in the Velondriake Marine Protected Area in southwest Madagascar, where human occupation spans from ca. 1400 BP to the present. Faunal remains from the Late Holocene sites of Antsaragnangy and Antsaragnasoa were identified using morphological analysis of remains, and a PCR-based bulk bone metabarcoding approach was applied at Andamotibe to molecularly identify fish and other vertebrates in a faunal assemblage that was particularly fragmented. Results were interpreted and contextualized using modern data on local fish diversity, climate and anthropogenic impacts on marine and estuarine habitats, as well as modern fishing practices (including preferred fishing grounds, tackle, taxonomic representation and volume of catch). Our use of multiple analytical and interpretative approaches has provided the most highly resolved view to date of past human subsistence in coastal southwest Madagascar. We contend that future research into human-environment dynamics on Madagascar should make use of diverse analytical methods, in order to more comprehensively evaluate past interactions between human communities and the native biota. Furthermore, we encourage an historical ecological approach, so that long-term perspectives on changing human-environment dynamics may be used to contextualize modern trends.

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1. Introduction

Human-environment interaction on Madagascar remains an intensely debated topic in archaeology. For nearly a century,

scholars from a range of disciplines have studied anthropogenic action on the island's unique biota and landscapes (for recent reviews see [Dewar and Richard, 2012](#); [Douglass and Zinke, 2015](#); [Radimilahy and Crossland, 2015](#)). Previous work on past human-animal interactions by archaeologists, paleontologists, and paleobotanists focused on elucidating the processes by which a large suite of endemic fauna, including the island's giant lemurs, giant tortoises, elephant birds and pygmy hippopotamuses, went extinct. These studies involved paleoecological reconstructions and the

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examination of skeletal remains (Burney, 1987, 1993; Burney et al., 2004; Crowley, 2010; Crowley et al., 2016; Goodman and Jungers, 2014; Goodman et al., 2013; Muldoon, 2010; Muldoon et al., 2009; Perez et al., 2005; Simons, 1995). The southwest coast features prominently in Madagascar's extinction debate, as the highest density of known megafauna sites on the island is located here. These sites, which include limestone caves and coastal marshes, act as taphonomic traps, where large numbers of animal bones accumulate over time (See Table 1 in Crowley, 2010). Interdisciplinary work has yielded evidence that people in the southwest processed carcasses of many now-extinct taxa, including lemurs (Godfrey and Jungers, 2003; Perez et al., 2005) and hippopotamuses (Gommery et al., 2011; MacPhee and Burney, 1991) beginning around 2000 BP (Crowley, 2010). Recent studies have further shown that the disappearance of endemic biota on Madagascar had significant cascading effects across the island's ecosystems and may allow us to predict which taxa and ecosystems are most at risk of extinction today (Federman et al., 2016; Kistler et al., 2015; Virah-Sawmy et al., 2015). Finally, paleoecological reconstructions have attempted to disentangle the relative contributions of climate and anthropogenic action associated with changes in landscape and biodiversity (Burney, 1993; Burns et al., 2016; Crowley et al., 2016; Douglass and Zinke, 2015; Virah-Sawmy et al., 2010).

Despite advances in our understanding of environmental change on Madagascar, the extinction question has overshadowed the need for more comprehensive investigations of past human-animal interactions on the island. Few archaeological projects have systematically analyzed faunal remains, documented in detail the range of taxa people exploited in the past, or described the roles animals played in the lifeways of ancient communities (see Rakotozafy and Goodman, 2005). The data presented in this paper are derived from the most detailed zooarchaeological study to-date of coastal villages in southwest Madagascar. Vertebrate assemblages from three proximal Late Holocene (ca. 1400 BP to ca. 50 BP) fishing villages (Antsaragnangy, Antsaragnaso and Andamotibe) located within the Velondriake Marine Protected Area (Fig. 1) are described using a combination of traditional morphological analyses and ancient DNA PCR-based bulk-bone metabarcoding (Grealy et al., 2016). Results are then contextualized within the backdrop of modern fisheries data. We examine the inter-site variation in exploited taxa observed at sites within a small geographical area, and attempt to discern the diversity of marine and terrestrial fauna exploited by ancient human communities on Madagascar.

2. Previous research in southwest Madagascar

In southwest Madagascar, prior to the Velondriake research presented here, zooarchaeological assemblages were only known from two areas, Rezoky/Asambalahy and Sarodrano. The sites of Rezoky and Asambalahy are located roughly 150 km inland and east of Velondriake, in a region today associated with the Bara pastoralists (Fig. 1). These sites are among the oldest known archaeological sites in Madagascar's interior, dating from ca. 700–400 BP, prior to the ascendancy of the Sakalava empire, from the mid-17th to early 19th centuries AD (Dewar and Wright, 1993; Vérin, 1971). The ancient inhabitants of Rezoky appear to have been cattle pastoralists as evidenced by large quantities of bovid remains collected during the site's excavation (Vérin, 1971). It is clear from the remains of wild endemic animals, including lemurs (Lemuriformes), carnivorans (*Cryptoprocta ferax*), and tenrecs (Tenrecidae), that wild taxa formed part of the staple diet. In addition to cattle and wild game, freshwater mollusks were said to have been a significant part of the diet at Rezoky (ibid), though limited information on mollusks is offered in the site report. The faunal component recovered from a

surface survey of Asambalahy, thought to be the younger of the two sites, is highly fragmented, but the range of taxa present was broadly similar to Rezoky suggesting a combination of cattle herding, hunting and gathering of freshwater mollusks. In addition to the taxa also seen at Rezoky, elephant bird eggshell remains were found at Asambalahy, and the original investigators believed they were contemporary with the site's occupation (ibid). Finally, a limited number of bones of extinct hippopotamuses were identified subsequent to the original report (Rakotozafy and Goodman, 2005).

The lack of information regarding past human-environment interaction is particularly striking when considering ancient coastal communities: given that a considerable proportion of the island's population lives in coastal areas, we know little regarding the contributions of estuarine and marine fauna to past human subsistence (Douglass, 2016b). Until the present study, Sarodrano, a large sand bar peninsula located 20 km south of the city of Toliara, was the best-known coastal archaeological site in southwest Madagascar (Fig. 1). Sarodrano was surveyed in the 1970s and 1980s (Barret, 1985; Battistini, 1995; Battistini and Vérin, 1975; Razafimisa, 1984). A total of 15 archaeological sites—named SAR I through SAR XV—were recorded (Razafimisa, 1984). Limited conclusions about the subsistence economy of Sarodrano were drawn from the excavations at SAR III (Barret, 1985, 1991). The site was likely a seasonal fishing camp, with evidence of ceremonial feasting. Large amounts of fish and shellfish remains were collected, and a list of identified species was presented (Barret, 1991).

In sum, the information regarding past human-animal interactions in southwest Madagascar is limited, despite what we can glean from the work done at Rezoky/Asambalahy and Sarodrano. A significant gap remains between research into Madagascar's extinct fauna (primarily conducted at sites that act as taphonomic traps) and the cause of their disappearance, and research into the interactions between archaeological communities and animals conducted at archaeological sites.

3. Site description

3.1. The Velondriake Marine Protected Area

Velondriake is a region in southwest Madagascar encompassing thirty-two modern-day coastal communities (Fig. 1). Just over a decade ago, in collaboration with Blue Ventures Conservation, these communities formed an association for the sustainable management of fisheries and coastal resources (Harris, 2007). Velondriake was the first locally managed marine area (LMMA) of its kind on Madagascar and today serves as a model for other coastal fisheries throughout the western Indian Ocean (ibid.). Velondriake is home to diverse communities, made up of people who identify as Vezo fishers, Masikoro farmers and herders, and Mikea foragers (Astuti, 1995; Koechlin, 1975; Poyer and Kelly, 2000; Tucker, 2003). Though these subsistence-based identities suggest strict livelihood specializations, most groups in southwest Madagascar today practice a mixed economy (Yount et al., 2001). Oral histories indicate that Vezo, Masikoro and Mikea communities are descendent from the same agropastoral clans that migrated into the region beginning in the 17th century, and recent genetic research confirms this shared ancestry (Pierron et al., 2014, 2017; Tucker, 2003). Further archaeological, ethnohistorical and aDNA research is needed to clarify the identities of earlier inhabitants of the region.

The archaeological research presented here was conducted along approximately 20 km of the central Velondriake coastline (Fig. 2). This area lies on unconsolidated sands with alluvial and lake deposits to the east, and considerable mangrove swamps to the

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