Morphological Abnormalities in Archaiasine Foraminifers from the Florida Keys, USA

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Abstract

Historically, *Archaias angulatus* has been a major contributor to foraminiferal assemblages and sediments in coral-reef environments throughout the Caribbean and western North Atlantic. A variety of anomalous features were observed in the tests of *A. angulatus* individuals collected live from the Florida reef tract in 2004 and 2005. Six types of anomalies were documented using scanning electron microscopy: microborings, bacterial infection, pitted surfaces, dissolution, calcification abnormalities, and growth abnormalities. Calcification abnormalities included mineralogical projections, lacy crusts, and repair marks. These abnormalities were found among both juvenile and adult *A. angulatus*, and similar features were also found among *Cyclorbiculina compressa* and *Laevipeneroplis proteus* specimens collected live in the same samples.

Previous studies have documented the sensitivity of miliolid test morphology to environmental influences. These larger miliolid taxa tend to be quite eurytopic with respect to temperature, and the range of sites from which anomalous specimens were collected argues against local pollutants or variations in salinity or solar irradiance. Given the inherent solubility of their magnesian-calcite test mineralogy, we speculate that these foraminifers may be sensitive indicators of declining carbonate saturation in seawater, which results locally from increasing benthic respiration rates and globally from rising concentration of atmospheric CO2.

Introduction

Archaias angulatus (Fichtel and Moll) are symbiont-bearing porcelaneous foraminifers with planispiral involute tests covered with pseudopores (e.g., Fichtel and Moll, 1798). Historically, *Archaias angulatus* has been considered a major contributor to foraminiferal assemblages and sediments in coral-reef environments throughout the Caribbean and western North Atlantic, Florida Bay, Florida Keys, and the Florida-Bahamas carbonate province.

Cockey and others (1996) reported dramatic changes in the foraminiferal assemblages of the Florida reef tract over the past 50 years. Analyses of surface sediments revealed a shift from symbiont-bearing taxa, such as *Archaias angulatus*, to smaller detritus consuming taxa. Cottey and Hallock (1988) investigated post-mortem (taphonomic) surface degradation of *A. angulatus* specimens in sediment samples collected from Key Largo, Florida, and La Parguera, Puerto Rico, in the early and mid 1980s. Analysis of field samples revealed several different types of degradational features including dissolution, breakage, impact features, pitted surfaces, scratches and microborings. None of these characteristics are out of the ordinary for biological sedimentary constituents such a foraminiferal tests, since many biological, physical, chemical, and geological processes immediately begin to alter a test after the individual dies.

In a sample collected from New Found Harbor in the Florida Keys in May 2004, surface texture anomalies appeared to be unusually common among live *Archaias angulatus* individuals. Under light microscopy, many specimens of symbiont-bearing porcelaneous taxa, including also *Laevipeneroplis proteus* (Wiesner) and *Cyclorbiculina compressa* (d'Orbigny), appeared to have a rough, etched finish to their tests. Some of these individuals exhibited a range of physical abnormalities including rows of mangled-looking chambers, ragged suture lines, and complete test malformations.

The purpose of this paper is to document anomalous test-surface textures and morphological abnormalities in *A. angulatus* collected live along the Florida reef tract.

Materials and Methods

We examined samples collected from several sites and depths along the Florida reef tract: New Found Harbor (3 m water depth) behind Looe Key in May 2004, and Molasses Reef (15 m depth) off Key Largo and Tennessee Reef (10 and 30 m depth) off of Long Key in July 2005 (Fig. 1). Specimens were determined to be live when collected by their algal-symbiont coloration and the presence of rhizopodia. Juvenile and adult specimens were examined using light microscopy for any surface-texture or morphological abnormalities. Prior to examination using scanning electron microscopy (SEM), specimens were rinsed in deionized water and air dried on paleontological slides. They were mounted onto aluminum SEM stubs using double-sided adhesive tabs and sputter coated with gold-palladium (approximately 10 nm thickness) using a Hummer 6.2 Sputtering System. Samples were then examined using a Hitachi S-3500N scanning electron microscope.

Results

Normal *A. angulatus* possess clearly defined round pseudopores, crisp concentric suture lines, and smooth surface texture. However, Six basic types features were observed on live specimens: microborings, bacterial infestation, calcification (structural) anomalies, pitted surfaces, dissolution, and test deformation .

FIGURE 1

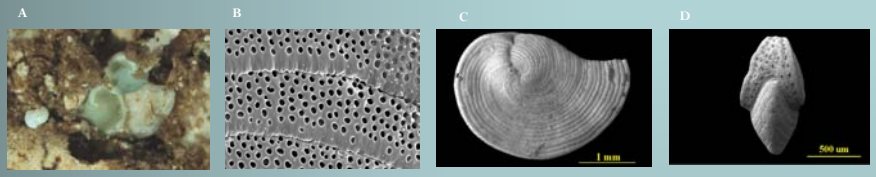

Figure 1. Normal specimens of *Archaias angulatus*; A) live individuals showing chlorophyte endosymbionts; B) close up of pseudopores and suture lines; C) SEM of normal adult; D) SEM of juvenile aperture

FIGURE 2

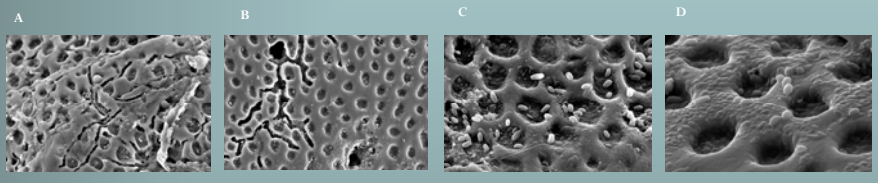

Figure 2. A) SEM of microborings on adult *A. angulatus* from New Found Harbor; B) SEM of microborings on *Cyclorbiculina compressa* adult from New Found Harbor; C) and D) SEMs of bacterial infection on *A. angulatus* from Tennessee Reef

FIGURE 3

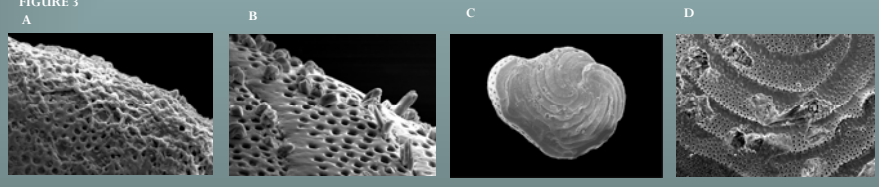

Figure 3. Structural anomalies included A) a lacy-looking crust on adult *A. angulatus* from Tennessee Reef and B) mineralogical projections on an adult from Tennessee Reef; C) SEM of a young adult *A. angulatus* with a pitted surface; D) SEM close up of pitted surface showing areas of repair

FIGURE 4

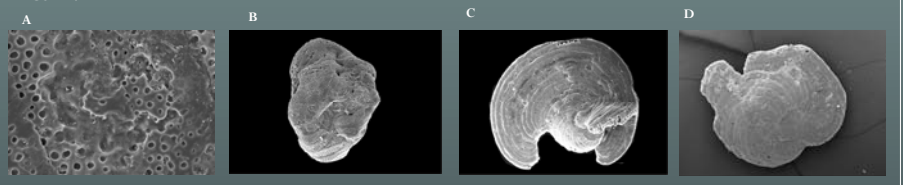

Figure 2. A) SEM of dissolution of an already pitted surface on an adult *A. angulatus* from Tennessee Reef; B) SEM of deformed juvenile *A. angulatus* from New Found Harbor; C) SEM of *Cyclorbiculina compressa* Siamese twins from New Found Harbor; D) SEM of a deformed *A. angulatus* from New Found Harbor

Conclusions

Deformed tests and calcification anomalies were observed in juvenile and adult *Archaias angulatus* and other miliolids with algal endosymbionts collected live along the Florida reef tract. Calcification anomalies included mineralogical projections and lacy crusts. Features typically considered taphonomic include microborings, pitted surfaces, bacterial infestation, and dissolution; evidence of test repair was also documented. Prevalence of such features may indicate that populations of these foraminifers are experiencing increasing environmental stress. These larger miliolids taxa tend to be eurytopic with respect to temperature and solar irradiance.

The range of sites from which these specimens were collected argues against local pollutants, variations in salinity, or solar irradiance as causal factors. Miliolid test morphology has previously been observed to be sensitive to environmental influences. Given the inherent solubility of their magnesian-calcite test mineralogy, these foraminifers may be among the most sensitive indicators of declining carbonate saturation in seawater, which results locally from increasing benthic respiration rates and globally from rising concentration of atmospheric CO_2.