A Walk on the Beach

Haustoriid amphipods as indicators of beach disturbance

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"Haustoriids are perhaps the most interesting group of amphipods and so diversified that by necessity many genera have been illustrated herein."

~J. Laurens Barnard, 1969

As you near the intertidal zone, where the last gasps of wave energy exhaust themselves upon the fine sand beach, note the band of mottled sanderlings (*Calidris alba*). These petite wading birds descend on the moist sand left by the retreating tide, pecking furiously for benthic critters. As the tide returns, the sanderlings bolt to dry land so that only their thin black legs are washed by seawater. They wait on the water's edge where they regroup; they will return.

Sandy beaches around the world attract thousands of tourists each summer—striped umbrellas and brightly colored beach towels with caricatures of sea creatures dot the landscape. Small children build sand castles while older siblings exchange blows with a cream-colored volleyball.

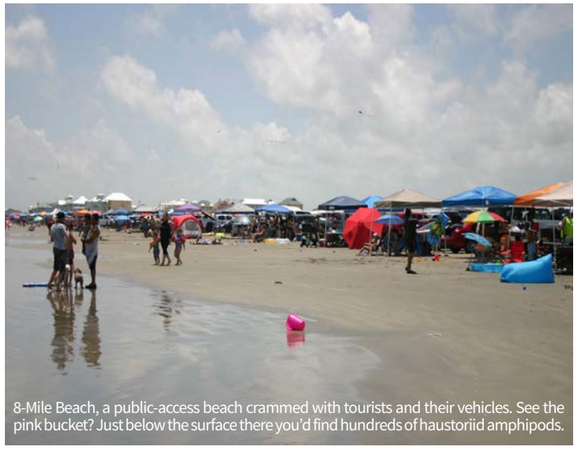
In Galveston, Texas, the occasional surfer can be seen attempting to ride the waves... and ending belly-flat on the board.

This increased foot traffic does not go unnoticed by shore residents. Schlacher et al. (2016) find that beach trampling by tourists can have an immense impact on beach-hoppers (Amphipoda) (~47% decrease in abundance). Black-bellied plover feed on these, and while the loss of these amphipods is negligible for adults, chicks scavenge for their own and are incapable of wandering far from the nest. If the shoreline near the nest is greatly disturbed by beach-goers, we could be looking at one unlucky chick.

Slivers of barrier islands line the Texas coast. South of Galveston, beyond Freeport and Port Aransas, is the Padre Island National Seashore. The park's website boasts that it has the "*longest stretch of undeveloped barrier island in the world*" (https://www.nps.gov/pais/index.htm). Indeed, about 70 miles of coastline are guarded from development.

Follow the main road beyond the visitor's center and you'll eventually find yourself on a beach highway clogged with RVs, trucks, campsites, and the occasional drunken crowd of tourists only mildly aware they're about to be struck by your vehicle. Traffic jams are common—someone is trying to turn around, backing into the dunes and slinging pillars of sand in wild puffs into the sweltering summer air—others are maneuvering around RVs parked just on the water's edge, partially sinking into the moist sand.

A view of the Galveston Seawall following beach replenishment program in March 2017. Before this, the ocean came right up to the wall. Photo credits: Janelle Goeke



8-Mile Beach, a public-access beach crammed with tourists and their vehicles. See the pink bucket? Just below the surface there you'd find hundreds of haustoriid amphipods.

This continues for 60 miles.

Numerous studies have addressed the impact of both on- and off-road vehicles on sandy beach health, most of which focused on the impacts on ghost crabs (*Ocypode* spp.) (Schlacher & Lucrezi 2010, Lucrezi *et al*. 2009). One exception examined effects on the coquina clam, *Donax deltoides* (Sheppard *et al*. 2009).

The impact studies mentioned for each of these disturbances—human trampling, vehicular traffic—use common shore animals to assess how these disturbances affect local biota. Each also argues for this idea in reverse; that is, that the abundances of these organisms can be used to predict the extent of disturbance. In this way, these critters are '***indicator species***.'

Specifically, indicator species are those that respond to certain ecosystem alterations in known ways. The most common of these for sandy beaches are ghost crabs. Schlacher *et al*. (2016b) performed a meta-analysis of all studies involving various *Ocypode* species as indicators of beach disturbance, ranging from trampling to off-road vehicles, replenishment, oil spills, and dune camping. Others (e.g. Ogden et al. 2014) have argued for shorebirds as indicators of coastal environmental health as they occupy a key role as macroinvertebrate predators.

Issues surrounding the use of shorebirds as indicators are obvious—they are difficult to physically assess without capturing, which may be forbidden for some endangered species. Ultimately, many studies (e.g. Schlacher et al. 2016a) resort to using the food source of the birds as proxies for population health. The ghost crabs, likewise, have their pitfalls as indicators, specifically on heavily trampled dunes. Lucrezi et al. (2009) discusses some of these short-comings, which include

Top: A ghost crab burrow at Port Aransas, TX.
Middle: Lateral view of an undescribed haustoriid amphipod from Jamaica Beach, TX.
Bottom: Dorsal view of the rostrum, antennae, and eyes of a haustoriiid collected at Padre Island National Seashore. The yellowish coloration behind the head is the sand that fills its digestive tract. Photo credits: Zach Hancock

The author sampling amphipods using a 435 micrometer sieve at Matagorda Beach, TX and Dr. Mary K. Wicksten releasing a Portuguese man-o-war (*Physalia physalis*), a common member of marine plankton.

the difficulty of fingering the casual impact factor of population differences.

Is it human trampling and beach recreation that have driven the crabs down-shore?

Or is it, instead, increased artificial light, such as from street lamps near seawalls, that have led them to migrate?

Since burrow-counts are proxies for crab numbers, this could lead to underestimating crab densities in two key ways:

(1) In areas that have been traversed, burrow-openings may be covered by sand, leading to an artificially reduced number.

(2) Ghost crabs readily enter old, abandoned burrows that may not be counted.

Back at the beach, those sanderlings have regrouped and are darting behind the retreating waves. In spastic, jerking motions they press their needle-like beaks into the wet sand—the same sand that is shifting and engulfing engulfing your bare feet.

What sustenance can be found in this unstable sediment?

At the wave's edge, there are effectively two players: spionid polychaetes, mostly *Scolelepis squamata*, and the burrowing amphipods of the family Haustoriidae.

The first is a hardy cosmopolitan species that is quite resistant to disturbance (Martínez *et al*. 2015). The latter, however, is susceptible to human trampling (Martínez *et al*. 2015) and vehicular traffic (Wicksten *et al*. 1987).

Additionally, haustoriids are impacted by oil spills (Sweet 1987), and populations decline following hurricanes (Croker 1968, Witmer 2011). They are easily collected with a shovel and sieve, allowing true counts of the organism instead of relying on burrows or nests. And yet, apart from the studies cited herein, haustoriids have received little attention for their potential roles as bioindicators.

For one, sand-burrowing amphipods on the Texas coast are small, less than 6 mm. They are transparent, with the only obvious coloration coming from their milky-white eyes and the sand that fills their digestive tract. Their small size is counterbalanced by the high density in which they occur in a square meter of sand (average reported by Grant 1980 was 1,111 individuals/m^2). Therefore, the two major factors crippling the usefulness of haustoriids as bioindicators are:

(1) Lack of awareness and
(2) Absence of a dichotomous key of Texas coast species

The former issue can be mitigated by promoting the unique ability of haustoriids to serve as a universal indicator of disturbance. Haustoriids are not hindered by the shortcomings of other bioindicators. For example, as burrowing species, artificial lights, such as from nearby streets or coastal infrastructure, have no appreciable effect on their distribution along the shore; they don't rely on the presence of dunes, and are thus useful for studying the effects of beach armoring (e.g., the Galveston Seawall). In addition, since they occur at the immediate land-sea interface, they are impacted by events offshore (such as oil spills, Sweet 1987).

Amphipods also lack a pelagic larval stage—the female brood their young through the first molt—which limits their ability for extensive migration. Furthermore, haustoriids are food sources for a variety of organisms, including shorebirds, cownose rays (*Rhinoptera bonasus*; Ajemian & Powers 2012), and various other fish (Croker 1967, Sameoto 1969).

The second issue is the most pressing. Witmer (2011) note that the absence of a key to Texas coast species hinders their usefulness in environmental assessment surveys. Sweet (1996) find that there may be as many as three undescribed genera in the Gulf of Mexico—no formal descriptions were ever published from this.

Past studies show that haustoriids vary in their zonation patterns, salinity and temperature tolerances, and reproductive seasonality (Sameoto 1969). For these reasons, formal taxonomic descriptions and a dichotomous key are critical to assess beach disturbance.

This task is being undertaken at Texas A&M University in the lab of Dr. Mary K. Wicksten. Using specimens collected by Witmer (2011), Collection of Marine Invertebrates at the Biodiversity Research and Teaching Collections (BRTC), and those I have collected over the past several months, I aim to fill in the taxonomic gap hindering haustoriids' usefulness in conservation biology. This will also facilitate future work on this relatively obscure but abundant family.

The issues illustrated above demonstrate the convergence of conservation and taxonomy. In recent years, there has been a dramatic shift away from classical descriptions; a move that has created the so-called 'taxonomic impediment' (Wheeler 2008, Bortolus 2008). And while advances in phylogenetics have reorganized taxonomic groupings, often no formal redescriptions are made (Padial & Riva 2007).

Sandy beaches are some of the most heavily impacted areas due to coastal development, which includes damming rivers that reduce the sediment flow to beaches resulting in erosion, tourism, oil spills from offshore platforms, and, ultimately, sea-level rise due to climate change.

To understand how we are affecting our planet, we need bioindicators that are accessible, numerically abundant, and form the base of the ecosystem in question. Haustoriid amphipods fill all three criteria.

Spare a final glance to the band of mottled sanderlings on the water's edge. Watch as they wiggle their little legs to disturb the burrowing amphipods, tricking them into revealing their location. How many thousands of years has natural selection worked molding this interaction? But the past is stone—unchanging, stoic. The past is guaranteed. The future of sandy beaches, and the fascinating creatures that live there, is not. ❐

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