

EPIZOAN COMMUNITIES ON MARINE TURTLES. III. BRYOZOA

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ABSTRACT

Marine turtles commonly carry diverse and numerous forms of epizoa, but Bryozoa are rare. Only two previously published records could be found, and a wide-ranging survey of five species of turtles in all oceans produced only eight additional cases. All of the eight bryozoan species identified are typical of intertidal and subtidal inshore marine habitats. Remarkably, although a variety of epipelagic forms have been found on sea snakes and nautilus, none have been documented from marine turtles. On the whole, it appears that Bryozoa are not able to colonize these reptiles. As with other marine turtle epizoa, in general *Caretta caretta* seems to provide the most suitable substrate for colonization—no records of Bryozoa are known from either *Dermochelys coriacea* or *Eretmochelys imbricata*. Surface characteristics of the shell, as well as behavioral and ecological habits of the hosts, are likely to relate to the presence of these epizoa, but it is not known how. In addition to more detailed ecological studies of epizoic associations, the taxonomy and eco-morphological variation of Bryozoa need further attention.

Although a large variety of organisms is found affixed to turtles (families Cheiloniidae and Dermochelyidae) (Ernst and Barbour, 1972; Frazier et al., 1985; Caine, 1986; Gramentz, 1988; Mohanty-Hejamdi et al., 1989; Frazier et al., 1991), there is scant information about epizoic Bryozoa. Caldwell (1968) reported encrustations on juvenile loggerhead (*Caretta caretta*) turtles, but subsequent examination showed that not Bryozoa but hydrozoans were present (see below). Hughes (1974:11) recorded bryozoans on marine turtles in South Africa; although he did not give the species of turtle host, the encrustation was identified as *Membranipora membranacea*. Caine (1986) recorded *Bugula neritina* on a nesting *Caretta caretta* from central Florida.

The present note documents eight cases of epizoic Bryozoa involving three species of marine turtles from Indian, Atlantic, and Pacific oceans and a total of at least eight species of Bryozoa. These records derive from a sample that included thousands of marine turtles of five different pantropical species, as Frazier et al. (1985) described.

Because there are so few records of epizoic bryozoans on marine turtles, the present observations are examined in the light of factors which may be related to this association. Physical, ecological, and behavioral characteristics of the epizoa and the host are discussed, and the findings of studies on epizoic bryozoa on other kinds of turtles and marine organisms are compared.

OBSERVATIONS

For each of the eight cases discussed below, the catalogue number (AMNH = American Museum of Natural History; UF = University of Florida; USNM = National Museum of Natural History), and/or the collector's field number, is given when available. Curved carapace length (CCL) of the turtle host is given in cm when known, as is host species, date and locality. Because of the fragmentary nature of the bryozoan specimens, no reproductive data on them is reported.

Case 1.—On 3 February 1984 a female *Lepidochelys olivacea* (Eschscholtz) (JGF 4230; CCL = 65.5) was found dead on the massed nesting (or "arribada") beach

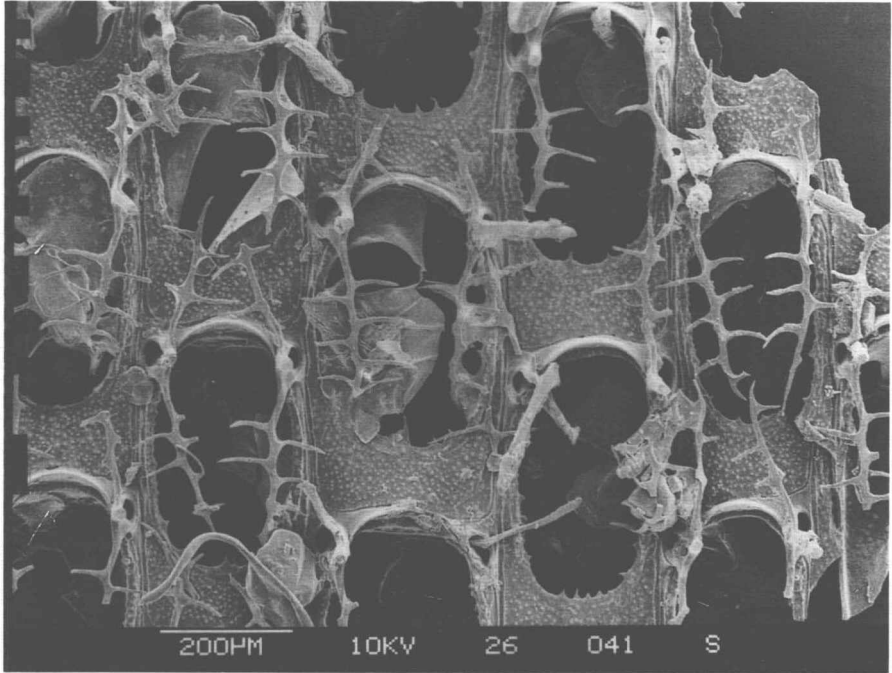


Figure 1. Scanning electron micrograph of bleached skeletons of *Membranipora amoyensis* (USNM 381041).

at Gahirmatha, Bhitarkanika, Cuttack District, Orissa, India. Attached to the posterior of the carapace were oysters, *Crassostrea* cf. *gigas* Thunberg (USNM 820298), barnacles and algae (Frazier et al., 1985). Mats of the encrusting bryozoan *Membranipora amoyensis* Robertson (USNM 381041) were also collected from the carapace (Fig. 1).

Case 2.—On 14 July 1984 a female *Caretta caretta* (L.) (USNM 247944; CCL = 101.0) was found dead on the beach at Little Cumberland Island, Georgia. This animal had nested on the island over a period of 20 years. Among the numerous epizoa attached to its carapace were many branching colonies of the ctenostome bryozoan *Anguinella palmata* (Van Beneden) (USNM 404480) (Calder, in litt., 17 May 1985).

Case 3.—On 22 July 1984 a female *C. caretta* (CAR 84.07.22.01; CCL = 64.0) was found dead on the beach at Cumberland Island. Attached to its carapace, along with several species of mollusks, was a branching colony of *Bugula neritina* (L.) (USNM 404481). Growing on this cheilostome was a smaller colony of a ctenostome, *Bowerbankia* sp. (Calder, in litt., 17 May 1985).

Case 4.—On 28 July 1985 a dead female *C. caretta* (CAR 85.07.28.02; CCL = 84.5) was found on Cumberland Island. Polychaetes, amphipods, and mollusks were collected from its carapace. A specimen of *Alcyonidium hauffi* Marcus (AMNH 706), attached to a chelonibiinid barnacle, was also collected.

Case 5.—On 15 June 1986 an adult-sized female *Chelonia mydas* (L.) (JGF 4900) was found dead on the beach at Hawksbay, Karachi, Pakistan. In addition to

small barnacles on the carapace, there was an encrustation of the bryozoan *Electra* sp. (AMNH 705).

Case 6.—On 5 January 1987 the carapace of a *L. olivacea* (JGF 5136; CCL = 62.0) was found on Bet Dwarka Island, Gulf of Kachchh, Gujarat, India. On the carapace were numerous very small barnacles, and at the posterior of the carapace was a colony of encrusting bryozoan *Membranipora hugliensis* Robertson (AMNH 709).

Case 7.—A *Chelonia mydas* was tagged on Quinta Playa, Galapagos in February 1977 and recaptured on 24 May 1978 at Santa Rosa, Ecuador. The “recaptured” tag, sent by Mr. D. Green to the National Museum of Natural History, was examined by A. Cheetham (in litt., 21 Feb. 1986) and found to carry an encrusting colony of *Membranipora arborescens* (Canu and Bassler).

Case 8.—An immature *Chelonia mydas* captured in November 1982 at Praia do Cassino, Rio Grande do Sul, Brazil, was held in captivity for about a month before it died. At the time of capture, its carapace was almost totally covered with a thick mat of epizoans, which included: algae (*Ulva fasciata* Delile), mussels (*Mytilus edulis platencis* Orbigny), Hydrozoa (*Tubularia* sp.) and Bryozoa (Ectoprocta); no further data are available, but photographs were taken (G. Marcovaldi, in litt., 21 Sept. 1983 and 4 Mar. 1984).

DISCUSSION

Records of Bryozoa on marine turtles are remarkably few. Caldwell (1968) mentioned “. . . light encrustations of bryozoans and worm tubes typical of sargassum weed communities. . .” on immature *Caretta caretta* that washed ashore in northeastern Florida. Neither a specific identification, nor further information, of the bryozoans was given. Examination of the only turtle specimen specifically mentioned by Caldwell (UF 27019; CCL ~ 6) revealed only reticular growths of a campanulariid hydrozoan (Calder, in litt., 24 April 1986).

Hughes (1974:11), recorded the bryozoan *Membranipora membranacea* L. on an unidentified marine turtle (probably *Caretta caretta*) in South Africa. This appears to be the first true record of a bryozoan epizoic on a marine turtle.

Caine (1986) scraped carapaces of 138 nesting *C. caretta* from South Carolina and Florida and found only one turtle with a bryozoan: *Bugula neritina*. Epizoia were sampled with a non-specific scrape of the carapace, and in the case of the South Carolina turtles only a 10 × 10 cm area of carapace was scraped. Hence, infestation levels may be higher than he reported—but they are clearly low.

Data on epizoic Bryozoa from non-marine turtles in estuarine conditions are likewise scarce. An adult male *Pseudemys alabamensis* (Baur) (Emydidae) from Dauphin Island, a barrier island fronting Mobile Bay, Alabama, was reported to carry encrusting barnacles and a large mat of *Electra crustulenta* (Pallas) on its carapace (Jackson and Ross, 1975). However, this bryozoan is arctic-boreal in distribution and found only as far south as the state of Maine; it is more probable that the species involved is in either the genus *Membranipora* or *Conopeum* (attempts to locate the specimen have been unsuccessful).

The occurrence of *Membranipora* sp. (a marine/estuarine form) on a costal plate of a Late Cretaceous *Podocnemis* from the Selma Formation of Alabama was documented by Zangerl (1948: 14, pl. 2). However, he argued that the epizoan had attached to disarticulated bones, not to the live animal.

Bryozoan records from turtles in non-marine situations are also remarkably rare (see reviews in Ernst and Barbour, 1972 and Jackson and Ross, 1975). Dixon (1960) documented *Plumatella* sp. on three species of freshwater terrapins from

Texas: *Sternotherus odoratus* (Latreille), *Graptemys pseudogeographica* (Gray), and *Trachemys scripta elegans* (Wied). Annandale (1912) reported two species of bryozoan on the carapaces of three species of freshwater terrapins from near Rajmahal (Santal Parganas Dist., Bihar) in the Ganges River, India; *Hislopia lacustris* Carter on *Hardella thurgii* (Gray), and a new species *Plumatella testudinicola* Annandale on *Hardella thurgii*, *Kachuga dhongoka* (Gray) and *Kachuga kachuga* (= *lineata*) (Gray).

Bryozoans, known to encrust a large variety of substrata, include many widely distributed fouling species found in the same places where turtles occur. Ruckdeschel and Shoop (1988) reported that occasionally stomachs and entire guts of *Caretta caretta* stranded at Cumberland Island were packed with an indigestible bryozoan, but no identification was given. Thus, the chances of at least casual, or opportunistic, associations between Bryozoa and turtles—especially marine species—do not explain the rareness of the epizoic association.

Moreover, the costs of carrying Bryozoa are likely to be insignificant to most marine turtles (other than very small individuals), while the benefits of attaching to a marine turtle could be enormous for the bryozoan. Attaching to a migratory marine turtle could be an excellent way to colonize vast geographic areas; Landman et al. (1987) suggested that the cephalopod *Nautilus belauensis* can serve as a dispersal agent for epizoic bryozoans (see also Jokiel [1984] for a discussion of the advantages of rafting). Yet, the scarcity of epizoic bryozoans found on the large number of marine turtles examined by the authors, combined with the paucity of published records, indicates that these invertebrates are unable to exploit marine turtles as either substrata or dispersal agents.

Caine (1986) argued that sessile epizoa have a low turn-over rate and are long-term residents on the carapace, but the bryozoan colonies found on the marine turtles reported herein were rarely more than 3 or 4 cm across. In tropical conditions some bryozoan colonies (including a *Membranipora* sp.) can grow to 4 cm in diameter, or more, in little more than a month (Ganapati et al., 1958; Menon and Nair, 1974). With the exception of Cases 2 and 8, in which the colony was much larger than a few cm across, and may have been established for many months, the small size of the epizoic colonies described in the present study suggests that they had been growing on their respective turtle hosts for only about a month. This is contrary to Caine's hypothesis and is more consistent with short-term residence; whether or not epizoic Bryozoa have high replacement rates is unknown.

Furthermore, all eight bryozoans that could be identified to species level in the present study—in addition to those reported by Hughes (1974) and Caine (1986)—are common in intertidal to subtidal inshore marine habitats. Six of them, *Anguinella palmata*, *Bugula neritina*, *Membranipora amoyensis*, *M. arborescens*, *M. hugliensis*, and *M. membranacea* occur in harbors and estuaries where salinities may be low and pollution levels high (Winston, 1977). Three species, *Anguinella palmata*, *Bugula neritina* and *Membranipora membranacea*, have been reported in studies of fouling communities (Woods Hole Oceanographic Institution, 1952). All of these are relatively opportunistic species, with high growth rates and short life spans, as is typical of organisms dominating communities in these unstable environments.

Bryozoan epibionts reported here from marine turtles differ from the assemblages found on the two other motile bryozoan substrata studied: pelagic sea snakes and *Nautilus*. Scales of sea snakes (Hydrophiidae) can carry *Membranipora tuberculata* (Bosc), a species most commonly found in the epipelagic *Sargassum*

community, and *Electra angulata* Levisen, a species common on inanimate flotsam such as sea beans, wood and plastic trash (Zann et al., 1975; Landman et al., 1987). None of these open ocean species of bryozoan have been reported from turtles.

Eight species of epizoic bryozoans have been reported from the shells of living *Nautilus*, notably *N. belauensis* from Palau. With the exception of *Electra angulata*, which occurs rarely, all the bryozoans are from deeper water reef or shelf environments which *Nautilus* spp. frequent. In contrast, drift (dead) shells of *Nautilus* harbored 11 species of bryozoans, only 2 of which had been reported from the live shells; many of the bryozoans on drift shells (e.g., *Electra angulata* and *Membranipora* spp.) are typical of epipelagic substrata (Landman et al., 1987). Once again, none of these bryozoans—from live or dead *Nautilus*—are known from turtles.

Landman et al. (1987) suggested that these epizoa are species specific on different species of *Nautilus*, and the occurrence of certain bryozoan species on different marine turtle species also appears to follow a pattern. Lightly calcified encrusting forms (*Electra* sp., *Membranipora amoyensis*, *Membranipora arborescens*, and *Membranipora hugliensis*) have been found attached to *Chelonia mydas* and *Lepidochelys olivacea*; the softer, more easily desiccated ctenostomes (*Alcyonidium haufti*, *Anguinella palmata* and *Bowerbankia* sp.) and an erect cheilostome (*Bugula neritina*) were restricted to *Caretta caretta*. This conforms with other evidence that the epizoan communities on *C. caretta* are generally more complex than those on other species of marine turtles (Frazier et al., 1985; 1991).

The absence of records of bryozoans from *Eretmochelys imbricata* (L.) is curious, for this is evidently the most sedentary of the marine turtles, which frequently carries large encrustations of calcareous algae. On the other hand, it is not surprising that no bryozoans have been recorded on *Dermochelys coriacea* (L.), for this turtle is generally free of epizoa, except for barnacles.

Morphological or compositional characteristics of the turtle carapace may be related to the occurrence and condition of epizoic bryozoans. Annandale (1912: 147) suggested that the skin of tryonichid turtles, which is "soft and slimy," is not suitable for bryozoan attachment or growth. The same argument applies to *Dermochelys coriacea* which, except in the hatchlings, lacks hard scales and instead is covered with a soft, smooth integument, encasing an oil/fat rich corselet. Even if a hard keratinous shell is present, details of its relief may affect growth and competitive characteristics of epizoic bryozoa (Annandale, 1912). It is notable that the keratinous covering of the carapace in *Caretta caretta* is often highly irregular, "shaggy," and not at all smooth as in *Chelonia mydas* and *Lepidochelys olivacea*; this may provide ideal attachment sites for Bryozoa, with tiny irregularities in the surface, accompanied by microeddies of water.

In *Nautilus* spp. there is marked contrast in the occurrence of Bryozoa on different living (sympatric) species, as well as on live and dead shells of the same species. Several factors have been suggested to explain this phenomenon: biochemical substances or a thin (or heavy) covering of mucus on the shell surface, contact with soft body and tentacles, the presence and condition of a periostracum, and smoothness of the shell surface. Irregularities in the shell surface, e.g., the umbilicus and repaired shell breaks, were important sites for epizoan attachment (Landman et al., 1987).

Ecological and behavioral habits of the turtle hosts may also affect bryozoan recruitment and survival. Possible risks to epizoans would occur during certain activities by turtles: desiccation (during nesting and basking); fouling (during

hibernation); and abrasion (during copulation, wedging under corals, grooming with flippers, etc.). However, only a few marine turtle populations are known to either bask or hibernate, and some of the risks would be significant only on a part of the turtle population—primarily the nesting females. It is notable that the bryozoans found on marine turtles are also able to successfully colonize intertidal substrates, where they are exposed to periodic desiccation.

In this respect, it is remarkable that marine turtles have *not* been found to host epipelagic bryozoans, such as *Electra angulata* and *Membranipora tuberculata*, found on a wide variety of substrates in the open ocean—including living animals. Marine turtles are well known for making transoceanic migrations, and there is abundant, and ever-growing evidence, that there are large numbers of turtles in several oceanic systems such as the eastern Atlantic (Brongersma, 1981) and eastern Pacific (Pitman, 1990). Why, given the epipelagic habits of certain marine turtles, are there no records of epipelagic species of bryozoans as epibiota?

Finally, other factors which may limit growth, survival, and even colonizing success of bryozoans, are competition for space and nutrients among the various epizoa on a turtle's carapace, as well as direct predation by certain species of the turtle epizoa community. These are important aspects in the succession of fouling communities, including those which contain Bryozoa (Ganapati et al., 1958).

No host-specific associations between marine turtles and bryozoans are known, although there are species-specific relationships involving these hosts and other epizoa taxa. The relationships involving Bryozoa and the Ganges terrapins may not be casual. There are few solid objects in the muddy river, and hard-shelled turtles provide a difficult-to-find resource for the Bryozoa—viz., a solid substratum. As the epizoa would be subjected to desiccation when their hosts leave the water to nest and for activities such as basking, this may have led to a modified life cycle, for only fixed statoblasts of *Plumatella testudinicola* were found on the Ganges turtle carapaces (Annandale, 1912).

In this respect, it is worth emphasizing that there are unsolved problems with the taxonomy of the Bryozoa. In a study of the epizoa on *Nautilus* spp. several undescribed species of bryozoan were found (Landman et al., 1987). In Case 1 of the present study (Fig. 1), involving *Membranipora amoyensis*, there may be a problem with species identity. The original description of this species (Robertson, 1921: 49, 50) was extremely brief. Although specimens of this species are now recorded from around the Indian subcontinent, there is great variation among them, and little is known of "ecotypical variation," so species identity is uncertain (Menon and Nair, 1975).

Confusion between different ecotypes and species may well involve other epizoic bryozoans as well. Furthermore, details of the life cycle are often not well known for many Bryozoa, and this complicates an understanding of the epizoa-host relationship. If, as Annandale (1912) suggested, details of carapace surface can affect the growth pattern of a bryozoan, there is ample chance for misidentifying species.

It is possible that the apparent lack of relationships between Bryozoa and turtles may not be a true reflection of the biological situation. For example, there were previously no records of bivalve or shelled gastropod mollusks on marine turtles, but on closer inspection it was found that mollusks are common on at least some populations of sea turtles (Frazier et al., 1985). As was found with bryozoan epibionts on *Nautilus* (Landman et al., 1987), further, more detailed, observations could show that epizoic Bryozoa are more common on some populations of marine turtles than is presently assumed.

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