JMBA2 - Biodiversity Records

Published on-line

Distribution patterns of epibionts on the carapace of loggerhead turtles, *Caretta caretta*

Joseph B. Pfaller*, Karen A. Bjorndal*‡, Kimberly J. Reich*, Kristina L. Williams†
and Michael G. Frick†

*Archie Carr Center for Sea Turtle Research and Department of Zoology, University of Florida, Gainesville, Florida 32611, USA.
†Caretta Research Project, PO Box 9841, Savannah, Georgia 31412, USA. ‡Corresponding author, e-mail: kab@zoology.ufl.edu

The spatial distribution of epibionts on carapaces of marine turtles may be influenced by variation in recruitment dynamics, water flow patterns, and levels of disturbance on different regions of the carapace. We determined the distribution of 18 taxa of epibionts among nine zones on the carapace of 18 nesting loggerhead turtles (*Caretta caretta*) on Wassaw Island, Georgia, USA. Frequency of occurrence (%F) of all epibionts and each taxonomic class was determined for each zone. Distribution patterns were compared with a uniform distribution, and the distribution of each taxonomic class was compared with that of all epibionts combined. The distribution of all epibionts was significantly different from a uniform distribution, with highest densities on the posterior and vertebral zones. Distributions of each class, except Malacostraca and Cirripedia, were not significantly different from a uniform distribution across the carapace. Malacostraca was most dense on the posterior zones, whereas Cirripedia was most dense in the vertebral zones. Distributions of individual classes were all significantly different from the distribution of all epibionts combined. The distribution of all epibionts was strongly influenced by the distributions of the two dominant organisms, the chelonibiid barnacles and the caprellid amphipods.

INTRODUCTION

One of the roles of marine turtles in marine ecosystems is to provide substrate for diverse communities of epibionts, primarily on the carapace (Bjorndal, 2003). Although all species of marine turtles host epibionts, these mobile communities apparently reach highest diversity on loggerheads (*Caretta caretta*); loggerheads nesting in Georgia, USA, host over 100 species of epibionts from a wide range of taxa (Frick et al., 1998, 2004a). Several studies have addressed species composition of epibiont communities (e.g. Frazier et al., 1985, 1991, 1992; Caine, 1986).

Few studies have evaluated interactions between epibionts and host turtles and interactions among epibionts. Most relationships are apparently facultative associations (Wahl, 1989), but associations approaching obligate status have been reported for some barnacles (Ross & Newman, 1967; Monroe & Limpus, 1979). Epibionts on turtles may benefit from increased survival, foraging, and dispersal compared with those on inanimate flotsam (Dellinger et al., 1997; Rawson et al., 2003; Frick et al., 2004b). The effects of epibionts on marine turtles are poorly understood. A few, including burrowing barnacles (order Acrothoracica), are clearly negative. The epibiotic Columbus crab, *Planes minutus*, may benefit turtles by cleaning the carapace of other epibionts (Davenport, 1994; Frick et al., 2004b). Potential negative effects, such as increased drag (Logan & Morreale, 1994), or benefits, such as cryptic protection from predators (Frazier et al., 1991), need to be evaluated.

The carapace of a sea turtle may not represent a surface of uniform quality to epibionts. Initial recruitment to regions of the shell may be affected by differential water flow patterns over the shell. Differential persistence of epibionts among regions of the carapace could result from different probabilities of desiccation, food accessibility, and abrasion from contact with turtle flippers or hard objects. We are aware of only one study that has statistically evaluated differential distribution of epibionts on sea turtles. Matsuura & Nakamura (1993) found that the distribution of the barnacle *Chelonibia testudinaria* on loggerheads nesting in south-west Japan was significantly non-uniform. In addition, several studies have noted apparent differential distributions of epibionts without statistical evaluation (e.g. Caine, 1986; Gramentz, 1988; Frick et al., 1998; Schärer, 2001).

In this study, we quantified the distribution of epibionts on the carapaces of 18 of the 20 loggerheads that nested in 2004 on Wassaw Island, Georgia, USA. We evaluate whether the distribution of epibionts was uniform over the carapace. If the distribution of epibionts is affected by the factors described above, distribution should not be uniform across the carapace. We also compared the distribution of each class of epibionts against the distribution of all epibionts combined. If the above factors affect different organisms differently, their distributions should vary as well.

MATERIALS AND METHODS

Wassaw Island (31°53.4'N 80°58.4'W) is part of the Wassaw Island Wildlife Refuge on the coast of Georgia, USA. The beach on Wassaw Island is ~14 km long and is monitored for turtle nesting activity each year from May through August. Data on loggerhead epibionts were collected during the 2004 season from 18 of the 20 female turtles that crawled onto the nesting beach. A template that divided the carapace into nine zones was used to map epibionts, and frequency (%F) of epibionts was determined for each zone. If an epibiont bridged two zones, it was assigned to the zone with >50% of the area of the epibiont. The nine zones (Figure 1A) were designed to have approximately equal area and to represent regions that would experience different water flow patterns and probabilities of desiccation and abrasion. Epibionts were grouped into taxonomic classes for distribution analyses.

Frequency data were analysed as binomial data (presence/absence in each template zone). We used the proportions parameters test (S-PLUS software, v. 6.1) to compare the distributions of all epibionts combined and distributions of each class against a uniform distribution, and the distributions of each class against the distribution of all epibionts combined. The proportions parameters test uses a Pearson's chi-squared statistic to assess whether two or more samples have the same proportion parameter.

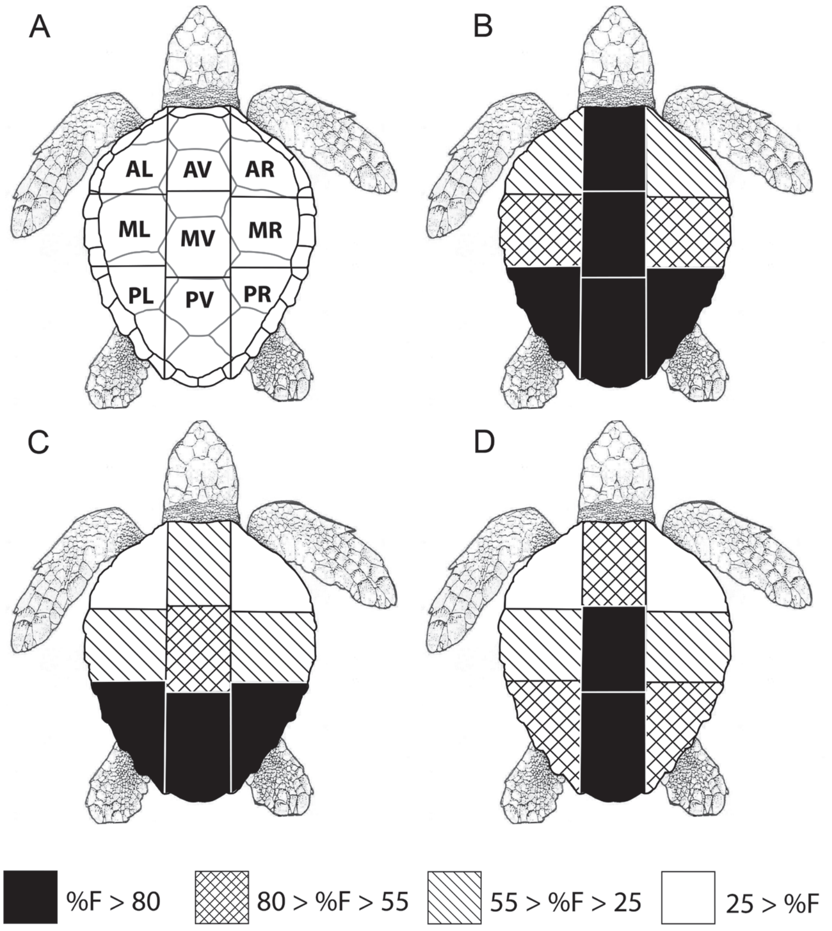

Figure 1. Distribution of epibionts in nine zones of equal size on the carapace of 18 nesting *Caretta caretta*. (A) Template of the nine zones (AL, Anterior Left; AV, Anterior Vertebral; AR, Anterior Right; ML, Middle Left; MV, Middle Vertebral; MR, Middle Right; PL, Posterior Left; PV, Posterior Vertebral; PR, Posterior Right); (B) frequency of occurrence (%F) of all epibionts combined; (C) %F of class Malacostraca; (D) %F of class Cirripedia.

RESULTS AND DISCUSSION

Eighteen genera of epibionts in nine classes were identified (Table 1). The only epibionts not previously recorded from sea turtles are *Caprella scaura* and *Pteria colymbus*. The single occurrence of *Cliona celata* (Class Demospongiae) was not included in analyses of distribution. The distribution of all epibionts (Figure 1B) was significantly different from a uniform distribution among the nine zones of the carapace (proportions parameters test, $P<0.001$, Table 1) with highest densities on the posterior and vertebral zones. Distributions of each class, except Malacostraca (Figure 1C) and Cirripedia (Figure 1D), were not significantly different from a uniform distribution (proportions parameters tests, Table 1). The distributions of each class were all significantly different from the distribution of all epibionts combined (proportions parameters tests, Table 1), and the distributions of class Malacostraca and class Cirripedia were significantly different from each other (proportions parameters test, $P<0.001$).

The significant non-uniform distribution of all epibionts in this study indicates that the surface of the sea turtle carapace is not of uniform quality for epibionts. The distribution of all epibionts was strongly influenced by the distributions of the two dominant organisms, the chelonibiid barnacles and the caprellid amphipods. The greater densities in the posterior and vertebral regions is a combination of the posterior amphipod distribution and the vertebral barnacle distribution. Similar to our results, Matsuura & Nakamura (1993) reported a significantly greater density of the turtle barnacle, *Chelonibia testudinaria*, in the vertebral zones compared to the lateral zones on 118 loggerheads nesting in south-west Japan. Our results are also consistent with the apparent non-uniform distribution of epibionts reported in other studies (Caine, 1986; Gramentz, 1988; Frick et al., 1998; Schärer, 2001).

Whether the differential distribution of epibionts over the carapace surface is a result of differential recruitment to regions of the carapace, differential survival in these regions, or a combination of the two, is still to be determined. The dynamics of recruitment and survival of epibionts are affected by a complex set of interactions. Factors that almost certainly play a role include water flow patterns over the carapace, turtle behaviour patterns, interactions among epibionts (e.g. predation, competition), and variation in tolerance of epibionts to desiccation and physical trauma.

Table 1. *Frequency of occurrence (%F) of epibionts on 18 nesting* Caretta caretta *from Wassaw Island, Georgia, USA. Uniform is the* P *value for comparison of the distribution of the class against a uniform distribution; all Epibionts is the* P *value for the comparison against the distribution of all epibionts (proportions parameters tests). Significant values are in bold font.*

Epibiotic Class – Taxon	% F	Uniform	All Epibionts
All epibionts	100%	<**0.001**	–
Class Hydrozoa		0.8053	<**0.001**
Tubularia crocea	33.3%		
Halacordyle disticha	11.1%		
Class Gastropoda		0.2352	<**0.001**
Crepidula fornicata, C. plana	22.2%		
Costoanachis avara	5.6%		
Class Bivalvia		0.2837	<**0.001**
Pteria colymbus	5.6%		
Ostrea equestris	11.1%		
Class Polychaeta		0.1181	<**0.001**
Nereis falsa	11.1%		
Sabellaria floridensis, S. vulgaris	16.7%		
Class Cirripedia		<**0.001**	<**0.001**
Chelonibia testudinaria and *C. caretta*	94.4%		
Balanus amphitrite	22.2%		
Lepas pectinata	11.1%		
Class Malacostraca		<**0.001**	<**0.001**
Capella andreae, C. equilibra, C. penantis, C. scaura	88.9%		
Podocerus chelonophilus	16.7%		
Hexopleomera robusta	5.6%		
Class Cheilostomata		0.5867	<**0.001**
Bugula neritina	27.8%		
Membranipora tenuis	11.1%		
Class Ascidiacea		0.1181	<**0.001**
Mogula manhattensis	22.2%		
Class Demospongiae			
*Cliona celata**	5.6%		

*, single occurrence within class was not included in analyses.

Carapace hydrodynamics probably affect epibiont distributions; differential drag and water flow patterns (Logan & Morreale, 1994) would create zones with different settlement and foraging conditions (Bjorndal, 2003). The very high rate of flow over the anterior region may deter settlement by epibionts and result in the lower densities observed in that region. Larvae of a barnacle (*Balanus improvisus*) did not settle on substrates exposed to high flow rates in an *in vitro* study and had reduced feeding rates when exposed to high flow rates (Larsson & Jonsson, 2006). Epibiont settlement may be higher on the posterior zones, as seen in this study, where flow rates are lower as seen by the settlement patterns of sediment and small particles (Schärer, 2001). Water flow patterns will also affect foraging success differentially among epibionts. Stationary filter feeders, such as barnacles, may be found in areas with moderate flow because of higher food availability, whereas motile grazers, such as caprellids, would not benefit from higher flow rates and were more common in the posterior region where flow is reduced. Although most classes had uniform distributions, not correlated with class Cirripedia, the presence of large barnacles, such as *Chelonibia testudinaria*, will alter water flow patterns resulting in micro-eddies, which may create additional favourable settlement sites for other species.

A number of turtle behaviours will also influence the distribution patterns of epibionts. Resting turtles often place their front flippers over zones AL, AR, ML and MR, which may impede colonization and contribute to the lower density of epibionts there. Physical trauma when the host turtle scrapes against hard surfaces or engages in mating behaviour will remove some epibionts, especially those not attached firmly to the substrate or protected by strong exoskeletons. Marine turtles sometimes float at the surface for extended periods with part of the carapace above water; during those periods, epibionts with low tolerance for desiccation will be differentially affected. Barnacles, with their resistance to abrasion and desiccation, are able to settle on the zones of the carapace (AV and MV) prone to these stresses but with the greatest water flow, allowing for maximum foraging potential.

The extent to which loggerheads actively attempt to remove epibionts is not known and is linked to the question of whether epibionts have negative, neutral, or positive effects on loggerheads. More research is needed to understand these symbiotic relationships and to explore the importance of marine turtles as hosts to these epibiotic communities. The role of sea turtles in maintaining biodiversity of epibionts depends upon the extent to which epibionts are endemic to sea turtles and whether sea turtles provide higher quality habitat for epibionts. Therefore, comparisons of productivity of epibionts on marine turtles and on inanimate flotsam would be particularly informative.

We thank the volunteer participants of the Caretta Research Project for their assistance, the Savannah Presbyterian Ecology Fund and Project AWARE Foundation for funding, Alan Bolten for his support, and Gustav Pauley for his help with taxonomic classifications. Research was conducted under Georgia Department of Natural Resources and United States Fish and Wildlife Service Special Use Permit (USFWS 41620-04021).

REFERENCES

Bjorndal, K.A., 2003. Roles of loggerhead sea turtles in marine ecosystems. In *Loggerhead sea turtles* (ed. A.B. Bolten and B.E. Witherington), pp. 235–254. Washington DC: Smithsonian Books.

Caine, E.A., 1986. Carapace epibionts of nesting loggerhead sea turtles: Atlantic coast of USA. *Journal of Experimental Marine Biology and Ecology*, **95**, 15–26.

Davenport, J., 1994. A cleaning association between the oceanic crab *Planes minutus* and the loggerhead sea turtle *Caretta caretta*. *Journal of the Marine Biological Association of the United Kingdom*, **74**, 735–737.

Dellinger, T., Davenport, J. & Wirtz, P., 1997. Comparisons of social structure of Columbus crabs living on loggerhead sea turtles and inanimate flotsam. *Journal of the Marine Biological Association of the United Kingdom*, **77**, 185–194.

Frazier, J., Goodbody, I. & Ruckdeschel, C.A., 1991. Epizoan communities on marine turtles. II. Tunicates. *Bulletin of Marine Science*, **48**, 763–765.

Frazier, J., Margaritoulis, D., Muldoon, K., Potter, C.W., Rosewater, J., Ruckdeschel, C. & Salas, S., 1985. Epizoan communities on marine turtles. I. Bivalve and gastropod mollusks. *Marine Ecology*, **6**, 127–140.

Frazier, J., Winston, J.E. & Ruckdeschel, C.A., 1992. Epizoan communities on marine turtles. III. Bryozoa. *Bulletin of Marine Science*, **51**, 1–8.

Frick, M., Williams, K. & Robinson, M., 1998. Epibionts associated with nesting loggerhead sea turtles (*Caretta caretta*) in Georgia. *Herpetological Review*, **29**, 211–214.

Frick, M.G., Williams, K.L., Markesteyn, E.J., Pfaller, J.B. & Frick, R.E., 2004a. New records and observations of epibionts from loggerhead sea turtles. *Southeastern Naturalist*, **3**, 613–620.

Frick, M.G., Williams, K.L., Bolten, A.B., Bjorndal, K.A. & Martins, H.R., 2004b. Diet and fecundity of Columbus crabs, *Planes minutus*, associated with oceanic-stage loggerhead sea turtles, *Caretta caretta*, and inanimate flotsam. *Journal of Crustacean Biology*, **24**, 350–355.

Gramentz, D., 1988. Prevalent epibiont sites on *Caretta caretta* in the Mediterranean Sea. II. *Naturalista Siciliano*, **12**, 33–46.

Larsson, A.I. & Jonsson, P.R., 2006. Barnacle larvae actively select flow environments supporting post-settlement growth and survival. *Ecology*, **87**, 1960–1966.

Logan, P. & Morreale, S.J., 1994. Hydrodynamic drag characteristics of juvenile *L. kempi*, *C. mydas*, and *C. caretta*. In *Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation* (ed. B.A. Schroeder and B.E. Witherington), pp. 248–252. NOAA Technical Memorandum NMFS-SEFSC-341.

Matsuura, I. & Nakamura, K., 1993. Attachment pattern of the turtle barnacle *Chelonibia testudinaria* on carapace of nesting loggerhead turtle *Caretta caretta*. *Nippon Suisan Gakkaishi*, **59**, 1803.

Monroe, R. & Limpus, C., 1979. Barnacles on turtles in Queensland waters with descriptions of three new species. *Memoirs of the Queensland Museum*, **19**, 197–223.

Rawson, P.D., MacNamee, R., Frick, M.G. & Williams, K.L., 2003. Phylogeography of the coronulid barnacle, *Chelonibia testudinaria*, from loggerhead sea turtles, *Caretta caretta*. *Molecular Ecology*, **12**, 2697–2706.

Ross, A. & Newman, W.A., 1967. Eocene Balanidae of Florida, including a new genus and species with a unique plan of "turtle barnacle" organization. *American Museum Novitates*, **2288**, 1–21.

Schärer, M.T., 2001. *A survey of the epibiota of hawksbill sea turtles (*Eretmochelys imbricata*) of Mona Island, Puerto Rico*. MSc thesis, University of Puerto Rico, Mayagüez, Puerto Rico.

Wahl, M., 1989. Marine epibiosis. I. Fouling and antifouling: some basic aspects. *Marine Ecology Progress Series*, **58**, 175–189.

Submitted 20 March 2006. Accepted 25 October 2006.

Published on-line