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Carapace epibionts of loggerhead turtles (*Caretta caretta*) nesting at Canaveral National Seashore, Florida

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A survey of the epibionts inhabiting the carapace of loggerhead sea turtles *Caretta caretta* (Linnaeus) nesting on Canaveral National Seashore, Florida was conducted from 2003–2004. Epibionts were sampled and identified to the lowest taxonomic level possible. Eleven newly documented epibiont species were observed from 52 individual loggerheads. We present the first records of sea urchins as loggerhead epibionts. Data are presented on the behavioural, physical, and ecological characteristics of some of these newly documented species to understand better the relationship between loggerhead turtles and their epibiota.

Keywords: epibiont; loggerhead; sea turtle; *Caretta caretta*; nesting

Introduction

Loggerhead sea turtles (*Caretta caretta* (Linnaeus)) are known to host a variety of plants and animals as epibionts, particularly on the carapace region (Dodd 1988). Many of these epibionts attach to a variety of substrates in habitats where loggerheads spend time between nesting events or while foraging (i.e. free-living forms) (Frick et al. 2004). However, some epibiont species, particularly some barnacles, are obligate commensals and can only be found on sea turtles or other large, motile vertebrates (Newman and Ross 1976).

Of the extant sea turtle species, the epibionts of loggerhead turtles are the most frequently documented and studied. Moreover, the breadth of information that exists on loggerhead epibionts represents the most extensive documentation of epibiosis in any animal species. However, reports concerning the nature of the relationships that exist between loggerhead turtles and their epibiota are limited. Moreover, many regions where loggerheads occur have yet to be examined with respect to epibiosis.

The present study represents a survey of epibionts from nesting loggerheads at Canaveral National Seashore (CNS), an area for which loggerhead epibionts have not been examined since a study by Caine (1986) over two decades ago. The presentation by Caine (1986) did not distinguish the number and identities of epibiont samples collected at CNS from samples collected at other, widely-separated localities in Florida; therefore a more site-specific assessment was carried out. Our results include 11 records of previously undocumented epibiont species from sea

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turtles, including the first report of sea urchins (Echinodermata: Echinozoa) from loggerhead turtles. We report data on the behavioural, physical, and ecological characteristics of some of these newly documented species to understand better the relationship between loggerhead turtles and their epibiota.

Methods

During the loggerhead turtle nesting seasons (May–August) of 2003 and 2004, 52 turtles were surveyed for epibionts while nesting on CNS, Brevard County, Florida. Turtles were examined and sampled for conspicuous epibionts following Frick et al. (1998). Samples were then studied in the laboratory under light microscopy (magnification up to 1000 ×) for inconspicuous or hidden epibionts (cryptofauna). Samples were then sorted and identified to the lowest taxonomic level possible. The appropriate morphometrics for the newly documented epibiota were recorded in mm using Vernier calipers or a computer-interfaced stereomicroscope/micrometer. Within the following section, an asterisk (*) will be used to denote whether a species in question is a new record.

Results and discussion

Host turtles were an average of 98.7 cm long (curved carapace length; range=86.5–112 cm; SD ± 3.6; *n*=52). Thirty-four epibiotic species representing nine phyla were found, of which 11 were previously undocumented species from sea turtles (see Table 1). Most taxa we report are found in Brevard County as free-living forms and do not represent obligate relationships. Barnacles (*Chelonibia testudinaria* (Linnaeus) and *Chelonibia caretta* Spengler), red algae (*Polysiphonia carettia* Hollenberg) and robust tanaids (*Hexapleomera robusta* (Moore)) were the only obligate commensals encountered during our survey and all have been reported before from the southeastern United States (Frick et al. 1998). Because most taxa found on CNS loggerheads in the present study have already been documented as sea turtle epibionts, we will focus our discussion on the previously undocumented interactions.

Of the taxa observed, by far, the most surprising epibionts encountered were the sea urchins, *Arbacia punctulata* (Lamarck)* (*n*=4; test-diameter=32–42.3 mm) and *Lytechinus variegatus* (Lamarck)* (test-diameter=31.9 mm). Both species are common throughout the range of loggerheads in the southeastern United States, an area extensively studied with respect to the epibionts of *C. caretta*, however, neither species has ever been documented from sea turtles. Moreover, only one other study has documented echinoderms of the subphylum Echinozoa from sea turtles (Schärer 2001). The pencil urchin, *Eucidaris tribuloides* (Lamarck), was collected from a hawksbill turtle (*Eretmochelys imbricata* (Linnaeus)) in the waters near Mona Island, Puerto Rico. Similar to our results, Schärer's (2001) report of this echinozoan suggests that such associations are rare, as she surveyed 105 turtles (curved carapace length: range=20.4–85.1 cm) and only one hosted *E. tribuloides*. A spherical shape and long, suckered tube feet allow urchins to withstand the strenuous environment associated with wave-pounded areas and likely the turbulence associated with an epibiotic existence on a large motile vertebrate. Thus, if this type of interaction was common in the marine environment sea urchins would be found more often as epibionts of nesting turtles.

Table 1. Epibionts collected from nesting loggerhead sea turtles (*Caretta caretta*) at Canaveral National Seashore, Brevard County, Florida, 2003–2004 ($n=52$ turtles).

Epibiont species	Colloquial name	# turtles (%)
CNIDARIA		
Leptogorgia virgulata	sea whip coral	7 (13.5)
Obelia dichotoma	hydrozoan	10 (19.2)
*Ricordia florida**	Florida false coral	3 (5.7)
Tubularia crocea	wildflower hydoid	37 (71.2)
BRYOZOA		
*Bugula fulva**	yellow bush bryozoan	4 (7.7)
*Membranipora arborescens**	white crust bryozoan	17 (32.7)
Membranipora tenuis	white crust bryozoan	6 (11.5)
*Membranipora tuberculata**	white crust bryozoan	2 (3.8)
Schizoporella unicornis	orange crust bryozoan	11 (21.1)
*Thalamoporella floridana**	lettuce bryozoan	2 (3.8)
MOLLUSCA		
Anadara transversa	transverse ark	2 (3.8)
*Chicoreus pomum**	apple murex	1 (1.9)
Mitrella lunata	lunar dove snail	34 (65.4)
*Strombus alatus**	Florida fighting conch	2 (3.8)
*Strombus gigas**	queen conch	1 (1.9)
ANNELIDA		
Nereis falsa	polychaete worm	36 (69.2)
Podarke obscura	swift-footed polychaete	21 (40.4)
ECHINODERMATA		
*Arbacia punctulata**	purple sea urchin	4 (7.7)
*Lytechinus variegatus**	long-spined sea urchin	1 (1.9)
CRUSTACEA		
Balanus amphitrite	pink-striped acorn barnacle	39 (75)
Caprella andreae	skeleton shrimp amphipod	47 (90)
Caprella equilibra	skeleton shrimp amphipod	5 (9.6)
Caprella penantis	skeleton shrimp amphipod	17 (32.7)
Caprella scaura	skeleton shrimp amphipod	6 (11.5)
Chelonibia caretta	turtle barnacle	47 (90)
Chelonibia testudinaria	turtle barnacle	52 (100)
Conopea galeata	sea whip barnacle	2 (3.8)
Hexapleomera robusta	robust tanaid	52 (100)
Lepas pectinata	goose barnacle	29 (55.8)
CHORDATA		
*Molgula occidentalis**	sandy sea squirt	21 (40.4)
ALGAE		
Acetabularia crenulata	green algae	13 (25)
Chaetomorpha linum	green algae	27 (51.9)
Polysiphonia atlantica	red algae	31 (59.6)
Polysiphonia carettia	red algae	52 (100)

*Denotes epibiont species previously undocumented from sea turtles.

Both urchin species, in addition to juvenile conchs (*Strombus gigas* Linnaeus* & *Strombus alatus* (Gmelin)*) and lunar dove snails (*Mitrella* (=Astyris) *lunata* (Say)), were found to be associated with turtles hosting green algae (*Acetabularia crenulata* Lamouroux and *Chaetomorpha linum* (Müller)). The presence of the aforementioned organisms as epibionts of *C. caretta* is likely attributable to their propensity for gleaning algae from a variety of substrates. Gastropods from the genera *Costoanachis* and *Crepidula*, as well as *M. lunata*, have been documented from *C. caretta* in the Western Atlantic on several occasions (Frazier et al. 1985; Caine 1986; Frick et al. 1998; Pfaller et al. 2006), and appear to associate with turtles also hosting algae.

A single *S. gigas* (axis length=45 mm) and two solitary *S. alatus* (axis length=42.3 mm and 36.1 mm) represent the first epibiotic records of gastropods from the family Strombidae, known as the true conchs. *Strombus gigas* is the largest mollusk native to North America (up to 300 mm) and the northern extent of its range is south Florida (Meinkoth 1992), including the CNS region. Juveniles are known to settle in shallow, sub-tidal habitats and move to deeper areas as they increase in size (Stoner and Sandt 1992). Due to the small size and shape of the observed *S. gigas* (<108 mm), it is likely that the observed specimen represents a first-year individual after metamorphosis from the planktonic, veliger larval stage (Berg 1976). While the interaction appears to be rare, this spatial overlap between juvenile *S. gigas* and nesting *C. caretta* at CNS likely facilitated the observed epibiosis.

In contrast, the smaller *Strombus alatus* (up to 110 mm) extend further north into North Carolina and are known to remain in shallow water areas throughout life (Abbott 2001). Much like the aforementioned *S. gigas*, spatial overlap occurs between *S. alatus* and nesting *C. caretta*, however that *S. alatus* has not been reported from loggerheads north of CNS is surprising. Perhaps further observations of turtles from this region will reveal this uncommon form of epibiosis.

Of the 15 species of gastropod mollusks currently documented as *C. caretta* epibionts (Frazier et al. 1985; Caine 1986; Frick et al. 1998), including the aforementioned conchs, we report only the second account of a muricid (family Muricidae) snail from loggerhead turtles, the apple murex, *Chicoreus* (=*Phyllonotus*) *pomum* (Gmelin)*, (axis length=31.2 mm). The other muricid gastropod reported from *C. caretta*, *Thais haemastoma floridana* (Conrad) (Florida Rock Snail), was documented by Frazier et al. (1985) from Hutchinson Island, Florida. *Chicoreus pomum* and *T. haemostoma floridana* are typically shallow-water tropical and subtropical predators of snails, bivalves, and barnacles (Ruppert and Fox 1988). The presence of *C. pomum* as an epibiont of CNS loggerheads is likely attributable to the relatively high frequency of potential prey items also found as epibionts, such as *M. lunata* and several barnacle species. Another muricid, *Rapana venosa* (Valenciennes) (rapa whelk), has been documented from green turtles in the Atlantic. Immature green turtles (*Chelonia mydas* (Linnaeus)) incidentally captured in gillnets off the coast of Uruguay were found to host large *R. venosa* aggregations of up to 49 individual snails per turtle (Lezama et al. 2006).

Three individual turtles harboured colonies of Florida false coral, *Ricordia florida* Duchassaing and Michelotti*. In each case, colonies were found attached to the surface of the obligate barnacle, *Chelonibia caretta*, which, along with *C. testudinaria*, are common and conspicuous epibionts of sea turtles and apparently play a key role in the development of epibiotic communities (Rawson et al. 2003).

Similar associations were found between another anthozoan cnidarian *Astrangia danae* (Agassiz) (star coral) and several barnacle species (*C. testudinaria*, *Balanus trigonus* Darwin, and *Chthamalus fragilis* Darwin) from nesting loggerheads in Georgia, USA, where coral colonies were not affixed directly to the turtle carapace but instead to epibiotic barnacles (Frick et al. 2000a). Whether these cnidarians are able to attach directly to the carapace is unknown. Other non-anemone anthozoans have been documented from loggerheads (*Leptogorgia virgulata* (Lamarck) and *Porites porites* (Pallas)) (Caine 1986; Frick et al. 1998) but the respective attachment sites of these species were not addressed. In the present case, *L. virgulata* was found attached directly to the costal scutes of nesting turtles.

The association between *R. florida* exemplifies how epibiont data can be used to identify and corroborate patterns of turtle habitat use and movement. For example, *R. florida* is a prominent benthic cnidarian colonizing the hard substrata of the coral reefs of southern Florida, the Bahamas and the Caribbean (Humann and Deloach 2002). Because spatial overlap is required for epibiosis to occur, this interaction most likely reflects the region of pre-nesting foraging and/or breeding grounds for *C. caretta* in these more southerly areas—areas already documented to host CNS nesters during post-nesting periods (Meylan et al. 1983).

Several bryozoan species have been documented as epibionts of sea turtles. *Membranipora membranacea* (Linnaeus) (Hughes 1974) and *Bugula neritina* (Linnaeus) (Caine 1986) have been reported from loggerheads. Frazier et al. (1992) report bryozoans from three turtle species (*Lepidochelys olivacea* (Eschscholtz), *C. mydas* and *C. caretta*). More recent studies by Frick et al. (1998) (loggerheads) and by Schärer (2001) (hawksbills) have documented 12 additional epibiotic bryozoans. In both cases at least one bryozoan species was found to be common, occurring on up to 100% of loggerhead and 58% of hawksbills. While the costs of hosting bryozoans are most likely insignificant, the benefits of attaching to migratory turtles may provide vast dispersal opportunities for the bryozoans (Frazier et al. 1992).

We report four previously undocumented bryozoan species as sea turtle epibionts: *Bugula fulva* Ryland*, *Membranipora arborescens* (Canu and Bassler)*, *Membranipora tuberculata* (Bosc)*, and *Thalamoporella* (=*Schizoporella*) *floridana* (Osburn)*. The arborescent bryozoan *B. fulva* (yellow bush bryozoan) resembles the more commonly documented epibiont *B. neritina* in growth form but colonies are usually smaller (colony height herein: 2–3 cm) and appear yellow or yellow-brown instead of reddish-purple like *B. neritina* (Ruppert and Fox 1988). While colonies of *B. fulva* are known to inhabit reefs and limestone outcroppings (depth to 53 m) from North Carolina to Florida (Maturo 1957)—areas frequently used by several species of sea turtles—this interaction appears to be rare. Furthermore, because arborescent bryozoans (*B. neritina*, *Amathia distans* Busk, and *Anguinella palmata* van Beneden) are found commonly as epibionts of nesting loggerheads in Georgia, USA (Frick et al. 1998; Pfaller et al. 2006), the presence of *B. fulva* may be attributable to the lack of spatial competition from other arborescent bryozoans on CNS loggerheads.

Both newly documented species of white-crust bryozoans, *M. arborescens* and *M. tuberculata*, were found encrusting the surface of *C. testudinaria* barnacles. Similarly, Frick et al. (2004) found the orange-crust bryozoan *Schizoporella unicornis* (Johnston) encrusting the shell of a *C. testudinaria*; however, in this case the barnacle was dead. The propensity of *M. arborescens* to grow on hard substrates as free-living colonies reflects the observed preference of this species for the hard plates of epibiotic barnacles. Conversely, *M. tuberculata* typically encrusts the leaves of gulfweed, *Sargassum*, a relatively soft substrate by comparison. Our results suggest that *M. tuberculata* actually attaches to a wider variety of substrates than previously believed, and its distribution and occurrence is likely related to habitat type rather than host specificity.

Several *Membranipora* species, as well as the epipelagic bryozoan *Electra angulata* (Levinsen), have been documented as epibionts attached to the scales of sea snakes (Hydrophiidae) (Zann et al. 1975) and the shells of living *Nautilus* (Landman et al. 1987). In addition, a colony of *M. arborescens* was found encrusting the metal tag of a recaptured green turtle on the coast of Ecuador (Frazier et al. 1992). While associations between *Membranipora tenuis* Desor and *C. caretta* are extremely common in Georgia, USA, occurring on 100% of the turtles observed (Frick et al. 1998), the occurrence of other *Membranipora* species is less prevalent.

Two individual turtles were found to host colonies of lettuce bryozoans, *T. floridana*, growing as secondary epibionts attached to sections of *L. virgulata* (sea whip) where the coenchyme had been stripped off, presumably by grazing gastropods (*M. lunata*). Similarly, *L. virgulata* and the hydroid *Thyroscyphus ramosus* Allman are common hosts of free-living *T. floridana* in the western Atlantic (Winston 1995). Young colonies of *Thalamoporella* begin as crusts that superficially resemble *Membranipora* sp. As the colony grows, zooecia move away from the initial crust, erecting rosettes and frills composed of individuals and their exoskeletons (Ruppert and Fox 1988). Because of their fragility, the growth of these larger structures appear to be inhibited by the harsh conditions associated with colonizing the carapace of sea turtles, making this rare association difficult to distinguish from the more common *Membranipora* observations.

We also report the first observations of the solitary tunicate *Molgula occidentalis* Traustedt* (sandy sea squirt) from sea turtles. Aggregations of this tunicate were found to be relatively prevalent on CNS loggerheads, occurring on approximately 40% of the turtles. That *Molgula manhattensis* (DeKay) (common sea grape), the more prevalent tunicate found on Georgia and North Florida loggerheads, was not present as an epibiont of CNS loggerheads is not surprising, as its geographic range gives way at about central Florida to the southern species, *M. occidentalis* (Frazier et al. 1991).

Aggregations of *M. occidentalis* were found to accommodate two annelid species, *Podarke obscura* Verrill and *Nereis falsa* Quatrefages, where worms were found underneath colonies and in between individual tunicates. On additional occasions, *N. falsa* was found to be associated with sediments built up between clusters of *Chelonibia* barnacles. Colonization by barnacles, tunicates, and other aggregated, sessile epibionts (e.g., *Tubularia crocea*, and *Bugula* sp.) commonly creates favorable microhabitats for particular motile epibiota (e.g., worms, crabs, amphipods, and snails) (Frick et al. 2004). In addition, colonization in some epibiont communities has been shown to exhibit a successional pattern, in which colonization by barnacles is followed by hydrozoans and bryozoans, which subsequently enhanced the settlement of tunicates (Frick et al. 2000b). The prevalence of pioneer species like *C. testudinaria* and *C. caretta*, and intermediate successional species like *T. crocea* and *Membranipora* sp. likely supports the presence of *M. occidentalis* as an epibiont of CNS loggerheads. Thus, due to the apparent successional nature of epibiotic communities, studies that attempt to document the diversity of epibionts hosted by sea turtles should sample across the entire nesting season to prevent a successional bias in species occurrence and density.

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