Echeneid-sirenian associations, with information on sharksucker diet

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Association of the sharksucker (*Echeneis naucrates*) and whitefin sharksucker (*E. neucratoides*) with the West Indian manatee (*Trichechus manatus*) and the dugong (*Dugong dugon*) is presented and discussed. Alimentary tract-content analysis and field observations suggest that coprophagy (feeding on host fecal material) may be the primary food source for echeneids associated with sirenian hosts.

Key words: *Echeneis*, *Trichechus manatus*, *Dugong dugon*, commensalism, coprophagy.

The taxonomic family Echeneidae includes remoras, sharksuckers, whalesuckers and suckerfish, all known to associate commensally or mutualistically with pelagic and reef fish, sharks, rays and cetaceans (O'Toole, 2002). Whalesuckers (*Remora australis* [Bennett, 1840]) are well-known associates of both whales and dolphins. Fertl and Landry (1999) and Fertl *et al*. (2002) speculated that some of these records might be, in actuality, also of the sharksucker (*Echeneis naucrates* Linnaeus, 1758). However, the association of echeneids (herein referred to with the general term "sharksuckers") with sirenians (the dugong [*Dugong dugon* (Müller, 1776)] and three species of manatees [*Trichechus* spp.]) has not been well-documented. Unidentified species of sharksuckers have occasionally been reported associated with West Indian manatees (*T. manatus* Linnaeus, 1758) (Hartman, 1979), and dugongs (Husar, 1975; Brownell *et al*., 1981). A whitefin sharksucker (*Echeneis neucratoides* Zouiev, 1786) was collected from a West Indian manatee captured in Puerto Rico (Williams & Bunkley-Williams, 1996; Mignucci-Giannoni *et al*., 1999). Feeding on host fecal material (coprophagy) was suggested in other echeneid species using fish hosts (Smith, 1950), but alimentary tract analysis in these species was not done or was inconclusive.

Echeneids were collected during routine physical examinations incidental to West Indian manatee radio-tagging activities in Puerto Rico. Sharksuckers, often only loosely attached, were removed from manatees or from the net where manatees were captured. The fish were placed in individual plastic bags, the bags covered with ice, and transported to a laboratory. Sharksuckers were identified to species by counting the paired lamellae on the disk following the key of Fischer (1978) and description in Williams and Bunkley-Williams (1996). They were measured (standard and total lengths), and their stomachs and intestinal tracts were examined for contents. One parasite species from these samples was reported by Bullard *et al*. (2000). Sub-samples of ingesta material were repeatedly rinsed, allowed to settle, and decanted until the solid matter in the sample could be examined using a dissection microscope. Two specimens of *E. neucratoides* and one specimen of *E. naucrates* were deposited in the U. S. National Museum (USNM) Ichthyology Collection, located at the Smithsonian Institution in Washington, D.C.

Counts and measurements were based on 25 sharksuckers and whitefin sharksuckers collected from manatees in Puerto Rico, 12 collected from manatees, measured-and-released in Florida, and 196 observations and size estimates from both localities. Sharksucker-manatee associations in Belize were documented at Gallow's Reef and the Drowned Cayes, within the Belize Barrier Reef lagoon system. Video images of manatees and sharksuckers were collected and analyzed using a JVC MiniDV camera in an Ikelite underwater housing at 25 locations within the labyrinth of bogues, channels, and seagrass beds that surround the Drowned Cayes and two locations on the nearby Gallow's Reef section of the Barrier Reef. Observations were also made incidental to manatee radio-tagging activities in Southern Lagoon, a freshwater-estuarine system, located inland along the coast in central Belize.

Additionally, a total of hundreds of dugongs were observed in Australia, the Persian (Arabian) Gulf and Mozambique in southeastern Africa. Video images of a herd of about 120 dugongs were taken in the Persian Gulf off the western portion of the United Arab Emirates, and of 20 dugongs in the Bazaruto Bay in south-central Mozambique.

WEST INDIAN MANATEES AS HOSTS

For many years, one of us (AAMG), has observed and received reports of sharksuckers (*Echeneis* spp.) on manatees in localities all around Puerto Rico (Fig. 1). We collected 25 sharksuckers from manatees captured in Puerto Rico. We determined that these were *E. naucrates* (*N*=17, USNM 348299) and *E. neucratoides* (*N*=8, USNM 348300). Both species were often found simultaneously on the same individual host specimen.

We also observed that the occurrence of sharksuckers on manatees in Florida were generally rarer and the fish were smaller than those found in Puerto Rico. In Puerto Rico, sharksuckers associated with approximately 45% of the observed manatees, but on less than 5% of manatees observed in Florida. One to 21 sharksuckers occurred on each manatee in Puerto Rico, but only one to three in Florida. The standard lengths of the sharksuckers on manatees in Puerto Rico ranged from 51-73 cm, while those from Florida were 25-35 cm.

FIG. 1. Sharksuckers (*Echeneis naucrates*) attached to a West Indian manatee (*Trichechus manatus*) off Aguadilla, Puerto Rico.

We found an unpublished museum record of a specimen of *E. neucratoides* collected from a manatee at Bocas de Laguna Guerrero, Bahía de Chetumal in the Mexican Caribbean (Zoology Musuem, El Colegio de la Frontera Sur, ECO-CH-2785, 24 May 1995).

In Belize, 103 images of manatees were "captured" by one of us (CSS) on 73 underwater video clips from 1999 to 2002 in the Drowned Cayes area, a marine habitat. Sharksuckers were observed in association with manatees in 49 of the clips. Sharksuckers were visually identified as *Echeneis* spp. These results are probably an under estimate of actual associations due to the quality of video samples, which varied due to visibility, distance from observer to target animal, and number of angles captured on tape. The number of sharksuckers associated with each manatee ranged from 1 to 16. No sharksuckers were observed in association with a manatee in 54 images, whereas one or more sharksuckers were observed in association with a manatee in 49 images (48% of the total number of captured images). When sharksuckers were visible, the number of sharksuckers associated with one manatee for most cases ranged from one to five. In three videos, however, we observed from 8 to 16 sharksuckers associated with a manatee. In contrast, of 24 individual manatees captured for radio-tagging a total of 61 times over a five year period from a freshwater/estuarine system in Central Belize, only one net set produced small 25-30 cm *E. neucratoides* associated with the target animal.

DUGONGS AS HOSTS

Husar (1975) reported an unidentified species of sharksucker on a dugong off Green Island, Australia. Brownell *et al*. (1981) noted unidentified sharksuckers on dugongs in Palau. Sharksuckers and possibly other species are common on dugongs in Australia, but rather rare in Mozambique and the Persian Gulf. One of us (VGC) only observed four small (approximately 20-30 cm) sharksuckers, one-each on four of six or seven dugongs, on one occasion in Bazaruto Bay, Mozambique. Quite a few dugongs in a herd of 120 had sharksuckers associated with them in the western portion of the United Arab Emirates in the Persian Gulf. In Australia, sharksuckers on dugongs ranged in size from about 30 cm (rarely smaller) to 100 cm. Most were *E. naucrates*, although other sharksucker species could be present. Up to four sharksuckers, often of different sizes, occurred on a single dugong. One large sharksucker (>80 cm) was seen attached to a recently orphaned dugong calf that was 1.5m in body length. Sharksuckers attached to all areas of the trunk of dugongs, caudal from the head. They were often tenacious in their attachment. When dugongs were pursued for capture and tagging, large sharksuckers (up to 100 cm) usually released from the dugong when it performed somersaults and sharp turns to avoid capture; however, smaller sharksuckers (up to 50 cm) often remained with the dugong when it was caught and during the tagging process unless the host was removed from the water.

SHARKSUCKER ASSOCIATION WITH SIRENIANS

The association of echeneids to manatees was first recorded in the Caribbean in accounts by early explorers (Fernández de Oviedo, 1526; Durand, 1983) and recently in Florida (Hartman, 1979). Sharksuckers associated with manatees were often assumed to be the *E. naucrates*, but this species is difficult to distinguish from the *E. neucratoides* in the field. Despite numerous previous studies of the manatee, the identity of its sharksucker associates was not previously confirmed. Fertl & Landry (1999) and Fertl *et al*. (2002) found a similar situation with the sharksuckers of dolphins. The species had been assumed to be the whalesucker, but through more careful examination, they found cases of the *E. naucrates* on bottlenose dolphins (*Tursiops truncatus* Montagu, 1821) and spinner dolphins (*Stenella longirostris* [Gray, 1828]).

Manatees with sharksuckers attached were found along all coasts of Puerto Rico where manatees occur only in saltwater. In Florida, this association occurred on both coasts and in marine, brackish, and freshwater habitats. Robins *et al*. (1991) consider that echeneids are not capable of invading freshwater, however, *E. naucrates* is well documented to enter freshwater in Lake Nicaragua (Thorson, 1976). Possibly the Florida and Nicaragua records are sufficient to establish *E. naucrates'* ability to invade freshwater habitats.

Like many shark, dolphin and whale species, dugongs and manatees may be a particularly attractive “habitat” for sharksuckers. Adult dugongs and manatees are large (up to 3 m long and 400 kg) and appear to be relatively safe from predation by most non-human predators. It seems

that sharksucker association in dugongs may be related to the host's group size. Dugongs often occur in large herds. It may not be energetically efficient for a sharksucker to chase after a single, or just a few dugongs, and associating with larger groups of dugongs may make it easier to change hosts, as has been observed in dolphins. Additionally, we speculate that dugongs and manatees may be desirable hosts as their seagrass-feeding behavior may provide small prey items for their attached sharksuckers. Dugongs typically create furrows that are about 15 cm wide and 5-10 cm deep and up to 10 m long (Preen, 1993), while manatees uproot material from large elliptical patches averaging 27 square meters in area (Lefebvre *et al*., 2000). These processes are destructive and they flush fishes and crustaceans and expose worms, mollusks and other invertebrates. Feeding dugongs often attract other fishes and cormorants that also exploit this potential source of food.

Some species of sharksuckers are known to have flexible host-specificity and dugongs and manatees often associate with other host species, potentially allowing host-switching by sharksuckers. Large (3-4 m) sharks are occasionally seen within 100 m of dugong herds and sea turtles and large rays associate closely with dugongs. Dolphins and sea turtles share some of their habitat with manatees in Florida and Puerto Rico and may also provide transport as they are often found in close proximity. It is an intriguing possibility that facultativly coprophagic sharksuckers may be able to vary the nature of their diet by switching between herbivorous and carnivorous hosts.

The sharksuckers associated with both manatees and dugongs appear to be generally larger and more common in the tropics (Puerto Rico and Australia, respectively) than in the subtropical and temperate regions (Florida and Southeast Africa, respectively). At present, we have too little information to suggest a cause for this trend.

FOOD HABITS OF SHARKSUCKERS

We analyzed the stomach and intestinal contents of 17 specimens of *E. naucrates* and eight specimens of *E. neucratoides* found associated with manatees in Puerto Rico. We found that almost all of the ingesta of the sharksuckers examined consisted of host feces. The consistency and texture of the material in the stomach was characteristic of the very digested ingesta typically passed through the host and not course and abraded as one might expect of material culled directly from the rooted plants (Burn, 1986; Marsh *et al*., 1999). We also observed numerous instances of sharksuckers associated with wild manatees in Florida feeding directly on manatee feces just after host defecation.

Smith (1950) suggested that sharksuckers consumed the feces of their hosts based on earlier observations by others of their feeding behavior. Strasburg (1959) belittled Smith's (1950) opinion and established the modern opinion of opportunistic feeding on host-scraps, plankton, and parasites. More information on the amounts (in terms of total diet) of parasite-picking was added later by Cressey & Lachner (1970). Our analysis of stomach and intestinal contents of sharksuckers associated with manatees in Puerto Rico, as well as direct observation of sharksuckers feeding on manatee feces just after defecation in Florida, suggest that Smith (1950) was correct.

The debate between Smith (1950) and Strasburg (1959) over fecal versus scrap and plankton feeding strategies in sharksuckers cannot be resolved by the analysis of stomach and intestinal contents of those sharksuckers associated with a piscivorous host. Generally, those scraps from the host during feeding, basically ingested planktonic fishes, and the hosts' fecal contents all contain similar things that are indistinguishable in the stomach and fecal contents of those sharksuckers. However, the contents of sharksuckers associated with manatees and dugongs can be analyzed conclusively, and can be used to resolve the general question. Sirenians eat submerged aquatic vegetation, not fishes or planktonic organisms. The stomach and intestinal contents of the sharksuckers we examined contained a large volume of pre-digested plant material, of a consistency that would suggest that it had already passed through the manatee's efficient digestive tract (only three small fish vertebrae occurred in one of 25 sharksuckers). Sharksuckers are known to have only fish remains in their stomach contents when found associated with piscivorous hosts. It is unlikely that they become almost exclusively herbivorous just because they associate with a plant-eating host. The most logical conclusion is that sharksuckers feed almost exclusively on the feces of their hosts. Sharksuckers on piscivorous hosts have fish remains in their stomachs and

intestines, while those on herbivorous hosts have plant material. Our evidence agrees with Smith's (1950) suggestion that a large part of the diet of sharksuckers was fecal material. Furthermore, the diet of sharksuckers associated with manatees we examined in this study is almost exclusively the fecal materials voided by their hosts. This may also be true of sharksuckers associated with other hosts.

Supportive of this theory is the rather elaborate intestinal tract of sharksuckers that is not typical of a piscivorous carnivore that feeds only on fish scraps, but is more suited to an animal consuming a variety of materials such as fecal material from different host species with widely varying diets. The optional digestion hypothesis predicts herbivorous fishes should have a longer digestive tract than carnivorous fishes (Helfman *et al*., 1997). Kramer and Bryant (1995) found that at a given size, intestinal lengths of herbivores are longer than those of omnivores, which in turn are longer than those of carnivores. Benavides *et al*. (1994) demonstrated that an increase in relative gut length is associated with an increase in the capacity to digest plant matter. We acknowledge, however, that additional studies should be conducted to rule out possible seasonal biases associated with plant availability and host habitat influences that could ultimately affect the foraging material available to sharksuckers. It would be interesting, for example, to document how sharksuckers cope with changing diets between a sirenian and a shark or dolphin host, and if individual sharksuckers can make the change in mid-life once the fish's gut flora is established and suited to a particular diet. Furthermore, additional studies, perhaps with captive animals of both sirenians and sharksuckers, may shed light on the implications of a derived vegetarian diet for sharksuckers given the low protein content of digested plant material that could ultimately affect growth rates and fecundity, among other factors.

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