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CARAPACE EPIBIONTS OF NESTING LOGGERHEAD SEA TURTLES: ATLANTIC COAST OF U.S.A.¹

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Abstract: A survey of carapace epibionts was conducted on nesting loggerhead turtles, *Caretta caretta* (L.), along a latitudinal gradient from South Carolina to Florida. The three-year survey on 138 turtles yielded 48 epibiotic species representing 6 phyla. Distribution of the epibionts on the carapace and factors that may influence the densities of the epibiont populations are discussed. Two distinct assemblages of carapace epibionts are recognized: a northern population and a southern population. The separation between the two populations is between Cape Canaveral and Daytona Beach, Florida. Indicator species within each carapace community are listed. Due to the nature of colonization by the epibionts, the presence of two distinct carapace communities suggests discrete northern and southern populations of loggerhead turtles along the Atlantic coast of the U.S.A.

Key words: *Caretta caretta caretta*; epibionts; turtle populations; carapace communities

INTRODUCTION

The major data bases for studying sea turtles rely upon: (1) small-scale observations of turtle behavior at sea, (2) observations, conservation efforts, and hatchery practices on nesting beaches, and (3) information from tag returns and distributional reports (Carr, 1980; Pritchard, 1980). Although significant contributions have been made over the last 40 years, large gaps remain in our basic understanding of sea turtle biology. Questions regarding the return of a female to the same nesting beach are being answered by re-nesting of tagged turtles, but questions about the turtle returning to the same feeding territory following nesting are dependent upon repeatedly capturing the turtle following each nesting episode. No information is available on a specific turtle repeatedly returning to the same feeding territory following nesting.

A potential tool for studying the movements of sea turtles is analysis of the carapace epibionts. Sessile carapace epibionts can only colonize the carapace when the ranges of the turtle and the epibiont overlap, so the territory of the turtle may be reflected in

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the carapace community. If turtle populations remain discrete in both their feeding and their nesting territories, then carapace epibionts could serve as indicators of separate turtle populations. Loggerhead turtles, *Caretta caretta caretta*, especially lend themselves to such analysis as they support extensive carapace communities (Pritchard *et al.*, 1982). Unfortunately, specific literature on carapace epibionts is scattered in taxon specific articles, and is largely hidden from turtle biologists. Reports that do focus on the turtles consist either of few specifics (e.g. Hubbs, 1977) or of generalized categories of epibionts (e.g. Pritchard *et al.*, 1982).

METHODS AND MATERIALS

Carapace epibionts of nesting loggerhead sea turtles, *C. caretta caretta* (L.), were sampled as the turtle was laying eggs and covering the nest. Samples were removed by scraping the carapace with a knife and placing the epibionts into 70% ethanol. Sampling for carapace epibionts was conducted in three different phases, corresponding to the 1982, 1983, and 1984 sampling periods. Samples collected in 1982 were taken from 41 turtles nesting on Pritchard's Island, South Carolina. Due to the high density of carapace epibionts, collections were restricted to a 10 × 10 cm square quadrat. For uniformity of sampling, the quadrat was confined to the posterior, right carapace quadrant. During the summer of 1983, 20 additional turtles were sampled on Pritchard's Island, using the same methods as for 1982.

Samples made in Florida were begun because of the relatively small number of turtles nesting in southern South Carolina. During six nights in June and July, 1983, 21 turtles were sampled on Hutchinson Island, Florida. Most Florida turtles had low epibiont densities (the first 17 turtles sampled in Florida yielded zero epibionts when sampling was restricted to a 10 × 10 cm sample area) so the entire carapace was scraped for the Florida samples.

The summer of 1984 was spent sampling carapace communities at five Florida locations: Hutchinson Island, Melbourne Beach, Cape Canaveral National Seashore, Flagler Beach, and South Ponte Vedra Beach (Fig. 1). The entire carapace community was collected for each of the 56 turtles sampled during the summer of 1984. Epibionts were sorted from the samples, counted, and identified.

A matrix was constructed consisting of epibiotic species and the locations where the epibiotic species were collected. The matrix was analyzed by cluster analysis to determine the homogeneity of the epibiotic communities along the latitudinal gradient.

The assemblages defined by cluster analysis were analyzed for species associations. Within each assemblage the occurrence on <20% of the turtles within the sample was used to define rare species and rare species were eliminated from further analysis. Epibiont data for the northern assemblage were tested for correlations of species co-occurrence using Spearman Rank Correlation analysis because the carapace community was only partially sampled on South Carolina turtles. Data on Florida carapace

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communities were compared using Stepwise Multiple Regression analysis because the entire carapace community was sampled.

RESULTS AND DISCUSSION

NESTING BEACHES

Beaches that were sampled differed in slope and in the depth of sand. Florida beaches south of Daytona Beach had a relatively steep slope which necessitated a crawl of 50-75 m for the female turtle. Sand extended below the depth of turtle nesting efforts. Due to the physical structure of the beach, nesting turtles typically were on the beach for <45 min during nesting.

Nesting beaches north of Daytona Beach had a relatively shallow slope which necessitated a crawl of 75-100 m by the female, and extended to >150 m in South

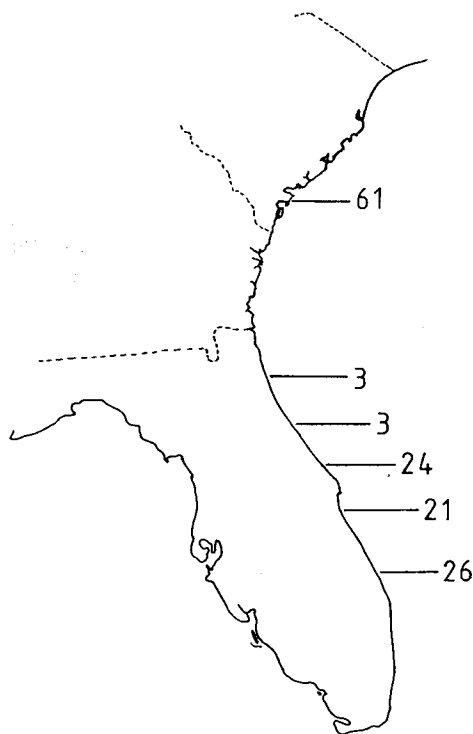


Fig. 1: Atlantic coast of the U.S.A. indicating the collection locations and number of turtles sampled in the survey: from north to south the locations are: (1) Pritchard's Island, South Carolina; (2) South Ponte Verde Beach, Florida; (3) Flagler Beach, Florida; (4) Cape Canaveral National Seashore, Florida; (5) Melbourne Beach, Florida; (6) Hutchinson Island, Florida; the separation between the northern and southern assemblages of carapace epibionts is between (3) Flagler Beach and (4) Cape Canaveral National Seashore.

Carolina. South Carolina beaches were eroding, and beach sand overlay an ancient coastal marsh so that a mud substratum could be encountered at depths > 25 cm. Turtles frequently abandoned a partially constructed nest site after encountering the mud, and crawled to another location on the beach where nesting again was attempted. Erosion of the historic dune line resulted in uprooted trees from within mature maritime forests, creating beach obstructions. Due to the length of the nesting crawl, beach obstructions, and frequent repeated attempts at nest construction, turtles nesting in South Carolina usually spent > 1.5 h on the beach, and two turtles were observed to spend > 3 h on the beach. Although some *Caprella andreae* were observed to have died during the prolonged beach exposure, samples yielded live specimens of each epibiont species that was collected. Thus, carapace epibiotic species collected in South Carolina had the ability to withstand the time of exposure if that female turtle nested in Florida. However, the converse of Florida epibionts being able to survive the prolonged nesting events characteristic of South Carolina beaches may not be true.

EPIBIONT OBSERVATIONS

Populations of sessile and motile epibionts were concentrated on the anteriormost margin and the posterior $1/3$ of the carapace. Barnacle distribution in the southern assemblage was limited to the mid-dorsal scutes, the scute lines of the remaining scutes, and the anterior margin of the carapace. Barnacle distribution included the posterior $1/3$ of the carapace in the northern assemblage. Turtles hosting the southern epibiotic assemblage had anterior-posterior oriented scratch marks on the carapace, which were absent among turtles hosting the northern epibiont assemblage. Turtles with such scratch marks did not have sessile epibionts within the scratched areas. The reasons for the scratch marks were not determined and removal of the sessile epibionts by scraping may have been a secondary effect of the turtle "wedging itself" under or bumping into coral or some other hard surface.

Turtles removed sand from the vicinity of the nest burrow by "flipping" the excavated sand anteriorly with the hind flippers. Sand was scattered in an anteriorly directed wedge pattern which overlapped the carapace. The resulting sand accumulation on the carapace was crescent shaped, covering the anterior $2/3$ of the carapace. Sand from each side, i.e. sand thrown forward by the rear flippers, converged to the carapace midline at approximately mid-carapace. Sand accumulations reached > 2 cm on some turtles, and may have affected the distribution of epibionts on the carapace.

Alternatively, the distribution of sessile epibionts may reflect the turtle's habit of placing the front flippers over the carapace while resting in the water. Patterns created either by sand displacement during nesting or by folding the front flippers would give the same distribution of epibionts. Distribution of epibionts on the carapace is similar in both male and female adult turtles (pers. obs.), and males do not undergo nest-covering behavior. Thus, distribution of carapace epibionts probably is the result of folding the flippers over the carapace.

TABLE I

List of species collected from the carapace epibiotic community of nesting loggerhead sea turtles: distinction between the northern and southern populations of turtles occurs between Cape Canaveral and Daytona Beach, Florida; data are the number of turtles upon which the epibiont was found with the percent occurrence within the respective assemblage in parentheses; number of turtles sampled: northern = 67; southern = 71.

Species	Northern No. (%)	Southern No. (%)
CNIDARIA		
Hydrozoa		
1 <i>Obelia dichotoma</i> (L.)	7 (10)	10 (14)
2 <i>Tubularia crocea</i> (L. Agassiz)	7 (10)	2 (3)
Anthozoa		
3 <i>Anemonia sargassiensis</i> Hargitt	3 (4)	0 (0)
4 <i>Anemone</i> sp.	0 (0)	4 (6)
5 <i>Leptogorgia virgulata</i> (Lamarck)	1 (1)	2 (3)
6 <i>Porites porites</i> (Pallas)	0 (0)	3 (4)
MOLLUSCA		
Gastropoda		
7 <i>Anomia simplex</i> Orbigny	0 (0)	3 (4)
8 <i>Crepidula fornicata</i> (L.)	2 (3)	0 (0)
9 <i>Crepidula plana</i> Say	10 (15)	3 (4)
10 <i>Mitrella lunata</i> (Say)	4 (6)	0 (0)
Bivalvia		
11 <i>Argopecten gibbus</i> (L.)	0 (0)	5 (7)
12 <i>Atrina</i> sp.	0 (0)	15 (21)
13 <i>Crassostrea virginica</i> (Gmelin)	3 (4)	0 (0)
14 <i>Gouldia cerina</i> (C.B. Adams)	4 (6)	8 (11)
15 <i>Ostrea equestris</i> Say	0 (0)	22 (31)
16 <i>Sphenia antillensis</i> Dall & Simpson	41 (61)	15 (21)
17 Bivalve 1	1 (1)	0 (0)
18 Mussel	2 (3)	0 (0)
ANNELIDA		
Errantia		
19 Polychaete 1	13 (19)	3 (4)
20 Polychaete 2	3 (4)	11 (15)
21 Polychaete 3	0 (0)	1 (1)
22 Polychaete 4	0 (0)	1 (1)
Sedentaria		
23 <i>Filograna vulgaris</i> Berkeley	9 (13)	5 (7)
24 <i>Sabellaria vulgaris</i> Verrill	16 (24)	1 (1)
25 <i>Serpula vermicularis</i> Marezeller	7 (10)	3 (4)
CRUSTACEA		
Cirripedia		
26 <i>Balanus amphitrite</i> Darwin	37 (55)	51 (72)
27 <i>Chelonibia caretta</i> (Spengler)	1 (1)	1 (1)
28 <i>Chelonibia testudinaria</i> (L.)	63 (94)	62 (87)
29 <i>Lepas anatifera</i> L.	5 (7)	18 (25)
Tanaidea		
30 <i>Zeuxo robustus</i> (H.F. Moore)	31 (46)	51 (72)

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TABLE I (continued)

Species	Northern No. (%)	Southern No. (%)
Amphipoda	65 (97)	68 (96)
31 <i>Caprella andreae</i> Mayer	1 (1)	0 (0)
32 <i>Caprella equilibra</i> Say	1 (1)	2 (3)
33 <i>Paracaprella tenuis</i> Mayer	9 (13)	21 (30)
34 <i>Ampithoe ramondi</i> Audouin	5 (7)	16 (23)
35 <i>Elasmopus rapax</i> (Smith)	0 (0)	23 (32)
36 <i>Erichthonius braziliensis</i> Dana	0 (0)	42 (59)
37 <i>Hyale</i> sp. 1	1 (1)	2 (3)
38 <i>Hyale</i> sp. 2	1 (1)	4 (6)
39 <i>Podocerus brasiliensis</i> (Dana)	1 (1)	58 (82)
40 <i>Podocerus cheloniae</i> Chevreaux	25 (37)	15 (21)
41 <i>Stenothoe minuta</i> Holmes	5 (7)	
Isopoda	2 (3)	0 (0)
42 <i>Sphaeroma quadridentatum</i> Say		
Brachyura	5 (7)	0 (0)
43 <i>Neopanope texana</i> (Stimpson)	0 (0)	2 (3)
44 <i>Pachygraspus</i> sp.	2 (3)	0 (0)
45 <i>Panopeus herbstii</i> H. Milne Edwards	1 (1)	1 (1)
46 <i>Planes minuta</i> (L.)		
BRYOZOA	0 (0)	1 (1)
47 <i>Bugula neritina</i> (L.)		
CHORDATA		
Urochordata	23 (34)	0 (0)
48 <i>Molgula manhattensis</i> (DeKay)		

Mating activities also have the potential to remove epibionts, especially from the female turtles. During mating, the male uses the single claw on the front flippers to grasp the anterior margin of the female's carapace and the plastron of the male rests on the posterior portions of the female's carapace (Ross Witham, pers. comm.). However, mating activities probably do not markedly affect carapace communities because: (1) male and female turtles have similar distributions of epibionts, (2) the majority of epibionts are concentrated on the posterior 1/3 of the carapace, which is within the region of contact between the plastron of the male and the carapace of the female, and (3) scutes of the turtle barnacle, *Chelonibia testudinaria*, are not rigidly held together so that depression from above only causes the barnacle to temporarily "flatten out".

EPIBIOTIC COMMUNITY

Forty-eight invertebrate species representing 6 phyla were found within the epibiont samples (Table I), with a range of 1-12 species occurring on any single turtle. I defined "common" species as species found on > 20% of the samples from each collection site and this criterion identified 17 common species (Table II) and 31 rare species. Cluster

TABLE II

List of carapace epibionts occurring on >20% of the turtles sampled within the northern and southern populations of nesting loggerheads (break point = Daytona Beach, Florida): numbers indicate the mean number of specimens collected per sample and the standard deviation; samples were restricted to a 10 x 10 cm carapace area for the northern samples but the entire carapace was scraped for epibionts in the Florida samples; an estimate of the population sizes of epibionts within the northern assemblage, in parentheses, was obtained by multiplying the sample data by 43; value obtained by planometric estimation from an overhead photograph of the sand-free area of the carapace of a nesting female, 103 cm carapace length.

Species	Southern	Northern
<i>Sabellaria vulgaris</i>		x 7.4 ± 3.1 (318)
Polychaete 1		4.5 ± 14.6 (194)
<i>Molgula manhattensis</i>	4.6 ± 18.1	4.6 ± 6.2 (198)
<i>Sphenia antillensis</i>	30.2 ± 59.1	9.3 ± 5.1 (400)
<i>Balanus amphitrite</i>	55.4 ± 97.8	38.1 ± 59.9 (1638)
<i>Chelonibia testudinaria</i>	15.4 ± 25.1	5.4 ± 16.0 (232)
<i>Zeuxo robustus</i>	491.9 ± 1096.0	527.2 ± 694.0 (22670)
<i>Caprella andreae</i>	228.6 ± 683.1	101.6 ± 532.9 (4369)
<i>Podocerus cheloniae</i>	1.0 ± 6.4	
<i>Atrina</i> sp.	1.8 ± 4.2	
<i>Ostrea equestris</i>	1.1 ± 4.7	
<i>Lepas anatifera</i>	2.5 ± 10.9	
<i>Ampithoe ramondi</i>	0.7 ± 2.8	
<i>Elasmopus rapax</i>	5.0 ± 29.9	
<i>Erichthonius braziliensis</i>	4.1 ± 7.6	
<i>Hyale</i> sp. 1	1.1 ± 6.6	
<i>Stenothoe minuta</i>		

remove epibionts, especially from the single claw on the front flippers to grasp and the plastron of the male rests on the Ross Witham, pers. comm.). However, affect carapace communities because: (1) the distribution of epibionts, (2) the majority of epibionts occur on the ventral surface of the carapace, which is within the carapace of the male and the carapace of the female, and (3) epibionts, such as *Chelonibia testudinaria*, are not rigidly held together so that the barnacle can temporarily "flatten out".

Using 6 phyla were found within the epibiont assemblages occurring on any single turtle. I defined 17 common species from each collection site (Table II) and 31 rare species. Cluster

analysis of the 17 common species distinguished a northern and a southern assemblage of carapace communities, with the region between Cape Canaveral National Seashore and Flagler Beach, i.e. the Daytona Beach area, as the separation zone. Analysis of each assemblage, as opposed to each collection site, yielded 9 common species for the northern assemblage and 14 common species for the southern assemblage (Table II). Six of the common species were found in both the northern and the southern assemblages, while three epibiotic species were uniquely common within the northern assemblage of carapace communities and eight epibiotic species uniquely common within the southern assemblage of carapace communities (Table II). Within the northern assemblage, at least one of the unique and common epibiotic species occurred on >64% of the turtles (43 of 67 turtles), and these species may be used as indicator species of the northern turtle assemblage. Similarly, in the southern assemblage, at least one of the unique and common epibiotic species occurred on >80% of the turtles (57 of 71 turtles), and these species may be used as indicator species of the southern turtle assemblage.

Using the indicator species as a reference, there is evidence of some turtle movement between the two turtle assemblages. Species designated as indicator species for the

northern assemblage occurred on three turtles in the southern assemblage (4.2% of the turtles in the southern assemblage) and species designated as indicator species for the southern assemblage occurred on nine turtles in the northern assemblage (13.4% of the turtles in the northern assemblage). If the amphipod, *Ampithoe ramondi*, is moved to the list of species common in both assemblages, even though *A. ramondi* only occurred on 13.4% of the turtles in the northern assemblage, then the seven remaining indicator epibiotic species still occur on > 80% of the turtles within the southern assemblage and the overlap with the northern assemblage is reduced to 7.5%.

Analysis of the rare species supports the probability of two identifiable carapace epibiotic assemblages. The coral specimens, *Porites porites*, collected within the southern turtle population are common within the Caribbean. Presence of a Caribbean coral indicates that the turtles, and the carapace epibionts, are of tropical origin. Within the northern assemblage of carapace epibionts, the anemone, *Anemonia sargassiensis* uses pelagic *Sargassum* of the Sargasso Sea as the primary habitat.

Variations in species occurrence between the two assemblages of carapace epibiotic communities indicate either that the turtles are normally resident in two different areas or that the epibionts have a high species turn-over as the turtles swim along the coast. The carapace community includes a number of long-lived and sessile organisms that are unlikely to be affected by short-term immigration and emigration. Occurrence of living barnacles (*Chelonibia*) > 2 cm diameter indicate a relatively long residence period. The presence of dead barnacle tests > 2 cm diameter which were fouled with algae and colonized by goose neck barnacles (*Lepas*) further suggest a slow turn-over rate for the sessile epibionts. Attachment probably lasts until the scutes of the turtle are abraded or shed. (Scutes are not shed as a single piece. Rather, small portions of the scutes "flake-off". Attachment of the turtle barnacle does not penetrate the epidermal layer of the turtle and, when a portion of the scute completely detaches from the carapace, barnacles attached to that piece are shed from the turtle; pers. obs.).

Analysis of the motile species within the epibiotic communities is more speculative than for the sessile species because motile species may immigrate into the carapace community at any stage of life. Some data from Pritchard's Island (South Carolina) indicate that the turn-over rates of motile epibiont species are low. Turtles nesting on Pritchard's Island were sampled from May through August (1982 and 1983). Turtles move into the waters adjacent to the nesting beaches prior to the onset of nesting and then remain in the vicinity throughout the nesting period. Date of nesting, therefore, is an indication of the time spent in the waters adjacent to the nesting beach. Female loggerhead turtles renest approximately every 2 wk during the nesting season so that the date of nesting also may be used as a gross indication of the number of nesting episodes that could have occurred, i.e. the turtle is out of the water and the carapace epibionts are exposed.

Only two of the common species within the northern assemblage of epibionts had negative correlations with date (*Podocerus cheloniae* and *Zeuxo robustus*), and these species were common to both northern and southern epibiont assemblages. The only

TABLE III

Regression correlation values for species pairs in the southern population of loggerhead sea turtles: refer to Table I for species number; only significant figures are listed.

	Algae	12	15	16	26	28	29	30	31	34	35	36	37	40
12	-	-												
15	-	-												
16	-	-	0.673											
26	-	-	-	0.230										
28	-	-	-	0.402	0.448									
29	-	-	-	-	-	-								
30	-	-	-	-	-	-	-							
31	0.231	-	0.460	0.721	-	0.266	-	-						
34	-	-	-	-	-	-	-	-	-					
35	-	-	-	-	-	-	-	-	-	0.349				
36	-	-	-	0.203	-	-	-	-	-	-	0.936			
37	-	-	-	-	-	-	-	-	-	0.423	0.266	-		
40	-	-	-	-	0.595	-	-	-	-	-	-	-	-	
41	-	-	-	-	0.218	-	-	-	-	-	-	-	0.518	-

TABLE IV

Spearman rank correlation values for species pairs of epibionts in the northern population of loggerhead sea turtles: refer to Table I for species numbers; only significant figures are given.

	Algae	16	19	24	26	28	30	31	40
16	-	-							
19	-	0.572							
24	-	0.189	-						
26	-	-	-	0.279					
28	-	-	-	-	0.478				
30	-	-	-	-	-	-			
31	-	-	-	-	-	-0.225	0.299		
40	-	-	-	-	-	-	-	-	
48	-	0.460	0.791	-	-	-	-	-	-

positive correlation of species occurrence with date was the xanthid crab, *Neopanope texana*. Of these three species, only *N. texana* has been reported from habitats other than the carapace epibiotic community and no species within the southern assemblage of epibionts had statistically significant correlations between occurrence and date.

The two conclusions from the above discussion are that (1) sessile species are long-term residents of the carapace community, and (2) turn-over among the motile species is low. Thus, emigration from and immigration into the carapace epibiotic

in the southern assemblage (4.2% of the species designated as indicator species for the northern assemblage (13.4% of the species). The amphipod, *Ampithoe ramondi*, is moved to the southern assemblage even though *A. ramondi* only occurred on the northern assemblage, then the seven remaining indicator species within the southern assemblage and reduced to 7.5%.

Probability of two identifiable carapace epibionts, *Porites porites*, collected within the southern population of the Caribbean. Presence of a Caribbean epibiont, are of tropical origin. Within the southern assemblage, the anemone, *Anemonia sargassensis* is the primary habitat.

The two assemblages of carapace epibiotic communities: normally resident in two different areas over as the turtles swim along the coast. Long-lived and sessile organisms that are common and emigration. Occurrence of living to a relatively long residence period. The epibionts which were fouled with algae and other suggest a slow turn-over rate for the epibionts until the scutes of the turtle are abraded or shed. Rather, small portions of the scutes does not penetrate the epidermal layer of the carapace, completely detaches from the carapace, and remains on the turtle; pers. obs.).

Epibiotic communities is more speculative. Species may immigrate into the carapace from Pritchard's Island (South Carolina) and other areas. Epibiont species are low. Turtles nesting on the southern beaches through August (1982 and 1983). Turtles nesting on the southern beaches prior to the onset of nesting and during the nesting period. Date of nesting, therefore, is related to the nesting beach. Female turtles nest for 2 wk during the nesting season so that the indication of the number of nesting episodes is related to the water and the carapace epibionts.

The northern assemblage of epibionts had *Chelonia* and *Zeuxo robustus*, and these species are common in the southern epibiont assemblages. The only

community is not occurring in a uniform or a continuous pattern. It is not clear if either the epibionts are colonizing in a random pattern, so that no correlations between epibiont population sizes and date are evident, or epibionts are colonizing at sites other than the nesting beaches. Studies on fouling communities colonizing floating docks near the Pritchard's Island nesting beaches (Caine, in prep.) have not yielded the species found among the carapace epibionts, which lends credence to the latter possibility.

Meylan (1982) and Bjorndal (pers. comm.) believe that turtles nesting in Florida may migrate to the Caribbean during the non-nesting season, and that turtles from South Carolina and Georgia may remain in the coastal area or migrate to the Sargasso Sea. Meylan based her conclusion on tagging data. Therefore, the separation of turtle populations based upon differences in the carapace communities is supported by more traditional methods.

CARAPACE COMMUNITY ORGANIZATION

Species associations within the respective carapace communities indicate limited competition (Tables II, IV). The only negative association was between a caprellid amphipod (*Caprella andreae*) and the turtle barnacles (*Chelonibia testudinaria*) within the northern assemblage of carapace epibionts, while the remainder of the species pairs exhibit either no statistically significant relationship or positive relationships with the other species. *Caprella andreae* obtains food by scraping periphyton and encrusting material from the carapace, and newly settled barnacle spat may be removed as the amphipod feeds. From the Pritchard's Island samples, the only collection site in the northern population area with a large sampling, the correlation between *Caprella andreae* and barnacles < 3 mm was -0.295 . This figure becomes -0.225 when considering all samples and *Chelonibia testudinaria* of all sizes within the northern area. Barnacle spat may be gleaned from the carapace as the amphipod feeds when densities of both the barnacle spat and amphipods are high. These two species have a positive association with the southern assemblage when densities are low. No negative correlations were found among pairs of sessile carapace epibionts. Both barnacle species had their highest associations with the other, and both had positive associations with sessile worms and tunicates. Thus, the carapace epibiotic communities were not being structured by interspecific competition within the community itself.

Five possibilities, either singly or in combination, may be important in structuring the epibiotic communities: (1) the epibiotic community is transient with constant emigration and immigration by all species, so that the pattern of species abundances is a random time factor, (2) stress due to desiccation during the nesting activities reduces populations below the carrying capacity of the community so that competition is avoided, (3) the carapace grows and growth of the carapace coupled with the abrasion and "flaking-off" of portions of the scutes provide new patches of "open" carapace, thereby reducing competition, (4) lack of food for the epibionts, and (5) epibionts are removed by agents outside of the epibiotic community, e.g. fish predation, turtle burial during hibernation

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which would smother the epibionts, and scraping the carapace against hard objects.

The premise of rapid species turn-over was addressed in the previous section and rejected. The possible influence of desiccation in limiting population sizes is questionable because turtles experience maximum exposure when nesting on the South Carolina beaches. These locations correspond to the location with maximum epibiont densities. The opposite pattern should be expected if desiccation caused by exposure during nesting activities reduced population sizes.

The third explanation, turtle growth and "flaking-off" of portions of the scutes may account for removal of some sessile organisms, resulting in open areas for epibiont colonization. Motile species, however, would have the opportunity to move as the portion of the scute gradually loosened prior to detaching.

Epibiont starvation is a real possibility for reduction in the epibiotic community. Tropical waters are notorious for low productivity and minimal detrital levels. The ultimate basis for the food web of the epibionts is filterable material in the water and periphyton growth on the carapace so absence of food may limit all epibionts. However, tropical rain forests and coral reefs have developed ways of maximizing the number of food pathways, thereby allowing these complex ecosystems to exist in the tropics. The occurrence of a diverse community of common and rare epibiotic species within the southern assemblage of turtles, rather than carapace communities dominated by few species, suggests either that food is not limiting within the community or that the energy flow within the epibiotic community follows diverse pathways.

The final explanation for the reduced densities of epibionts within the southern assemblage of turtles is that of epibiont removal by outside agents. This possibility has not been tested, but Limpus (1980) states that such removal is possible and turtles in aquaria have been observed to scratch themselves against submerged objects. Support for this hypothesis is generated through the presence of carapace scratch marks in the southern assemblage of turtles. Scraping the carapace may result from the turtle wedging itself between coral colonies, rather than an active process of epibiont removal. Similarly, burial in the mud by hibernating or secretive turtles would smother the epibionts. Motile epibionts may be gleaned by foraging fish, but this possibility has not been tested.

TWO TURTLE POPULATIONS

The discussion has focused on the epibionts, but the conclusions on the epibionts have a direct impact on the turtles. If the epibionts represent two distinct populations with minimum overlap, then the loggerhead turtle hosts must also represent separate populations. The presence of two populations of sea turtles requires a reappraisal of conservation practices and protective regulations, especially in regard to the lower number of nesting turtles within the northern population of turtles.

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REFERENCES

- CARR, A., 1980. Some problems of sea turtle ecology. *Am. Zool.*, Vol. 20, pp. 489-498.
- HUBBS, C.L., 1977. First record of mating of Ridley turtles in California, with notes on commensals, characters, and systematics. *Calif. Fish Game*, Vol. 63, pp. 263-267.
- LIMPUS, C.J., 1980. The green turtle, *Chelonia mydas* (L.). In, *Eastern Australia. Management of turtle resources. Vol. 1.* Research Monogr., Townsville, Australia. James Cook Univ., North Queensland, pp. 5-22.
- MEYLAN, A., 1982. Sea turtle migration - evidence from tag returns. In, *Biology and conservation of sea turtles*, edited by K. A. Bjorndal, Proc. World. Conf. Sea Turtle Conserv., Smithsonian Inst. Press, Washington D.C., pp. 91-100.
- PRITCHARD, P.H.C., 1980. The conservation of sea turtles: practices and problems. *Am. Zool.*, Vol. 20, pp. 609-617.
- PRITCHARD, P.H.C., P. R. BACON, F.H. BERRY, J. FLEETMEYER, A.F. CARR, R.M. GALLAGHER, R.R. LANKFORD, R. MARQUEZ, L.H. OGREN, W.G. PRINGLE, H.M. REICHART & R. WITHAM, 1982. Sea turtle manual of research and conservation techniques. *Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions*. San Jose, Costa Rica, 95 pp.