# New Freshwater Molluscs from the Panamá Canal Miocene Cucaracha Formation and Paleoenvironmental Reconstruction Implications

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## Abstract

The Cucaracha Formation (early Miocene, 18.8 Ma (B. MacFadden, pers. comm., Oct. 2012)) of the Panama Canal Basin preserves a rare record of terrestrial neotropical paleoenvironments and is important in understanding the history of biotic interchange between North and South America in the geologic past. We describe a new assemblage of freshwater molluscs from the Cucaracha Fm., the paleoenvironment in which they were preserved, and potential paleobiogeographic implications. The mollusc assemblage consists of 1 taxon of freshwater mussels (Superfamily Unionoidae) and 4 taxa of freshwater gastropods (Superfamily Cerithioidea). Three of the gastropod taxa are tentatively assigned to the family Thiaridae. Observed sedimentological characteristics suggest the mollusc fauna was preserved in a small, high flow velocity fluvial system within a seasonally dry tropical forest. These sedimentological characteristics suggest the mollusc fauna was preserved in a small, high flow velocity fluvial system within a seasonally dry tropical forest. Prior to this study, the gastropod genera *Aylacostoma* and *Hemisinus* are only known from South American deposits during the Miocene and late Oligocene.

Stable Isotope Analyses are not yet completed but are underway at the University of Arizona.

## Geology

The Panama Canal Gaillard Cut is an extensive cut through central Panama trending southeast from Gatun Lake. The primary sedimentary rock units are fluvial and deltaic sandstones, and pedogenic paleosols (see figure 1). Most of these units are cross-cut by breccia pipes, and basaltic dikes and sills. As you can imagine, this has made the preservation of the shells obliquely compressed and making identification difficult, see figure 2.

The mollusc assemblage is preserved in the horizontally laminated litharenite component of an interbedded sandstone/organic rich mudstone horizon. Mudstone intraclasts within the sandstone are consistently oriented and occasionally imbricated. The interbedded sandstone/mudstone has an erosional lower contact with a well-developed red paleosol, which was previously interpreted as representing a dry forest soil. **These sedimentological characteristics suggest the mollusc fauna was preserved in a small, high flow velocity fluvial system within a seasonally dry tropical forest.**

Unit 19 is traceable along the Gaillard Cut as it follows the Pedro Miguel basalt flow, however the fossiliferous package of Unit 19 is locally known to only be at location STRI 630027.

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Figure 1. (Courtesy: Jeff Martin) Picture orientation is southwest. Cross-section of Unit 19 of Centenario site 3/7. Note: **imbricated** mussels and gastropods, **cross-bedded sandstone**, and also the sub-bituminous coal stringer. Scale (black bar) = 2.54 cm (1 inch). Strike and Dip of sedimentary unit is 308°, 55° SSW.

Figure 2. (Courtesy: Hector Zamora) Picture orientation is southeast along the western bank, towards Puente Centenario (the Centennial Bridge). This is the exposure of the mollusc bearing unit 19 (black unit) of the upper Cucaracha Formation. Bracket is approximate; maximum unit thickness is ~2.5 m.

## Stable Isotope Analysis

Bivalve mollusks growth increments contain a record of environmental conditions in the form of geochemical variation. Stable isotope profiles, in particular, can provide an archive of the seasonal $\delta^{18}O$ variation in surface waters. This seasonal cycles can be interpreted using the temperature-dependent oxygen-isotope fractionation between molluscan aragonite and water.

$$T°C = 20.6 - 4.34(\delta^{18}Oar - \delta^{18}Ow)$$

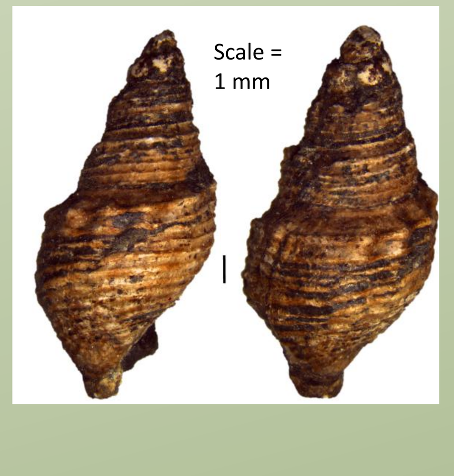
$$\delta^{18}Oar = PDB$$

$$\delta^{18}Ow = SMOW$$

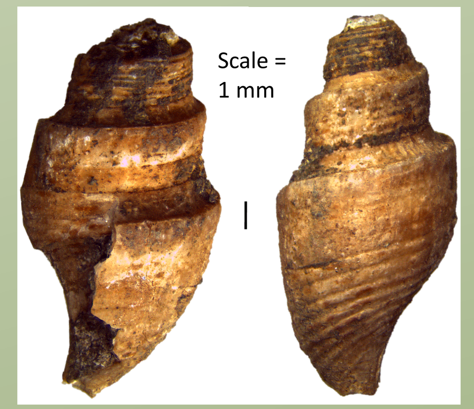
- Diagenesis is currently being assessed with staining methods to recognize the textural and compositional differences in the rock. Unaltered aragonite shells are needed for this study.
- Sections of bivalve shell are mounted on glass slides. Micromilling will be used to sequentially separate growth increments as thin as 20 µm across. This technique allows us to resolve annual cycles in thin shelled bivalves and to replicate maximum and minimum $\delta^{18}O$ values in our shells.
- Aragonite shell pretreatment include heating in vacuum at 200°C to remove volatiles without inverting aragonite to calcite. Carbonates will be analyzed on a Finnigan MAT 251 gas-ratio mass spectrometer coupled to a Kiel carbonate preparation device at the University of Arizona. This allows small samples to be analyzed (10 to 30 mg) with a standard precision of 0.08% for $\delta^{18}O$.

## Mollusc Morphology and Description

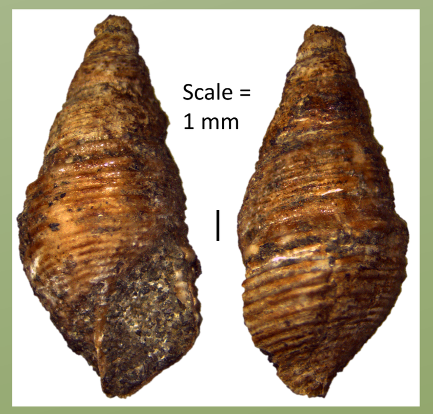

- Superfamily Unionoidae – (Bivalves) The mussels superficially resemble unionid bivalves, but until specimens are further prepared and muscle scars and dentition described, identification will be reserved.



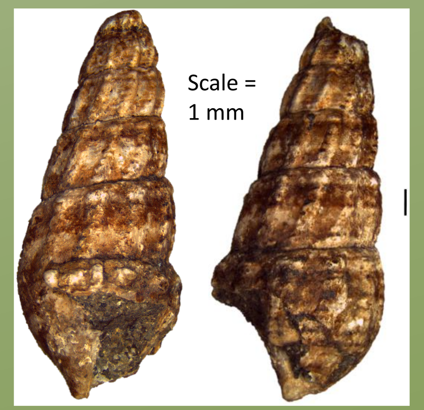

- Superfamily Cerithioidea; Family Thiaridae – (Snails) spindle-shaped gastropod shells, distinctive spiral ribs, an anteriorly truncated columella, and separate inner/outer lips of the aperture.
- cf. *Aylacostoma* sp. – Nodulose variety - based on a distinctive ornamented shoulder on later whorls. The shell overall is spirally ornamented, moderately shouldered cerithoid, with moderate spiral striae. Unfortunately, the aperture is too broken or absent on next to all specimens.
- Previously found in Pebas Formation, Amazonia, Peru, Miocene (18-9 Ma) (Wesselingh, 2006).




- cf. *Aylacostoma* sp. – Shouldered variety - based on a distinctive shoulder on later whorls. The shell overall is spirally ornamented, moderately shouldered cerithoid with fine spiral striae. Unfortunately, next to all specimen's apertures are too broken or absent to give a description.
- Previously found in Pebas Formation, Amazonia, Peru, Miocene (18-9 Ma) (Wesselingh, 2006).




- cf. *Hemisinus* sp. – Carinate variety- possesses slight, distinctive opisthocline axial ribbing, distinctive spiral ribs only on the last whorl, and connected inner/outer lips of the aperture. Overall, the shell has moderate spiral striae, with a very fine shoulder, with between five and seven whorls. Moreover, the specimen's apertures are too broken or absent to give a more detailed description.
- Previously found in Pebas Formation, Amazonia, Peru, Miocene (18-9 Ma) (Wesselingh, 2006).




- cf. *Jugo/Aylacostoma* – Auger variety – this last morphotype is small and possesses between six and nine whorls with distinctive, moderate opisthocline axial ribbing, with a slight shoulder. There are two possible identifications this taxon. According to Burch (1989), within Pleuroceridae, *Jugo plicifera* (extant) is "distributed west of the continental divide [of North America] along the drainages of the… Pacific slope." However, Parodiz (1969) has a similarly described taxon from South America belonging to Thiaridae, *Aylacostoma (Longiverena) waringi* or *A. (L.) mugrosana*. Frustratingly, up to date phylogenies are in flux for many gastropod groups.
- No previous paleoenvironment given. From the upper Oligocene of Colombia.

## Conclusions & Discussion

- Prior to this study, the gastropod genera *Aylacostoma* and *Hemisinus* are only known from South American deposits during the Miocene and late Oligocene. Our observations of the Cucaracha mollusc fauna provides evidence suggesting an **early dispersal event of freshwater invertebrates between South and Central America, well before the mammalian Great American Biotic Interchange.** Not only is the early dispersal an important addition to the scientific community, but so is the new reinterpretation of the paleoenvironment.
- **How did these freshwater snails get to Panama over the Pacific Ocean from Colombia 18.8 million years ago?**
  - Currently, there are no **birds** found in the Cucaracha Formation, thus making it difficult to assume dispersal via birds as seen today with snails, but it is still a hypothesis.
  - Perhaps **rafting** is an option, but the authors find it difficult to accept this. However, rafting should not be discredited.
  - A third option is **saltwater incursion** of the snails with the ability to return to the freshwater habitat (Wesselingh, 2006).
- The $\delta^{18}O$ of surface waters is primarily controlled by the $\delta^{18}O$ value of atmospheric precipitation in the catchment which roughly correlates with MAT. Seasonal $\delta^{18}O$ cycles can be expected if runoff is a primary recharge source.
- In warm low-altitude, low latitude environments, negative $\delta^{18}O$ values (SMOW) are unusual and only achieved by the amount effect and rain shadows.
- From previous studies, seasonal paleotemperature ranges for the Cucaracha Formation, determined from chemical analyses of paleosol Bt horizon (Unit 19), indicate mean annual temperatures of 15-16 $\pm$ 4.4 °C and mean annual precipitation of 296-1142 mm.
  - Precipitation and temperature estimates imply a rain shadow from a high (1400–4000 m) volcanic mountain range to the west.
- While the oxygen isotope analysis is currently in progress, several observations can be expected from the stable isotope profiles assuming the previous parameters:
  - **$\delta^{18}O$ values will tend towards negative values reflecting the rain shadow effect**
  - **A high volcanic mountain range will also drive profiles towards negative $\delta^{18}O$ values by contributing highly fractionated $\delta^{18}O$ depleted waters.**

References:

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Acknowledgements: I would like to thank NSF and the PCP-PIRE project for funding and support of this project including Bruce MacFadden, Jon Bloch, Aaron Wood, and Austin Hendy as well as the Smithsonian Tropical Research Institute, Carlos Jaramillo Lab for housing and a future well-established partnership with the University of Florida. I would also like to thank my fellow interns: Hector Zamora, Hannah Riegel, and Jason Carr for awesome times in the field. Also the Department of Geosciences at East Tennessee State University, especially Jim I. Mead for additional help in identification and support.

Go see: Hannah Riegel, *et al.* Paleoenvironments of the upper Cucaracha Formation (Early Miocene, Panama): Evidence from pedofacies and fluvial deposits. Poster 256.

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