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Cleaning Symbiosis Between Hawksbill Turtles and Reef Fishes at Fernando de Noronha Archipelago, off Northeast Brazil

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Abstract. – **Hawksbill turtles (*Eretmochelys imbricata*) are cleaned and followed by reef fishes at Fernando de Noronha Archipelago, off northeast Brazil. During foraging, turtles are cleaned by damselfishes (*Abudefduf saxatilis* and *Stegastes rocasensis*), and followed by juvenile wrasses (*Thalassoma noronhanum* and *Halichoeres radiatus*).**

Marine turtles often have an assorted and sometimes luxuriant growth of organisms on their shells or soft body parts (Dodd 1988; Hirth 1997). The turtles may dislodge some of these attached organisms by sweeping their shells with their forelimbs (Losey et al. 1994). The growth may also be lessened by the action of other animals, mostly herbivorous, grazing reef fishes (Losey et al. 1994; Perrine 2001; C. Sazima et al. 2004). Another mode of being relieved of the attached organisms is achieved when the turtles seek the services of cleaners such as fishes (Booth and Peters 1972; Losey et al. 1994) or shrimp (I. Sazima et al. 2004a). In cleaning symbiosis, a fish or a shrimp obtains food from the body of another animal, which is relieved of its ectoparasites and necrotic tissue (Losey 1987; Côté 2000). Several cleaner species tend cleaning stations at particular places of the reef habitat, which are sought by so-called clients (Losey 1978). There are records of cleaner fishes handling animals as disparate as octopuses and turtles (Booth and Peters 1972; Losey et al. 1994; I. Sazima et al. 2004b).

Cleaning symbiosis between marine turtles of the Cheloniidae and reef fishes is recorded for the green turtle (*Chelonia mydas*) in the Indo-Pacific and more recently in the Atlantic, this turtle being known to be cleaned by damselfishes (Pomacentridae), wrasses (Labridae), and surgeonfishes (Acanthuridae) (Booth and Peters 1972; Losey et al. 1994; C. Sazima et al. 2004). For the less-studied hawksbill turtle (*Eretmochelys imbricata*), there is a brief mention of cleaning by the angelfish *Pomacanthus paru* (Pomacanthidae) in the Caribbean (Smith 1988), and a recent account of cleaning by barber pole shrimp in the Southwest Atlantic (I. Sazima et al. 2004a).

We report here on hawksbill turtles cleaned by 2 fish species of the Pomacentridae, the sergeant major (*Abudefduf saxatilis*) and the Rocas damselfish (*Stegastes rocasensis*), in the reef habitat at Fernando de Noronha Archipelago, Southwest Atlantic. Additionally, we record foraging hawksbills being followed by individuals of two fish species of the Labridae, the Noronha wrasse (*Thalassoma noronhanum*) and the puddingwife (*Halichoeres radiatus*). Following behavior is a widespread association between reef fishes and involves a nuclear foraging species that disturbs the bottom, and opportunistic carnivores that capitalize on prey uncovered or flushed by the nuclear forager (review in Strand 1988).

We addressed the following 3 main questions in our study: 1) Does the turtle seek the cleaners or does the fish find the turtle and clean it? 2) Does the turtle pose for the cleaners on a defined spot or is it cleaned while foraging and/or moving? 3) What body parts of the turtle are nibbled by the cleaners? As marine turtles followed by reef fishes have only recently been reported in the Southwest Atlantic (C. Sazima et al. 2004), we also addressed the question of what food type the 2 labrid species were seeking while following foraging turtles. Additionally, we comment on a putative stage for the origin of cleaning symbiosis between marine turtles and reef fishes.

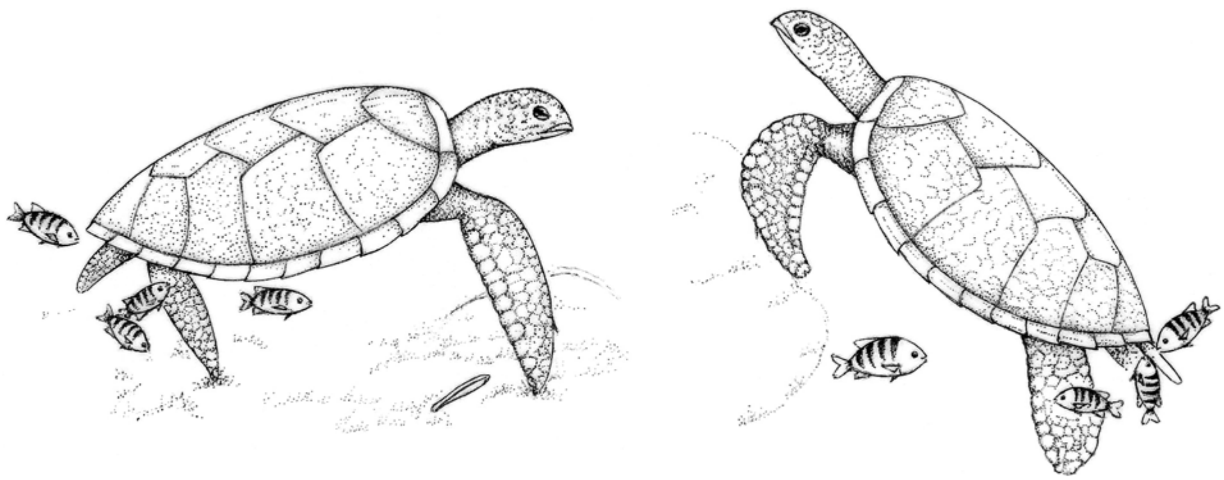

Figure 1. Two postures displayed by the hawksbill turtle (*Eretmochelys imbricata*) while being cleaned by juvenile sergeant majors (*Abudefduf saxatilis*) in the Baía do Sueste at Fernando de Noronha Archipelago, off Northeast Brazil. This 71-cm CCL individual was resting on the reef flat (left), or hovering in the water column close to a rocky outcrop cleaning station (right), both postures being characteristic of a cleaning interaction. Note a follower wrasse (*Thalassoma noronhanum*) near the right flank of the resting turtle. Based on photographs.

Methods. — We recorded the marine turtle–reef fish symbiosis at Fernando de Noronha Archipelago (03°50′S, 32°25′W), about 345 km off northeast Brazil (see Maida and Ferreira 1997, and Carleton and Olson 1999, for map and description). Field observations were conducted from June to October 2002, and May and June 2003. The observations on sergeant majors' stations were made at the Baía do Sueste, on a reef flat composed of rocky ledges sparsely to thickly covered by brown foliose algae, red coralline algae, and stony corals (Maida et al. 1995; Sanches and Bellini 1999; C. Sazima et al. 2004). Depth at this site ranged up to 2 m at high tide and the observations were limited to periods of ebbing flow, as the turtles were absent at the study site at the peak of ebb tide (A. Grossman, *pers. obs.*). The observations on Rocas damselfish algae gardens were made at the rocky shores of the Baía do Sancho and Praia da Conceição, both sites with bottom types similar to that described above, and a depth of up to 6 m at high tide.

Hawksbill foraging activity as well as cleaning and following behavior by fishes were recorded over 36 nonconsecutive days (30–60 minutes each day) while snorkeling. During observational sessions of 5–15 minutes we used focal animal samplings, in which all occurrences of specified actions were recorded (Altmann 1974). We focused on the postures adopted by the turtles while being cleaned or followed, and on what body parts the fishes were nibbling. Behavioral events were observed directly, photographed, and recorded on videotape; the tape is on file at the Museu de História Natural, Universidade Estadual de Campinas (ZUEC, tape 15) and at Projeto Tamar headquarters in Fernando de Noronha. One stomach of a hawksbill found dead ashore was examined for its contents. Sponge pieces were deposited in the Porifera collection of the Museu Nacional de Rio de Janeiro (MNRJ 8308–9); additional sponge as well as algae pieces are in the vertebrate stomach contents collection at ZUEC (unnumbered).

Results. — Individual hawksbill turtles spent up to 4 hours foraging on the reef flat, biting off portions of sponges on mixed algae/sand mat and stirring the substrate during their activity. While on the reef flat the turtles periodically sought cleaning stations tended by juvenile sergeant majors. The stations were mostly rocky outcrops with little or no algae growth that were conspicuous landmarks on the reef flat. One of the most visited stations was a particularly large outcrop measuring 2.6 m wide, 3.5 m long, and 1.1 m high. Groups of 6–27 juvenile sergeant majors 8–11 cm total length (TL) hovered in the water column at the station and occasionally picked at drifting algae and plankton, or grazed on algae and picked at benthic organisms.

As the turtle approached a given cleaning station, its stirring of the substrate while foraging became more intense, a behavior that caused the sergeant majors to approach the turtle. Once at the station, the turtle either hovered in the water column or rested on the bottom. While hovering in the water column it displayed a characteristic oblique posture with its limbs extended downwards (Fig. 1), and moved mostly to hold its position. While resting on the bottom it held its limbs stretched and elevated its body (Fig. 1), a behavior that allowed the cleaners to reach its underside. After being cleaned for ca. 2–3 minutes ($n = 5$) the turtle moved away from the station followed by the cleaners for about 2–3 meters, and resumed foraging. Additionally, during its foraging in the vicinity of cleaning stations, the hawksbill occasionally paused and posed on the bottom with all limbs stretched, allowing the nearby sergeant majors to clean it for ca. 1 minute ($n = 3$) before resuming its movement on the flat.

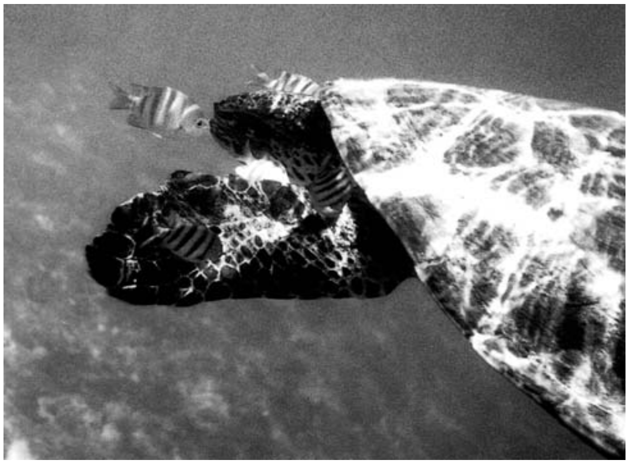

Figure 2. Juvenile sergeant majors (*Abudefduf saxatilis*) grouping and nibbling at a hawksbill turtle's hind limbs.

During the cleaning, the sergeant majors congregated around the turtle and nibbled at its neck and limbs (Fig. 2), visibly picking portions of molting skin and algae. Upon some of the nibbles, especially on the soft skin around the neck and eyes, the turtle shuddered a little, a behavior that indicates parasite or tissue removal (Losey 1971, 1993; I. Sazima et al. 1999; C. Sazima et al. 2004). This contrasts with the report of Smith (1988), who recorded no jerking or twitching of the hawksbill while being cleaned by French angelfish. Seven turtles (45–71 cm curved carapace length, CCL), recognized by natural marks or numbered tags, revisited the same station over their daily foraging period on the reef.

Hawksbill turtles 34.5–39.5 cm CCL also rested on or near the algae turfs farmed by Rocas damselfish (4–7 cm TL), generally on small plateaus on rocky shores at about 3 m depth at high tide. While being cleaned, the turtles remained motionless with their limbs extended downwards, and the damselfish nibbled at the limbs, carapace, and around the eyes. When we first observed this behavior, we thought that this highly territorial damselfish (Rodrigues 1995; Guerriero 2002) tried to chase the turtle away from its garden. However, a closer look revealed that the fish was first inspecting and then nibbling at a given spot on the turtle's body. We recorded 7 such cleaning sessions, one of which lasted 4 minutes after it was first sighted (thus it probably lasted longer), after which the turtle moved away. Two other situations involving hawksbill turtles cleaned and/or grazed by adult and juvenile Rocas damselfish were recorded. In 3 instances, the hawksbills moved nearby the garden, the fish left its original location and followed and nibbled at the turtle for a while, after which it returned to the garden. Additionally, we recorded on 2 occasions a turtle resting on the reef in a crevice close to a garden and a juvenile damselfish nibbling over its body. In 9 out of these 12 records the damselfish nibbled the turtle around the eyes.

While foraging for sponges on the mixed mat that covered the reef flat, the hawksbill was occasionally followed by the wrasses *Thalassoma noronhanum* and *Halichoeres radiatus* (individuals of both species about 6–8 cm TL). The fishes were feeding both on drifting particles and on small benthic invertebrates exposed during the bottom-stirring by the turtle (see comments on this association type in C. Sazima et al. 2004).

The stomach content yielded pieces of 2 sponge species (*Chondrosia collectrix* and *Chondrilla nucula*) as well as red, brown, and green algae. These latter included pieces of *Gelidiopsis variabilis*, *Gelidium crinale*, an unidentified crustose corallinaceous species (red), *Sargassum* sp. (brown), and *Caulerpa sertularioides* (green). Volumetric assessment was not possible because of decomposition of most of the content, but a rough estimate was that about 70%–80% of the material was composed of sponges and the remainder was composed of algae and unidentified particulate material.

Discussion. — All hawksbill individuals recorded foraging on the reef flat or the rocky reefs and posing at cleaning stations were juveniles. Our observations agree with an 11-year study on hawksbills at Fernando de Noronha Archipelago, with no adults recorded there (Sanches and Bellini 1999). The CCL size of our smallest hawksbill agrees with the minimum size of this species leaving the pelagic environment and beginning to forage on coral reefs and rocky outcrops (Bjorndal 1997; Perrine 2001). However, adults may benefit from cleaning symbiosis on reefs along the mainland coast. This suggestion is partly supported by the observation of one large adult being cleaned while resting in a shipwreck at Northeast Brazil's coast at a 20-m depth (C. Bellini, *pers. obs.*).

The postures and the general behavior displayed by the hawksbills while being cleaned are similar to that reported for the green turtle (Booth and Peters 1972; Losey et al. 1994; C. Sazima et al. 2004; see also pictures in Perrine 2001), which indicates that the symbiosis between cheloniid turtles and reef fishes follows a pattern. We predict that other reef-dwelling turtles will be recorded in cleaning association with reef fishes, and the loggerhead (*Caretta caretta*) is one of the most likely candidates, as it is often observed lingering in the reef habitat (Dodd 1988) including reefs at Fernando de Noronha Archipelago (Bellini and Sanches 1998). We hypothesize that cleaning of sea turtles by reef fishes is a common and widespread phenomenon, and the scarcity of records may be explained by a lack of attention, and thus of studies, on this subject. However, the possibility remains that the reported instances relate to events very localized in space and time, and/or to rare behaviors restricted to a few populations of turtles and/or cleaning fishes (see Losey et al. 1994; Sazima and Sazima 2001 for this view).

The symbiotic relationship between marine turtles and reef fishes might have followed relatively few and simple steps from one possible origin. Learning processes might have set the stage for natural selection to favor individuals (both turtles and fishes) that would learn or even have innate disposition to put themselves in situations where the learning would be initiated. One such situation could be hawksbills resting in crevices under ledges, which would favor their cleaning by shrimps (see I. Sazima et al. 2004a). The main steps might be as follows: 1) herbivorous and/or omnivorous fishes grazed on algae and other epibionts on turtles, which would be perceived by the fishes as an additional feeding substrate; 2) the turtles eliminated fouling epibionts and received tactile stimuli, both factors advantageous and/or pleasant for the turtles; 3) turtles would learn to seek the cleaning stations and to pose for the attending fishes to obtain the above-mentioned advantages; and 4) the fishes would learn to seek the posing turtles to obtain additional food and/or complementary nutrients. This plausible scenario is strengthened by studies on cleaning association involving cleaner fishes and shrimp, and marine turtles (e.g., Losey 1979; Losey et al. 1994; Côté 2000; C. Sazima et al. 2004; I. Sazima et al. 2004a), being reminiscent of the view presented for the putative origin of cleaning symbiosis between bottom-attached cleaner gobies and reef sharks (Sazima and Moura 2000)

Our records of hawksbill turtles seeking and posing at cleaning stations tended by the damselfish *A. saxatilis* are similar to the reports on other cleaner species such as the wrasse, *Thalassoma duperrey*, cleaning green turtles in the Pacific (Losey et al. 1994), because both cleaner species are station-based and work in a group on their posing turtle clients. Damselfishes (Pomacentridae) are regarded as occasional cleaners of other fishes (e.g., McCourt and Thomson 1984; I. Sazima 1986), and few damselfish species are reported in overviews on cleaning symbiosis (Van Tassell et al. 1994; Côté 2000). The feeding aggregation of juvenile *A. saxatilis* close to the rocky outcrops used as turtle cleaning stations is typical of the feeding behavior recorded for several diurnal reef planktivores, and is similar to that recorded for the sergeant major in the Red Sea (Fishelson 1970).

The hawksbill being cleaned by the damselfish, *S. rocasensis*, on or close to its algae garden seems odd at first sight, as this and other territorial damselfishes are known for the bold defense of their feeding areas against other herbivorous fishes (e.g., Sammarco and Williams 1981; Klump et al. 1987). As the hawksbill behaves like a very large herbivore while foraging on the reef, defense of the algae garden by the tenant damselfish would be expected (however, no hawksbill feeding on any of these gardens was recorded). On the other hand, portions of molted skin and occasional parasites may be a welcome addition to the mostly herbivorous diet of this fish (Rodrigues 1995). In the Caribbean, the sergeant major is regarded as an omnivore, whereas species of *Stegastes* are reported to feed on small invertebrates besides their diet based on algae (Randall 1967). The nibbling around the eyes by Rocas damselfish and less often by the sergeant major may possibly aim at the fluid the turtles and other marine reptiles secrete in that body part (Dunson 1976). This secretion contains nutrients such as calcium, magnesium, and bromine (Lutz 1997), which perhaps complement the mostly herbivorous diet of Rocas damselfish and, to a lesser extent, of the omnivorous sergeant major.

Hawksbills stir a large amount of organic particles while foraging on sponges, thus attracting highly opportunistic follower fishes such as labrids (Randall 1967; C. Sazima et al. 2005; this paper). Green turtles stir the bottom less while selectively picking algae, and thus probably attract less attention from followers (I. Sazima and Sazima 1983; C. Sazima et al. 2004). A comparative study of foraging modes of these 2 turtle species and their influence on follower reef fishes at Fernando de Noronha would be enlightening. Although *E. imbricata* is viewed as a specialized sponge-eater (Meylan 1988), our field observations and the stomach contents we examined are consistent with available data on feeding habits of hawksbills worldwide (reviews in Witzell 1983; Márquez-M. 1990), which indicate that this turtle has a broader diet, including sponges, algae, coelenterates, crustaceans, and other benthic invertebrates. However, the nutritional role and the relative importance of algae in *E. imbricata* diet need further evaluation.

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