Neoichnological Framework of Coastal Habitat Shifts Represented by Bahamian Decapod Burrows

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NEOICHNOLOGICAL FRAMEWORK OF COASTAL HABITAT SHIFTS REPRESENTED BY BAHAMIAN DECAPOD BURROWS

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Introduction: In coastal settings, the cumulative spatial and temporal impacts of burrowing, ichnofabric formation, and biodeposition by large crustaceans have been largely neglected at zoogeomorphic scales [1]. These traces also serve as important (paleo-)environmental and (paleo)hydrologic indicators, both vertical (tidal or groundwater level) and lateral (areal wetland or basin extent)[2-6]. To date, only few studies have addressed the comparative value of decapod ichnites generated by land crabs in carbonate settings [7,8]. The aim of this paper is to introduce a general conceptual framework for burrows created by three crab species in the Bahama Archipelago, using examples from San Salvador Island (Fig. 1).

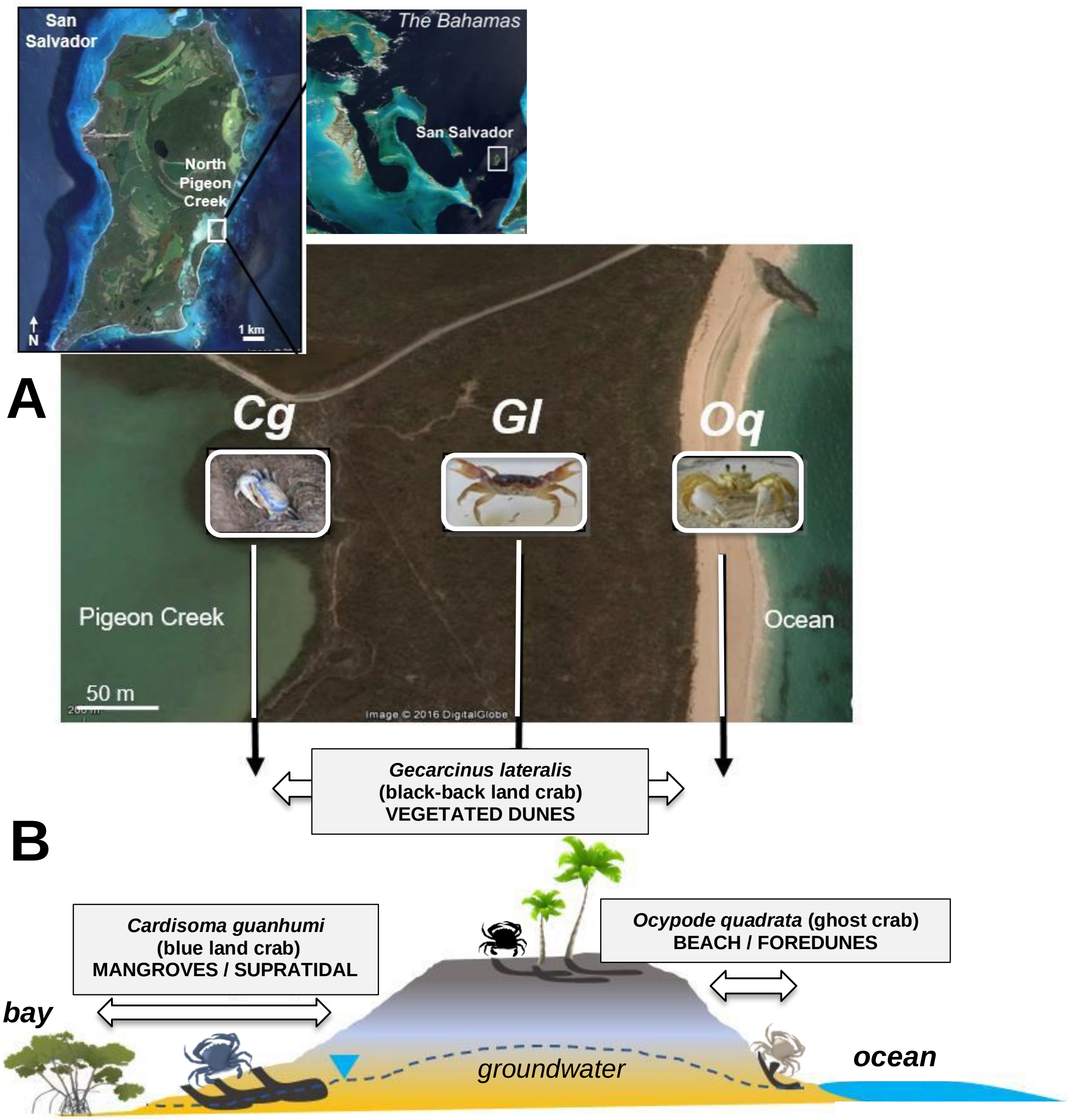

Figure 1. Study area location on San Salvador Island, Bahamas (insets at top) and land crab habitats: A) Photographs of three decapod species and their preferred biotopes in the Pigeon Creek area (see Fig. 1B for species acronym key); B) Schematic cross-section showing habitats, relative elevations, and general morphologies of decapod burrows.

Methodology: This work is based on neoichnological observations and measurements, photography, georadar images, and burrow casting. Since 2013, building on decades of research [3-6], the main effort was focused on San Salvador Island (Fig. 1A), with additional sites on Little Exuma and Eleuthera Islands.

Results and Summary: On most Bahamian Islands, three species of land crabs occupy distinct habitats: black-back land crab *(Gecarcinus lateralis; Gl)* prefers dunes, ghost crab *(Ocypode quadrata; Oc)* lives primarily along the beach, and the blue land crab *(Cardisoma guanhumi; Cg)* is closely connected with low-energy microtidal margins of lagoons and mangroves (Fig 1B). Recent research on San Salvador allowed detailed characterization of biotope boundaries represented by the respective biogenic structures, which increase in size from *Gl* to *Oc* to *Cg*, respectively. Applications of non-invasive remote sensing and subsurface imaging methods (e.g., georadar) aided in augmenting traditional field efforts that are often destructive in nature [8-10].

Assessment of burrow distribution and association (ichnocoenosis [5,6]) along insular habitats formed the basis for a simple conceptual model, with the three species as end members on a ternary diagram (Fig. 2). The benefit of such a framework is not only in its static comparative value, but also in a predictive "dynamic" context. For example, habitat shifts resulting from changes in water table, tidal inundation (e.g., related to sea-level changes), aeolian flux, or storm activity, can be all considered as forcings or perturbations leading to burrow overprinting. A recent intense storm (Hurricane Joaquin, 2015) provided sufficient sand on the upper beach for overtop deposition, with *Ocypode quadrata* invading the habitat otherwise dominated by *Gecarcinus lateralis* (Fig. 2; inset). Likewise, along low-energy margins, large supratidal burrow complexes of *Cardisoma guanhumi* may completely rework and mask the smaller burrows of other crustaceans, with a reverse trend predicting their move into intertidal habitats of *Uca speciosa* [3-8].

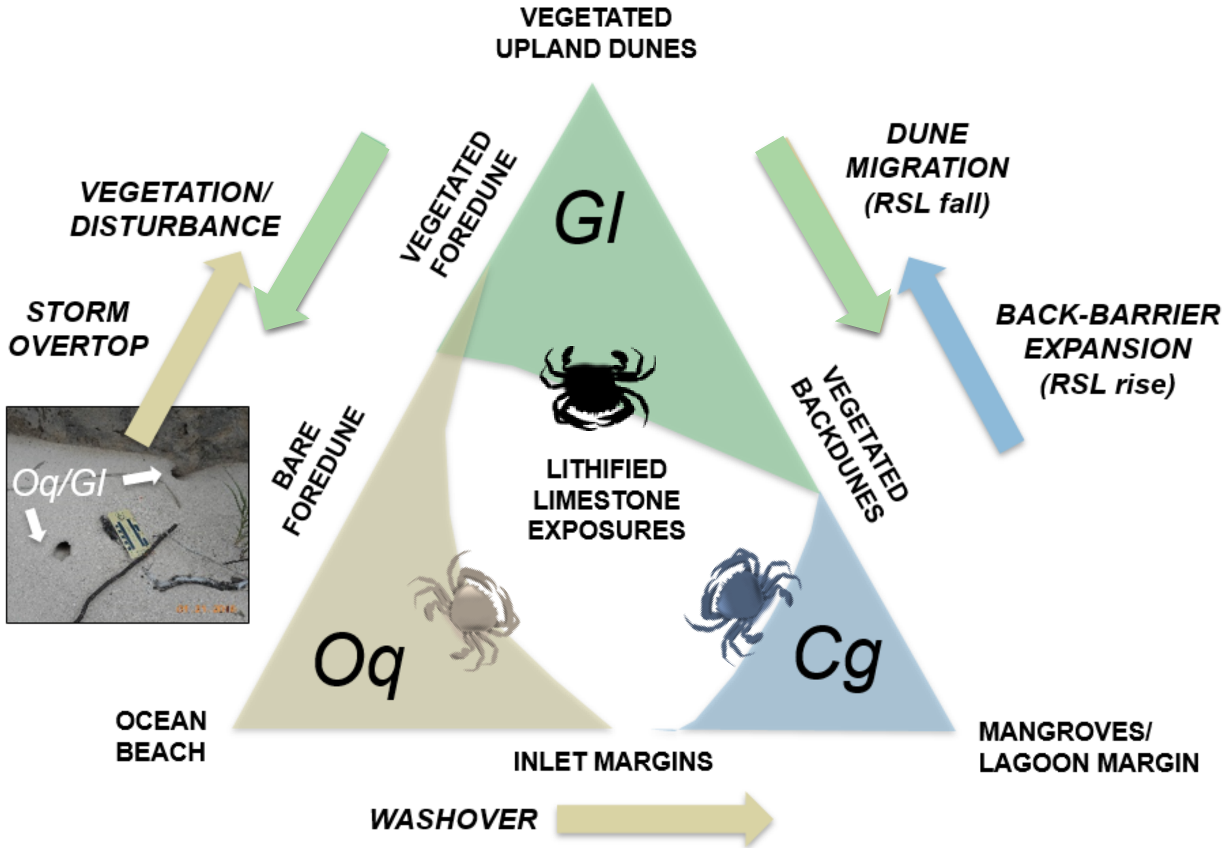

Figure 2. Conceptual model of three end-member habitats dominated by decapods with specific traces. Arrows show observed (post-Hurricane Joaquin, 2015) and predicted biotope shifts. These trends aid in forecasting ichnite overprinting, such as *Oq* in a *Gl* setting (photo inset). See Figure 1 for preferred decapod habitat distribution.

Our study demonstrates the importance of pervasive zoogenic structures as integral components of (paleo)landscape studies. Such framework should be of use to paleoichnologists, geomorphologists, petroleum geologists (reservoir porosity/permeability), soil scientists (paleosols), and ecologists [4-6, 10-12]. Combined with other indicators, decapod traces have the potential to enhance pale-environmental reconstruction and the predictive value of habitat shifts. Future efforts will include neoichnological field experiments to refine the proposed framework.

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