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Short communication

Interactions between non-native armored suckermouth catfish (Loricariidae: *Pterygoplichthys*) and native Florida manatee (*Trichechus manatus latirostris*) in artesian springs

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Abstract

Non-native suckermouth armored catfishes (Loricariidae) of the genus *Pterygoplichthys* are now common throughout much of peninsular Florida. In this paper, we present preliminary observations on interactions between a *Pterygoplichthys* species, tentatively identified as *P. disjunctivus* (Weber, 1991), and endangered native Florida manatees, *Trichechus manatus latirostris* (Harlan, 1824), in artesian spring systems in Florida's St. Johns River drainage. The introduced catfish have become abundant in spring habitats, sites used by manatees as winter thermal refuges. In the spring runs, *Pterygoplichthys* regularly attaches to manatees and grazes the epibiota on their skin. On occasion, dozens of *Pterygoplichthys* congregate on individual manatees. Manatee responses varied widely; some did not react visibly to attached catfish whereas others appeared agitated and attempted to dislodge the fish. The costs and/or benefits of this interaction to manatees remain unclear.

Key words: Loricariidae, *Pterygoplichthys*, Florida, behavior, springs, manatee, non-native species

Suckermouth armored catfishes (Loricariidae) of the genus *Pterygoplichthys* (the sailfin catfishes) are native to South America. Several members of the genus have been widely introduced, and non-native populations now exist in inland waters in parts of North and Central America, Asia, the Caribbean (Puerto Rico and Jamaica), and Hawaii (Fuller et al. 1999; Nico and Martin 2001; Page and Robins 2006; Nico et al. 2009). Much of the biology and natural history of introduced populations of *Pterygoplichthys* remains un-studied. At least two different *Pterygoplichthys* species, including possible hybrids, have invaded streams, canals, and lakes throughout much of peninsular Florida. One form, tentatively identified as the vermiculated sailfin catfish *Pterygoplichthys disjunctivus* (Weber, 1991), has become increasingly common in central Florida drainages (Nico 2005); large numbers of the catfish may be easily observed in several artesian spring habitats within the St. Johns River drainage.

Several of the same Florida springs colonized by *Pterygoplichthys* are also occupied seasonally by the Florida manatee, *Trichechus manatus latirostris* (Harlan, 1824), an endangered aquatic mammal native to Florida. Manatees aggregate in large numbers in the thermally moderated waters of the springs during winter months to avoid unsuitably cold waters elsewhere (Deutsch et al. 2003; King and Heinen 2004). Northern Florida springs normally range from 19.4ºC to 23.9ºC year-round (Stamm 1994), and Blue Spring in Volusia County, the largest of the St. Johns River springs, flows at a constant 22.5ºC (O'Shea 1986). Because the native range of *Pterygoplichthys* is largely tropical (Weber 1992; Nico and Martin 2001), the catfish also likely use Florida springs as winter thermal refuges.

Among fishes in Florida, *Pterygoplichthys* are markedly distinct in morphology, trophic ecology, and behavior (Nico 2005; Nico et al. 2009). During the past several years, manatee researchers and other visitors to Florida springs have witnessed these non-native catfish attaching to manatees. To date, however, this unique interaction has gone unreported in the scientific literature. This brief communication reports our short-term observations of interactions between *Pterygoplichthys* and manatees in Florida springs, mostly during winters from 2005 - 2009. We also speculate on the significance of those interactions for each species' ecology and for manatee conservation.

Fieldwork was conducted at clear-water artesian springs in the St. Johns River drainage, Florida. Our main study site was Blue Spring and its 0.6-km long, 20 to 30 m wide, spring run in Volusia County (28º56'37"N, 81º20'26"W). Additional observations were made at Salt Springs and its 7-km long outflow channel in Marion County (29º21'02"N, 81º43'49"W). During the winter months, Blue Spring and its run are a designated manatee sanctuary with prohibitions against entry by boats and swimmers. Researchers must obtain special permission from state authorities to enter the water. Because species-level identification of the St. Johns' population remains uncertain, preserved whole *Pterygoplichthys* from the drainage, and muscle tissues useful for genetic analysis, have been retained at the U.S. Geological Survey facility in Gainesville, Florida. Most of this voucher material will be deposited in the ichthyological collection at the Florida Museum of Natural History.

We first observed behavioral interactions between *Pterygoplichthys* and manatees during visits to Blue Spring in 2004. Researchers studying manatees provided some of the first underwater photographs of interactions between *Pterygoplichthys* and manatees in 2005 (Figure 1).

Observations described in present paper were largely conducted along Blue Spring Run during five days in January and February 2009. On 29-30 January and 8-9 February, direct observations were conducted during daylight hours from viewing platforms situated along the run. Water in the spring run is generally clear to the bottom, enabling unobstructed observation of fish and manatee behavior from the platforms. In addition to shoreline observations, we performed diurnal direct observations while snorkeling on 26 February. In February, behaviors were also recorded with two videotape cameras and a digital-still camera by observers on the shoreline

Figure 1. Non-native *Pterygoplichthys* (16 individuals visible) gathering around an adult female Florida manatee (*Trichechus manatus latirostris*) and her yearling calf at Blue Spring Run, Volusia County, Florida (8 February 2005). The catfish often settle on manatees apparently to graze on algae and other epibionts growing on their skin, note the near absence of epibionts on the manatees. Many of the smaller pale fish, barely visible, are juvenile bluegill (*Lepomis macrochirus*). Photograph by James P. Reid

platforms, and with two digital-still submersible cameras by the two snorkelers. Resulting video footage and images were later examined in the laboratory to assess behavior patterns. Voucher samples of photos and video-recording are on file at the U.S. Geological Survey facility in Gainesville, Florida. Additional underwater observations were made by JPR and other manatee researchers while conducting annual surveys in Blue Spring and Salt Springs between 1995 and early 2009, a period that includes pre- and post-colonization by *Pterygoplichthys*.

During visits to Blue Spring Run in early 2009, we observed *Pterygoplichthys* regularly clustering around manatees and often attaching. The catfish appeared at times to be resting, but at other times grazed on the algae and other epibiota that commonly grow on manatee bodies. While snorkeling, we were able to approach closely (< 1 m) to catfish attached to manatees, observing that catfish thought to be resting were actually slowly but actively grazing by moving the sucker mouth in a circle over a small area. *Pterygoplichthys* attached to nearly all parts of the manatee, including head and snout, dorsal and ventral regions of mid–body, and caudal fluke. Catfish routinely attached to swimming and resting adults as well as to young manatees. When attached to swimming manatees, the catfish typically depressed their dorsal and caudal fins, presumably to reduce drag.

The versatility of these catfish was evident in that they attached to manatees independently of the mammal's location in the spring run, including when they were near the water surface, near bottom in deep areas (> 2 m) where the current was fairly rapid, or in shallows (< 0.5 m) where there was little or no current. Larger loricariid catfish are known to avoid shallow water where they are vulnerable to fishing birds (Power 1984). Perhaps responding to the presence of large wading birds (e.g., Great Blue Herons *Ardea herodias* Linnaeus, 1758) prowling the shallows, *Pterygoplichthys* in Blue Spring Run generally avoided near-shore shallows or clustered beneath the bodies of resting manatees there. Over open sand, resting manatees also help camouflage catfish.

Most *Pterygoplichthys* that attached to manatees were adults estimated to range 30 to 40 cm total length (TL). The number of *Pterygoplichthys* attached to manatees varied widely and was highly dynamic, with catfish attaching and then disengaging multiple times over the course of a few seconds or minutes. Within a group of manatees, we observed individuals with no attached *Pterygoplichthys* while others had one to many, attached catfish. Occasionally, large numbers of *Pterygoplichthys* congregated on a manatee - in the most extreme case, more than 40 *Pterygoplichthys* massed on a single manatee and nearly hid the mammal from view (Figure 2). This congregation lasted about four minutes, then ended abruptly, with the manatee remaining largely inactive throughout. In another event, about a dozen *Pterygoplichthys* massed near the bottom of the run in 1-meter deep water on the edge of a shallow area where a group of manatees was resting. Whenever a manatee approached the area where the catfish were assembled, many of the fish immediately attached to it.

When not attached to manatees, the larger *Pterygoplichthys* were usually scattered throughout the spring run, often lying singly or in small groups on the bottom or on submerged logs, occasionally swimming short distances. In our study site, we commonly observed individuals periodically dart to the surface, apparently gulping air, then immediately return to the bottom, behavior related to air breathing or for maintaining buoyancy (see Armbruster 1998). Although many of the *Pterygoplichthys* remained in the lower reach of the spring run occupied by manatees, large numbers were also found at the spring head, several hundred meters upstream from where the manatees typically occurred. On one occasion, we observed several small *Pterygoplichthys* (<15 cm TL) in the spring run, but they remained in cover, grazing the underside of a submerged log in the shallows, away from open water and manatees. Juvenile catfish were never observed attaching to manatees.

Based on past research, common behaviors exhibited by manatees inhabiting thermal refugia areas include surface and bottom resting, milling about, nursing, bottom and surface feeding, slow and fast swimming, and cavorting or playing (King and Heinen 2004). During the present study, we observed many of the same behaviors, while also noting varied responses to attachment by *Pterygoplichthys*. Some individuals remained relatively motionless, apparently resting, and did not visibly react to the catfish. In contrast, others appeared agitated and attempted to dislodge the catfish by rolling, flipping the caudal fluke, or rubbing their bodies against branches, logs, or the stream bottom (Figure 3). Rolling is also

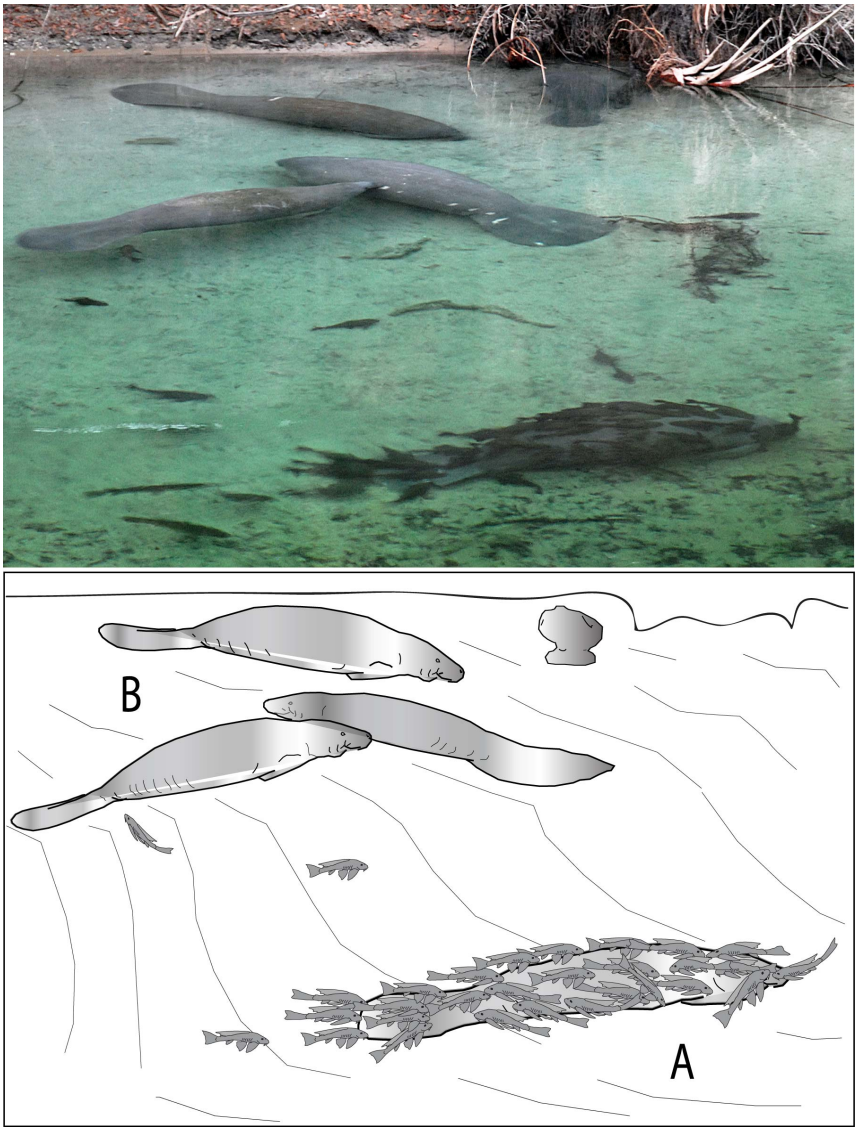

Figure 2. Photograph and line-drawing rendition showing a single adult Florida manatee (A) resting on bottom in water approximately 2-m deep while being grazed by more than 40 *Pterygoplichthys*. This event lasted about 4 min (17:45 to 17:49 h), then terminated as the catfish slowly dispersed. The manatee remained relatively stationary throughout. As manatee "A" was grazed, four others (B), with no attached catfish, rested nearby in shallow water (< 1 m deep). Site: Blue Spring Run, Volusia County, Florida (8 February 2009). Photograph and drawing by Leo G. Nico

employed by sharks, apparently to dislodge remoras (Echeneidae) from certain body areas (Brunschweiller 2006). In some instances, manatees temporarily abandoned shallow waters where other manatees rested, seemingly in response to congregating catfish. On one occasion, we observed several *Pterygoplichthys* begin to attach to a female manatee and her calf while the calf was nursing. Both individuals appeared agitated and, presumably in response to the catfish, nursing ceased temporarily.

Pterygoplichthys and other members of Loricariidae are bottom-dwelling catfishes with dorsoventrally depressed bodies covered by large bony plates, and a ventral suctorial mouth (Adriaens et al. 2009). The mouth enables adherence to a variety of substrates, even in fast water, and in combination with specialized teeth, is an adaptation for feeding by scraping or rasping submerged substrates. Food items consumed typically consist of periphyton (aufwuchs), including associated microorganisms

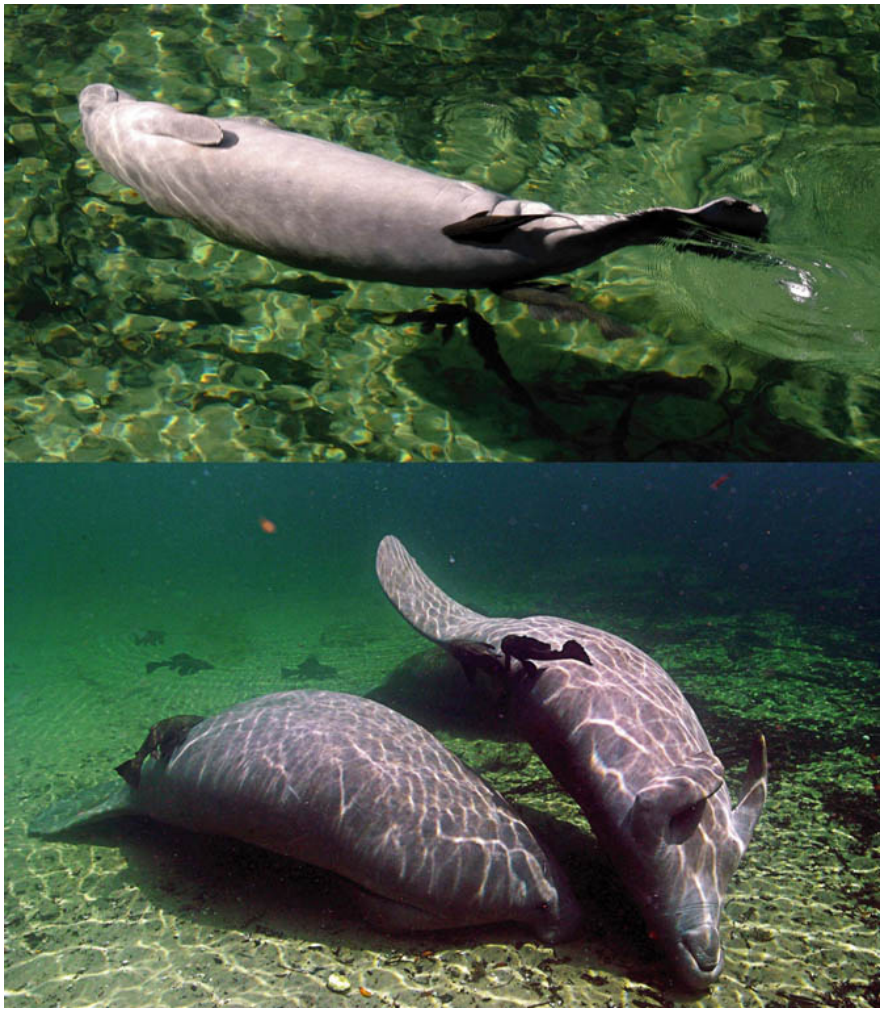

Figure 3. Adult Florida manatees (*Trichechus manatus latirostris*) performing body rolls presumably to dislodge attached *Pterygoplichthys* at Blue Spring Run, Volusia County, Florida. Upper image shows manatee rolling while swimming near surface (9 February 2009). Lower image shows manatee (on right) that was resting near bottom immediately before initiation of body roll (25 February 2009). Photographs by Leo G. Nico

and small invertebrates, as well as detritus and organic sediments (Nico and Taphorn 1994; Buck and Sazima 1995; Yossa and Araujo-Lima 1998; Delariva and Agostinho 2001). Typical substrates grazed by *Pterygoplichthys* and other loricariids include submerged rocks, boulders, bedrock, logs, and leaves and stems of live plants (Buck and Sazima 1995; L.G. Nico, personal observations). Many loricariids are popular aquarium fishes used to control attached algae and the source of introduced populations is associated with the ornamental fish trade (Fuller et al. 1999).

Based on their usual foraging behavior, it is not especially surprising that *Pterygoplichthys* attach to manatees. The large, broad body of manatees resembles substrates that loricariid catfish normally graze. Even slowly swimming manatees differ little in structure from submerged logs that sway in the current. More importantly, the skin of manatees harbors a variety of commensal or parasitic organisms that may serve as food for the grazing catfish (Figure 4). Epibionts recorded from the skin of manatees include various types of algae (i.e., Cyanophyta, Bacillariophyta, Rhodophyta, and Chlorophyta), copepods, ostracods, barnacles, tanaids, isopods, small gastropods, and leeches (Humes 1964; Hartman 1979; Mignucci-Giannoni et al. 1999; Bledsoe et al. 2006; Suárez-Morales 2007; Harr

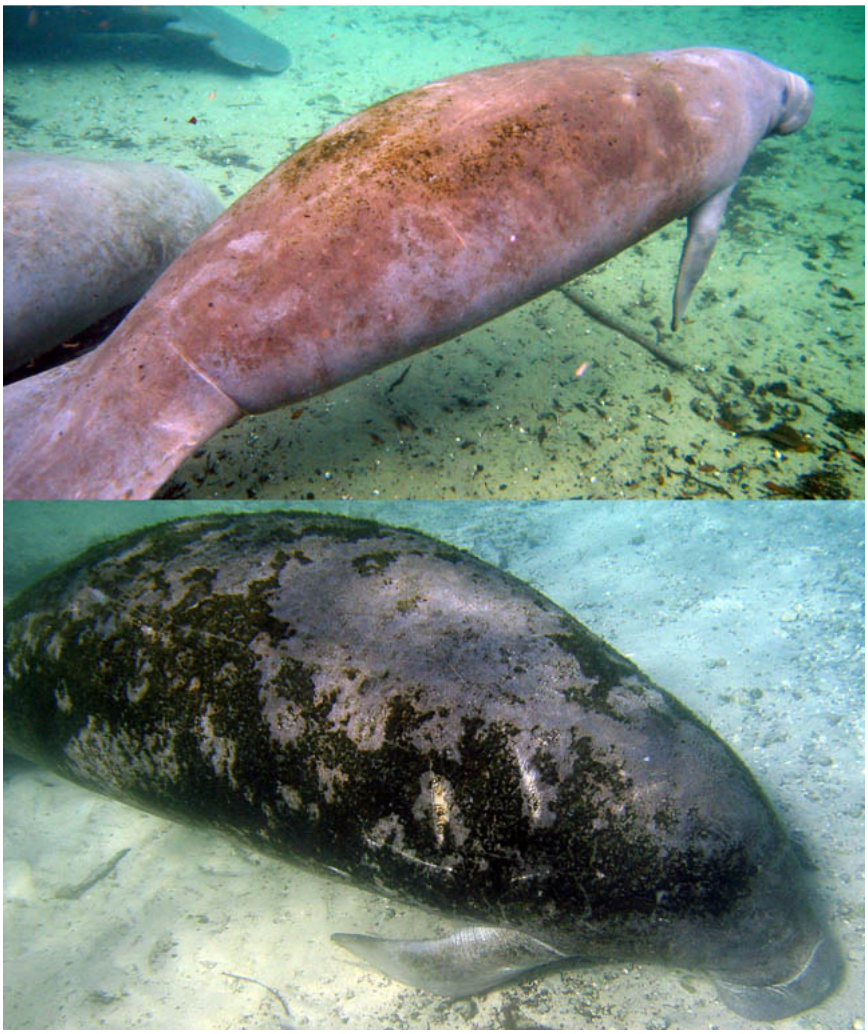

Figure 4. Adult Florida manatees (*Trichechus manatus latirostris*) with normal epibiont coverage. Upper image—individual at Blue Spring, Florida (25 February 2009) with algal coverage (Although *Pterygopolichthys* were present, the catfish were not observed attaching to this individual even though it exhibited the highest amount of epibiont coverage among the manatees present). Lower image- adult at Crystal River, Florida (6 February 2008) with a moderate amount of epibiont coverage, which is common in this region The upper portion of Crystal River is a principal aggregating site for manatees along the west-central coast of Florida; the drainage has not yet been colonized by *Pterygoplichthys*. Photographs by James P. Reid

et al. 2008; Morales-Vela et al. 2008). Other advantages for *Pterygoplichthys* attaching and grazing on manatees are undocumented but may include some level of protection from various predators (e.g., large birds and American alligator *Alligator mississippiensis* (Daudin, 1801)), and possible thermoregulation on the warm surface of the manatee's body.

In general, manatees tend to not react visibly to most fishes that occupy the same habitats, although they have been reported to be irritated occasionally or frightened by some behaviors, usually when pecked by large fish (Hartman 1979). A few native fishes have been observed interacting closely with manatees. Two remora species, the sharksucker *Echeneis naucrates* Linnaeus, 1758 and the whitefin sharksucker, *E. neucratoides* Zuiew, 1786, occasionally associate with manatees in marine waters (Mignucci-Giannoni et al. 1999; Williams et al. 2003) and are observed occasionally on manatees occupying coastal springs. Alimentary tract-content analysis and field observations suggested that the remoras feed on the manatee's fecal

material, possibly their primary food source when associating with sirenian hosts (Williams et al. 2003).

In inland waters of Florida, a native centrarchid (bluegill *Lepomis macrochirus* Rafinesque, 1819) has been reported to nip at resting manatees, possibly feeding on items present on manatee skin (Hartman 1979; Powell 1984). On at least two occasions (February of 2005 and 2009) while snorkeling in Blue Spring Run, we also observed large numbers of bluegill juveniles congregating around resting manatees and occasionally picking at algae or other manatee epibiota, and on prey disturbed by swimming manatees (Figure 1). The feeding behavior of these small fish was markedly different from that of *Pterygoplichthys* and did not appear to illicit any evasive or fright response from the manatees; however, in Crystal River (Florida), manatee researchers have observed native sheepshead, *Archosargus probatocephalus* (Walbaum, 1792), a large porgy (Sparidae) with incisor-like teeth, nipping at manatees and eliciting a reaction that suggested the fish was irritating the manatees (J.P. Reid, personal observations). Fishes nipping at manatees are reminiscent of cleaning association recorded between reef fishes and marine turtles (Grossman et al. 2006).

Until more intensive studies are conducted, we can only speculate as to costs and benefits of these interactions to manatees. Most manatees observed in Blue Spring in early 2009 exhibited remarkably clean skin uncharacteristically devoid of epibionts, with a body coloration of bright blue gray and occasional brilliant white scars (mostly healed propeller wounds). A few individuals had a continuous light covering of algae (Figure 4), but catfish did not attach to those individuals during our observations. Little is known about the normal epibiota coverage of Florida manatees and whether there are marked seasonal or habitat differences. It is known that manatees inhabiting Crystal River commonly have moderate epibiont coverage (Figure 4). The Crystal River has not yet been colonized by *Pterygoplichthys*. In contrast to manatees in the St. Johns River drainage, manatees in Crystal River are more likely to have marine algae/epibionts because they spend much of the year in coastal marine habitats.

A potential benefit from catfish cleaning may be the removal of ectoparasites and diseased or injured tissue, as recorded for the association of remoras (Echeneidae) and marine mammals and turtles (Sazima et al. 2004; Sazima and Sazima 2006); however, during our study, we did not observe *Pterygoplichthys* attaching to or feeding on manatee scars, most of which had healed. Likewise, fresh scars on a few individuals were not specifically targeted by grazing catfish. Although grazing by the catfish may have some benefits, potentially negative aspects may also exist. Manatees are subject to a variety of diseases, and biologists have speculated that dermal scavenging by sheepshead may be a vector by which the papilloma virus has spread among these mammals (R. K. Bonde, personal communication). Because individual *Pterygoplichthys* commonly graze on multiple manatees, these catfish may also play a role in disease transmission.

It is conceivable that epibionts protect the skin in some fashion and their removal detrimental. For example, moderately severe skin burns have been reported for Amazonian manatees, *Trichechus inunguis* (Natterer, 1883), after extended exposure to direct sunlight while out of the water (Rosas 1994). However, we doubt that the algae cover on Florida manatees is a necessary protection against ultraviolet (UV) radiation. Their skin is quite different (thicker) than other mammal skin (Kipps et al. 2002; Lightsey et al. 2006) and overexposure to UV radiation by submerged manatees in subtropical Florida is not likely. It is also possible that the dark layer of epibionts on the back of the manatee play a role in heat absorption as the mammal rests in the shallow, clear waters of the spring. If that is the case, removal of the layer by catfish might affect manatee heat balance.

Another potential cost for the manatee may result from energy expenditure through habitat displacement. If irritation by catfish drives manatees from spring runs into the colder river waters, as we suspect, the mammals probably expend more energy in thermoregulation than had they remained in the spring. There is evidence that *Pterygoplichthys* is increasingly abundant in much of the St. Johns River, but it is not known whether they are common or active in the river during winter. Because of high turbidity outside of the springs, and because loricariids are often nocturnal (Power 1983; Buck and Sazima 1995), potential interactions between *Pterygoplichthys* and manatees in the river cannot be assessed. During our short study, it appeared that *Pterygoplichthys* increased their activity near dusk, but whether they continue attaching to manatees at night remains unknown.

In Blue Spring, the manatee wintering population during recent years has exceeded 200 individuals (U.S. Geological Survey-Sirenia Project, unpublished data). In contrast, the minimum winter population of *Pterygoplichthys* in the spring run probably numbers several thousand individuals. Our first record for *Pterygoplichthys* in the St. Johns River drainage was in early 1999 (L.G. Nico, unpublished data). According to a Blue Spring State Park ranger (Wayne C. Hartley, personal communication), the catfish were first observed there in low numbers ca. 2002. At least three other non-native fish species occur in Blue Spring Run, including large numbers of blue tilapia *Oreochromis aureus* (Steindachner, 1864), a small resident population of pirapatinga or redbellied pacu *Piaractus* cf. *brachypomus* (Cuvier, 1818), and occasional large grass carp *Ctenopharyngodon idella* (Valenciennes, 1844), but none were observed associating closely with manatees. Because the association between *Pterygoplichthys* and manatees in the drainage is very recent, further study of the *Pterygoplichthys*/Florida manatee interactions is needed to assess the potential effect on the endangered mammal posed by the introduced catfish.

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