

## NOTES

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### **The Highest Mountain in the Caribbean: Controversy and Resolution via GPS**

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Since 1851 when British consul Sir Robert H. Schomburgk climbed Monte Tina and estimated the height at 3140 m above mean sea level, there has been controversy over which peak in the Cordillera Central of the Dominican Republic is the highest in the Caribbean, and how high that point is (Bolay 1997). In 1912 the botanist Padre Miguel Fuertes declared a mountain he called Loma Rucilla highest at 2855 m, and later the botanist Eric Ekman climbed what he believed to be the same mountain, which he referred to as Loma La Pelona and described as a "barren plateau with two peaks" (Bolay 1997). Ekman's description fits the mountain whose south peak (mapped at 19°01'21"N, 70°59'54"W on the Manabao 1:50000-scale topographic sheet) is named Pico Duarte on modern maps, and whose northern peak (mapped at 19°01'54"N, 71°00'21"W on the Lamedero 1:50000 sheet) is named Loma La Pelona.

One of those two peaks is the highest point of land in the Caribbean—but which one? Pico Duarte is traditionally considered the highest, but the topographic maps show an elevation of 3087 m for both peaks. The name Loma La Rucilla has been given to a peak mapped at 19°02'43"N, 70°57'32"W (see Fig. 1), whose height the topographic map shows as 3038 m, clearly shorter than the other two. While conducting tree-ring research on the northern flank of Loma La Pelona, I had the opportunity to carry global positioning system (GPS) instruments to the top of Pico Duarte and Loma La Pelona to measure precisely the

difference between the heights of these two peaks. I did this by setting up a Trimble Pathfinder Pro XRS receiver as a GPS base station with its antenna fixed to the roof of the new shelter on Loma La Pelona, and then collecting carrier-phase correction data for more than 1 hour at each summit using Trimble GeoExplorer II receivers. Within that local reference frame, my height measurement accuracies are  $\pm 5.8$  cm for Pico Duarte and  $\pm 13.5$  centimeters for Loma La Pelona (99% confidence intervals). On each peak, I set the GPS to measure the tallest surface of natural rock that I could find (avoiding the bust of Juan Pablo Duarte and the flagpole on Pico Duarte, and the fire lookout on Loma La Pelona).

My results indicate that Pico Duarte is indeed the higher of the two peaks, by  $4.34 \pm 0.19$  m when elevation is measured above the 1984 World Geodetic System (WGS 84) ellipsoid (Table 1). Measurements relative to this earth model represent true geometry working from the center of the planet, but do not reflect height above sea level. "Sea level" is actually rather complicated because it follows an equal-gravity surface called the geoid which is somewhat lumpy and dimpled like a raisin (cf. Hoffmann-Wellenhof et al. 2001); GPS software can only estimate where sea level actually is in any given place, and within the Dominican Republic sea level slopes because of the gravity fields of the two tectonic plates, among other reasons. The 1997 Caribbean gravity surface model (Smith and Small, 1999) estimates that "sea level" is about 2.6 cm closer to the center of the earth at Pico Duarte than at Loma La Pelona, relative to the ellipsoid height. This amount adds to the height difference between the two peaks when they are compared in terms of height above estimated sea level (Table 1).

Although I collected these GPS data to accurately determine the elevation *difference* between the Caribbean's two highest peaks, my results also provide estimates of the peaks' actual elevations that may improve somewhat upon the surveying used for existing topographic maps. These estimates are limited by the accuracy with

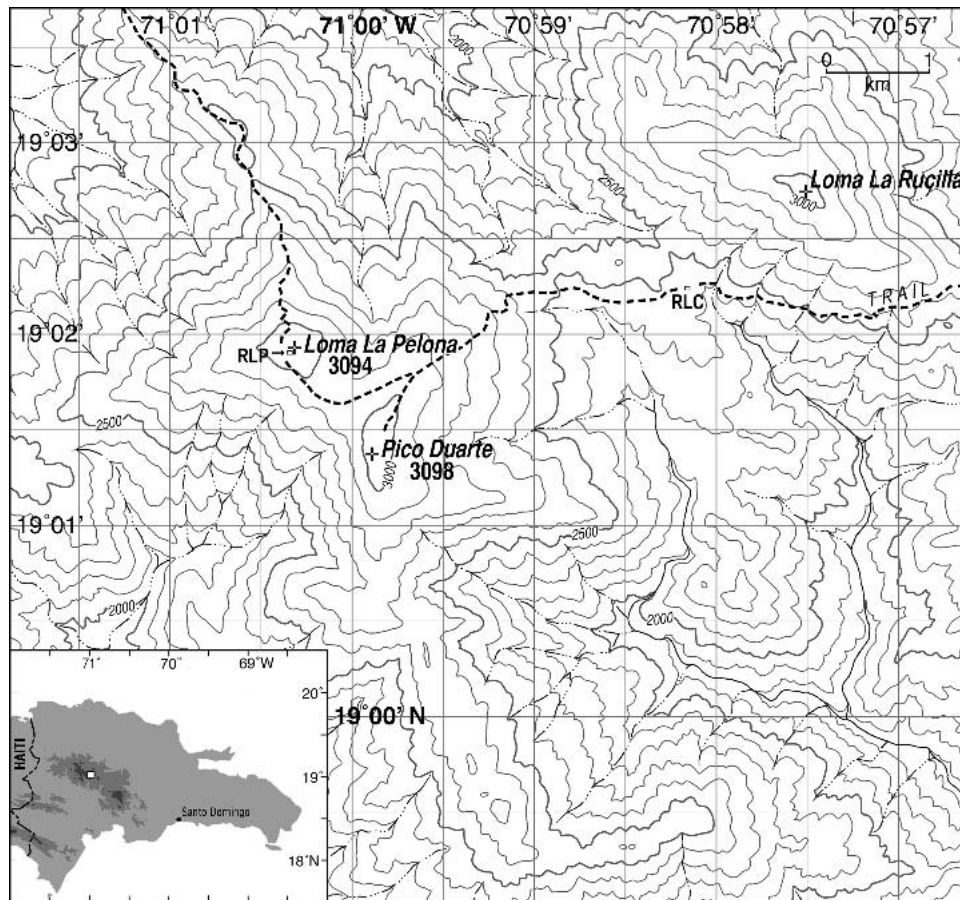


FIG. 1. Map showing locations discussed in text. Contour interval is 100 m. RLP: Refugio La Pelona. RLC: Refugio La Compartición. Inset shows Dominican Republic with location of main map highlighted. Datum is WGS 84; projection is Universal Transverse Mercator (19N). Trails and shelters were mapped using GPS and aerial photography; topography and streams were adjusted from the Lamedero (NW, 1969), Manabao (NE, 1969), Juan de Herrera (SW, 1969) and Gajo de Monte (SE, 1962) 1:50000 scale topographic quadrangles published by the U.S. Army Map Service and compiled by that group in collaboration with the Instituto Cartográfico Militar, the Instituto Cartográfico Universitario and the Inter-American Geodetic Survey.

which I measured the elevation of my temporary base station (by taking the mean of 6,376 fixes, most of them differentially corrected in real time, collected over 15.6 hours), and by any differences between sea level as modeled by Smith and Small (1999) and the vertical datum used in mapping. The global precision of the resulting elevation estimate (99% confidence interval) is  $\pm 2.38$  m, and a conservative estimate of agreement between modeled sea level and the historical vertical datum is  $\pm 2$  m. Adding these and the local-reference-frame uncertainties given above, the global error

term for elevation estimates is approximately  $\pm 4.5$  m—a level of accuracy less than would be ideal, but perhaps good enough to improve upon existing elevational data for the peaks. Estimated using the 1997 Caribbean geoid model (Smith and Small 1999), the elevations are 3,098 m for Pico Duarte, and 3,094 m for Loma La Pelona. These estimates raise the roof of the Caribbean some 11 m at Pico Duarte and 7 m at Loma La Pelona, or more than the uncertainty term in each case. Even the elevation estimate of the new shelter on Loma La Pelona is 3,090 m (at floor level)—i.e. three

TABLE 1. New GPS measurements of the Caribbean's highest points. WGS 84: World Geodetic System 1984 ellipsoid and datum. NAD 27 [Caribbean]: Caribbean implementation of the North American Datum of 1927.

	Loma La Pelona	Pico Duarte
Height relative to WGS 84 ellipsoid surface (99% confidence within local reference frame)	0.00 ± 0.00 m	4.34 ± 0.19 m
Height relative to estimated mean sea level (99% confidence within local reference frame)	0.00 ± 0.00 m	4.36 ± 0.19 m
Height above WGS 84 ellipsoid (99% confidence re. global accuracy)	3,066.4 ± 2.5 m	3,070.8 ± 2.4 m
Estimated elevation above mean sea level (conservative confidence re. estimation precision)	3,094 ± 4.5 m	3,098 ± 4.5 m
GPS Latitude/Longitude (WGS 84 datum) (99% confidence <0.03")	19°01'55.29"N, 71°00'18.93"W	19°01'22.73"N, 70°59'53.08"W
GPS UTM Coordinates (NAD 27 [Caribbean] datum of 1:50000 topographic maps)	288,906 mE, 2,105,379 mN	289,650 mE, 2,104,370 mN
UTM coordinates as mapped (NAD 27 [Caribbean] datum of 1:50000 topographic maps)	288,881 mE, 2,105,405 mN	289,663 mE, 2,104,378 mN

meters higher than the mapped elevation of the peak that rises above it.

Table 1 also lists latitude and longitude of Pico Duarte and Loma La Pelona relative to the modern WGS 84 datum (99% confidence intervals are less than a meter or less than 0.03" latitude or longitude). These positions differ from those on the 1:50000 series of Dominican topographic maps, which date to the 1960s and were based on a different earth model, the Caribbean implementation of the North American Datum of 1927 (NAD 27 [Caribbean]). For convenience in comparing to those maps, I also report GPS-derived Universal Transverse Mercator (UTM) coordinates (zone 19 North) relative to the NAD 27 [Caribbean] datum that was used for creating the topographic maps. In that system the GPS-derived UTM coordinates for the new shelter on Loma La Pelona are 288,872 m E, 2,105,372 m N. This shelter provided a comfortable research base for our recent work and its existence may be of interest to other scientists planning research and travel in the vicinity of the Caribbean's highest peaks.

I have found that very few members of the general public are aware that the Caribbean harbors the highest mountains in

the Americas outside of the principal western cordilleras. The results reported here modestly improve the precision of that claim to fame, and very conclusively establish Pico Duarte as the tallest.

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## First Records of the Pantropical Spotted Dolphin (*Stenella attenuata*) for the Puerto Rican Bank, with a Review of the Species in the Caribbean

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Pantropical spotted dolphins (*Stenella attenuata* [Gray 1846]) are known as an oceanic tropical and subtropical species occurring around the world (Perrin et al. 1987; Perrin and Hohn 1994). The species is well documented for the Pacific Ocean, but its geographical range for the Atlantic Ocean is poorly known, except for the Gulf of Mexico (Mullin et al. 1994; Waring et al. 2002). Leatherwood et al. (1976) speculated that it is common in the Caribbean near coastal areas and islands, parapatric to or replacing the Atlantic spotted dolphin (*Stenella frontalis* [Cuvier 1829]) in the West Indies and Lesser Antilles. However, Perrin and Hohn (1994) only report eight records of *S. attenuata* for the Caribbean, and in Puerto Rico alone, for example, over 50 records exist of the Atlantic spotted dolphin (Mignucci-Giannoni 1998), but none of pantropical spotted dolphins. We document the first records of pantropical spotted dolphins from Puerto Rico, review and present new records for the western North Atlantic and the Caribbean and based on

these, describe the species zoogeography in the Caribbean.

We surveyed the coastal and offshore waters of the Puerto Rico Bank (Puerto Rico, U.S. Virgin Islands and British Virgin Islands) between 16 February and 9 March 2001 aboard the 68.3-m NOAA Ship *Gordon Gunter* (Swartz et al. 2001). Transect survey lines covered the area off the north coast of Puerto Rico out to 293 km, the east coast of Puerto Rico out to the Virgin Passage, the waters around the U.S. and British Virgin islands, the south coast of Puerto Rico out to 257 km from shore, and the entire Mona Channel west to the Dominican Republic.

The genus *Stenella* is thought to be an artificial taxon, containing some species more closely related to species of *Tursiops*, *Delphinus* or *Sousa* than to each other (LeDuc et al. 1999). *S. frontalis* is genetically more closely related to *T. truncatus* and *T. aduncus* (Ehrenberg 1833) than to *S. attenuata* (LeDuc et al. 1999). Differentiating between similar species in this group, as in the case of the pantropical and Atlantic spotted dolphins, is not easy for the untrained observer. Roden and Mullin (2000) noted that spotted dolphin records published before the revision of the spotted dolphins by Perrin et al. (1987) are difficult to interpret or corroborate. It is important to have both written and pictorial observation records to confirm the identification of spotted dolphins. For this purpose, we used descriptions for both species of spotted dolphins based on Perrin et al. (1987), Jefferson et al. (1993), Perrin and Hohn (1994), Perrin et al. (1994), and Perrin (2002a,b) (Table 1, Fig. 1), which should help as a future reference in identifying the two species in Caribbean waters. Aside from having spots, the two species are very distinct, and diagnostic differentiation between the two can be summarized: (1) for carcasses, the vertebral count of *S. attenuata* is distinct (74-84) from that of *S. frontalis* (67-72); (2) the color pattern for *S. attenuata* consist of two parts (dark gray dorsal cape with sharply defined border and lighter lateral and ventral areas), while in *S. frontalis* it consists of three parts (dark gray dorsal

cape, lighter gray lateral field, and white ventral field); (3) a lighter gray spinal blaze invades the dorsal cape in *S. frontalis*, and is absent in *S. attenuata*; (4) the penduncle is divided into upper dark and lower light halves in *S. attenuata*, not in *S. frontalis*; (5) *S. frontalis* exhibits a combination of blaze and spots; and (6) *S. attenuata* has white lips and a marked white tip of the snout.

*Sightings.*—We observed numerous Atlantic spotted dolphins, bottlenose dolphins (*Tursiops truncatus* [Montagu 1821]), rough-tooth dolphins (*Steno bredanensis* [Lesson 1828]), shortfin pilot whales (*Globicephala macrorhynchus* Gray 1846), false killer whales (*Pseudorca crassidens* [Owen 1846]), beaked whales (*Mesoplodon* spp.), Cuvier's beaked whales (*Ziphius cavirostris* Cuvier 1823), sperm whales (*Physeter macrocephalus* Linnaeus 1758) and humpback whales (*Megaptera novaeangliae* [Borowski 1781]) (Swartz et al. 2001). On four occasions, we observed groups of pantropical spotted dolphins (Table 2). These were distinguished from Atlantic spotted dolphins based on morphological features and coloration pattern (Table 1, Fig. 1).

On 16 February 2001, five pantropical spotted dolphins were observed riding the bow wave of the ship, 23.2 km W of Punta Guaniquilla, Cabo Rojo, Puerto Rico. On 18 February, 18 pantropical spotted dolphins were observed over the Puerto Rican Trench, 95.4 km NNE of Cabo San Juan, Fajardo, Puerto Rico. These dolphins were bowriding when three rough-tooth dolphins approached the ship's bow and displaced them. We sighted the species again on 28 February after observing a group of 20 Atlantic spotted dolphins bowriding 11.1 km SW of Punta Cucharas, Ponce, Puerto Rico. Following the departure of the Atlantic spotted dolphins from the ship's bow wave, two pantropical spotted dolphins approached the ship and rode the bow wave (Fig. 2). Later that same day 15 pantropical spotted dolphins were observed 33.3 km SSW of Punta Brea, Guánica, Puerto Rico. These were traveling perpendicular to the ship's course and rode its bow.

*Historical review of Caribbean records.*—Ninety-two previous records of the pantropical spotted dolphin exist from the Ca-

ribbean (Table 2), most either unpublished, in gray literature or in scattered published literature.

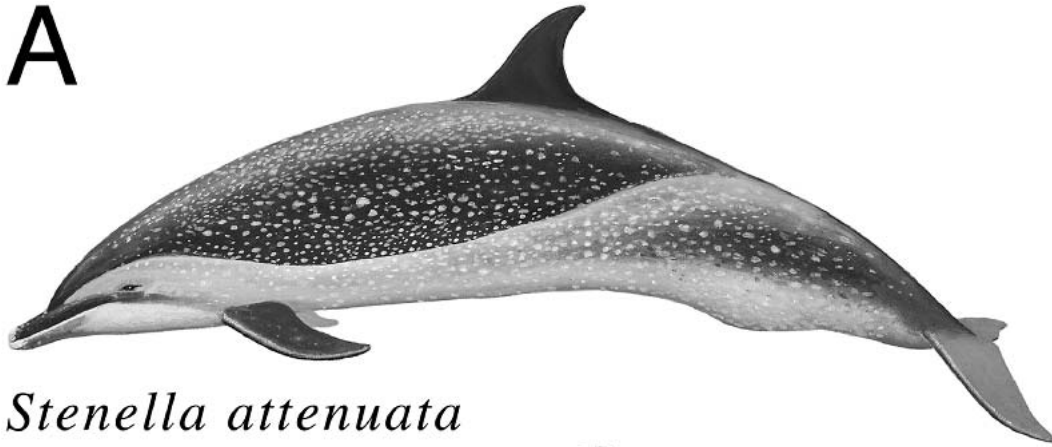
Two *S. attenuata* were captured and killed in the small-cetacean fishery off Saint Vincent in 1967 and 1968 (Caldwell et al. 1971). Taruski and Winn (1976) conducted surveys in the West Indies and Lesser Antilles between 1969 and 1973 aboard the R/V *Trident* and *Sir Horace Lamb*. They recorded 12 sightings of spotted dolphins (*Stenella* spp.), but did not specify which of the two species was observed. They divided the sightings into two groups, one for animals found near the South American mainland (species "A") and one for animals off the island chains (species "B"). However, at this time it is difficult to corroborate whether either group of sightings ("A" or "B") was of *S. attenuata* or *S. frontalis*. At least one sighting off Grenada in February 1972 (not detailed in Taruski and Winn [1976]) is of a *S. attenuata* based on photographic evidence (W. F. Perrin pers. comm.). A pantropical spotted dolphin was reported stranded at Ensenada de Gayraca, Parque Nacional Tayrona, in Magdalena, Colombia in 1974 (Vidal 1990). Two *S. attenuata* were sighted during Bryde's whale (*Balaenoptera edeni* Anderson 1878) research off the west part of the Península de Paria, Venezuela in 1979 (G. N. Di Sciara pers. comm., Romero et al. 2001).

Perrin et al. (1987) reported opportunistic sightings of pantropical spotted dolphins off the western end of Haiti's southern peninsula in 1980, Saint Lucia in 1983, and off western Cuba in 1984 and 1985. A stranded *S. attenuata* was reported at Isla Pirata in the Parque Nacional Natural Corales del Rosario in Bolívar, Colombia in 1983 (C. A. Bohorquez pers. comm., Vidal 1990). Dedicated surveys for cetaceans, especially sperm whales, aboard the *Eleuthera II*, *Ida-Z* and *Abel-J* between 1981 and 1995, yielded numerous sightings of pantropical spotted dolphins off Dominica, Martinique and Guadeloupe (Watkins and Moore 1982, Watkins et al. 1985, Watkins et al. 1993, Watkins et al. 1994, Watkins et al. 1997). Surveys conducted in the southwestern Caribbean aboard the R/V *Siben* in 1988, R/V *Malpelo* in 1990 and R/V *Odyssey* in

TABLE 1. Comparisons of morphological, anatomical and color pattern diagnostic characteristics used in species identification between pantropical spotted dolphins (*Stenella attenuata*) and Atlantic spotted dolphins (*Stenella frontalis*).

Characters	<i>Stenella attenuata</i>	<i>Stenella frontalis</i>
Body	Slender and streamlined.	Robust or stocky body, similar to bottlenose dolphins, but with a narrower peduncle.
Snout	Long and narrow, with a clear demarcation with the melon.	Of medium length, not as short as that of the bottlenose dolphin and not as long as that of <i>S. attenuata</i> or the spinner dolphin. There is a clear demarcation between the snout and the melon as in the bottlenose dolphin.
Dorsal fin	Curved, narrow and pointed at the tip.	Tall, distinctly falcated backwards, pointed at the tip, and located at mid-body.
Flippers	Small and pointed.	Curved at the leading edge and pointed at the tips.
Flukes	Pointed at the tips, with a slight notch in the middle and have slightly concave trailing edges.	Thin with a median notch.
Color pattern	Bipartite color pattern. The peduncle is divided into dark upper and light lower halves. It has a sharply defined dark gray cape on its back, running from the melon to behind the dorsal fin. A medium gray flank runs from the apex of the melon, just above the eyes to the peduncle and flukes. A dark gray coloration circles the eye, with a connecting stripe towards the melon and upper jaw, and a stripe towards the flipper, sometimes referred as the bridle. In adults, the lips are strikingly white as well as the tip of the snout, a diagnostic characteristic easily observed from elevated platforms such as airplanes and large vessels.	Three-part color pattern: a dark gray dorsal cape, lighter gray sides and a white belly. The base color is blue or gray. The cape is dark gray and is interrupted on each side by a lighter spinal blaze that sweeps up and back near the dorsal fin. There is a light gray line connecting the flippers with eyes. The tip of the snout is often white, but not as striking as in <i>S. attenuata</i> .
Spotting	In adults, the dark cape region is covered with medium gray spots, while the flank and belly have darker spots. Juveniles and calves have very few or lack spots all together. Spots develop during the onset of puberty, first with dark spots in the underside and then light spots on the upper side.	The ground pattern is superimposed with dark ventral and light dorsal spots. Spots develop at the onset of puberty. The extent of spotting becomes more intense with age, somewhat obscuring the three-part pattern. Smaller individuals lack spots.
Regional spotting	In the Pacific Ocean, offshore individuals are less spotted than coastal forms. Dolphins in the southwestern Caribbean were lightly or not spotted. Animals in the West Indies were more heavily spotted than the animals in the Gulf of Mexico.	In comparison to other areas, Atlantic spotted dolphins from the Caribbean show medium spotting with the underlying ground pattern visible even in mature animals.
Length	160-240 cm.	Smaller than other geographical populations of the species, 165-205 cm, averaging 180 cm when full grown.
Weight	Up to 120 kg.	Up to 143 kg.
Maturity	Females at 190 cm, males at 200 cm.	Females at 186 cm.
Birth size	85 cm.	76-120 cm.
Dentition	Conical teeth, 35-48 on each row of the upper jaw, 34-47 in each side of mandible, totaling 138-190. Tooth size is between 2.6 and 4.1 mm in diameter.	Conical teeth, 32-42 on each row of the upper jaw, 30-40 in each rami of the mandible, totaling 124-164. Tooth size is between 3.2 and 5.3 mm in diameter.
Vertebral formula	C <sub>7</sub> T <sub>16</sub> L <sub>20</sub> Ca <sub>37</sub> = 80 (74-84)	C <sub>7</sub> T <sub>14</sub> L <sub>17</sub> Ca <sub>32</sub> = 70 (67-72)

A

*Stenella attenuata*

B

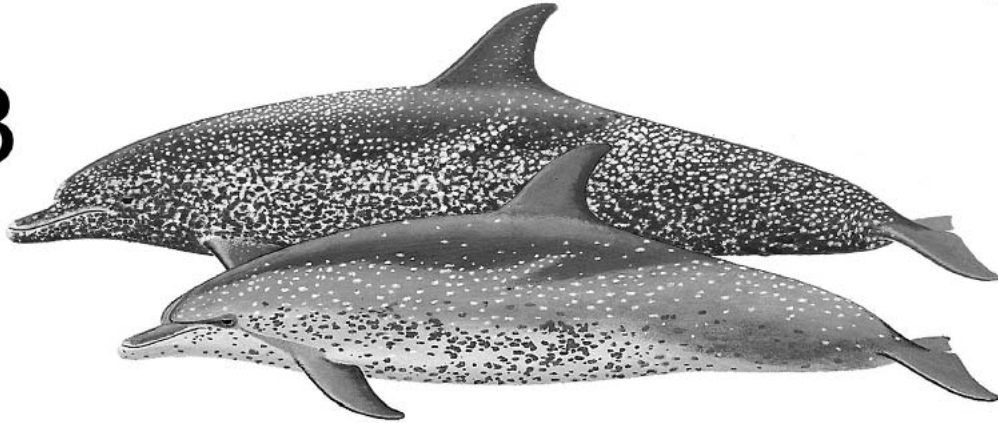
*Stenella frontalis*

FIG. 1. Species portraits of a (A) pantropical spotted dolphin (*Stenella attenuata*) and two (B) Atlantic spotted dolphin (*Stenella frontalis*), illustrating morphological and color pattern diagnostic characteristics used for species identification. Illustration by Pieter Arend Folkens.

1994 (Palacios et al. 1996) yielded a sighting of 300-400 pantropical spotted dolphins in Jamaican waters near the Serranilla Bank in August 1990 (Palacios et al. 1995).

Caribbean surveys by Jefferson and Lynn (1994) in 1991 reported sightings of *S. attenuata* southeast of the Bahamas, near Martinique, north of Santa Marta in Colombia, off Panamá, Honduras and Belize. A July 1991 stranding of a dolphin in Curaçao, Netherland Antilles, initially identified as a striped dolphin (*Stenella coeruleoalba* [Meyen 1833], Debrot and Barros 1994), was later confirmed by genetic analysis to be *S. attenuata* (LeDuc et al. 1997). A stranding initially reported as a female *S. frontalis*



FIG. 2. A pantropical spotted dolphin (*Stenella attenuata*) riding the bow of the NOAA Ship Gordon Gunter south of Puerto Rico in February 2001.

TABLE 2. Sighting, stranding and capture records for the pantropical spotted dolphin (*Stenella attenuata*) in the Caribbean.

Date	Locality	Latitude/longitude	No. animals	Depth	Temp	Event	Reference
1 Jun 1967	Barrouallie, Saint Vincent, VC	13°14.4'N 61°16.6'W	1	—	—	Capture	Caldwell et al. 1971
24 May 1968	Barrouallie, Saint Vincent, VC	13°14.4'N 61°16.6'W	1	—	—	Capture	Caldwell et al. 1971
-- Feb 1972	Grenada, GD	—	—	—	—	Sighting	Perrin et al. 1987
21 Jun 1974	Ensenada de Gayraca, Magdalena, CO	11°20.0'N 74°05.0'W	1	—	—	Stranding	Vidal 1990
--- 1979	6 km N of Isla Picuda Chica, Anzoategui, VE	10°21.8'N 64°33.8'W	2	—	—	Sighting	Romero et al. 2001
22 Jul 1980	50 km WNW of Cap Dame-Marie, HT	18°52.0'N 74°50.0'W	30	1719 m*	—	Sighting	Perrin et al. 1987
23 Jul 1980	30 km WNW of Cap Dame-Marie, HT	18°43.0'N 74°42.0'W	—	1558 m*	—	Sighting	Perrin et al. 1987
--- 1983	S coast of Isla Pirata, Islas del Rosario, Bolivar, CO	10°10.8'N 75°46.6'W	1	—	—	Stranding	C. Bohorquez, upubl. data
31 Oct 1983	9 km NW of Pointe Du Cap, LC	14°11.0'N 61°00.0'W	35	746 m*	—	Sighting	Perrin et al. 1987
14 Nov 1983	19 km WSW of Indian Gallows, Saint Vincent, VC	13°12.0'N 61°27.0'W	100	—	—	Sighting	Watkins et al. 1985
19 Mar 1984	1 km W of Point Ronde, DM	15°32.0'N 61°30.0'W	12	819 m*	—	Sighting	Watkins et al. 1985
20 Mar 1984	2 km SW of Prince Rupert Bluff, DM	15°34.0'N 61°30.0'W	10	664 m*	—	Sighting	Watkins et al. 1985
21 Mar 1984	2 km NW of Prince Rupert Bluff, DM	15°33.0'N 61°35.0'W	40	—	—	Sighting	Watkins et al. 1985
23 Mar 1984	7 km W of Cap Salomon, MQ	14°30.0'N 61°10.0'W	20	2300 m*	—	Sighting	Watkins et al. 1985
23 Mar 1984	7 km W of Cap Salomon, MQ	14°30.0'N 61°10.0'W	100	2300 m*	—	Sighting	Watkins et al. 1985
24 Mar 1984	3 km SW of Pointe du Diamont, MQ	14°26.0'N 61°05.0'W	40	750 m*	—	Sighting	Watkins et al. 1985
25 Mar 1984	5 km SW of Pointe du Precheur, MQ	14°46.0'N 61°16.0'W	25+	800 m*	—	Sighting	Watkins et al. 1985
26 Mar 1984	11 km W of Case Pilote, MQ	—	10	—	—	Sighting	Watkins et al. 1985
27 Mar 1984	11 km WSW of Prince Rupert Bluff, DM	15°36.0'N 61°30.0'W	20	806 m*	—	Sighting	Watkins et al. 1985
27 Mar 1984	5 km WSW of Grand Savanne, DM	15°25.0'N 61°30.0'W	30+	888 m*	—	Sighting	Watkins et al. 1985
27 Mar 1984	7 km WNW of Grand Savanne, DM	15°27.0'N 61°31.0'W	80+	—	—	Sighting	Watkins et al. 1985
29 Mar 1984	4 km WSW of Cape Melville, DM	15°38.0'N 61°30.0'W	10	753 m*	—	Sighting	Watkins et al. 1985
29 Mar 1984	4 km WSW of Cape Melville, DM	15°38.0'N 61°30.0'W	30	753 m*	—	Sighting	Watkins et al. 1985
3 Oct 1984	52 km NW of Cabo Jutias, CU	23°00.0'N 84°20.0'W	12-25	—	—	Sighting	Perrin et al. 1987
18 Sep 1985	168 km S of Cabo Corrientes, CU	20°14.0'N 84°35.0'W	5	—	—	Sighting	Perrin et al. 1987
18 Sep 1985	183 km S of Cabo Corrientes, CU	20°06.0'N 84°29.0'W	25	—	—	Sighting	Perrin et al. 1987
28 Apr 1987	3 km W of Prince Rupert Bluff, DM	15°35.0'N 61°31.0'W	2+	1063 m*	—	Sighting	This paper
29 Apr 1987	8 km WSW of Point Ronde, DM	15°31.0'N 61°34.0'W	3+	1685 m*	—	Sighting	This paper
30 Apr 1987	2 km ESE of Pointe du Precheur, MQ	14°47.0'N 61°13.0'W	300	400 m*	—	Sighting	This paper
1 May 1987	2 km SW of Prince Rupert Bluff, DM	15°34.0'N 61°30.0'W	100	664 m*	—	Sighting	This paper
5 May 1987	20 km NNE of Pointe du Marigot, MQ	15°00.0'N 61°00.0'W	20	850 m*	—	Sighting	This paper
7 May 1987	25 km W of Pointe Bottereau, GP	16°00.0'N 61°00.0'W	100	1024 m*	—	Sighting	This paper
6 Aug 1990	330 km SSW of South Negri Point, JM	15°25.0'N 79°17.0'W	300-400	2222 m*	—	Sighting	Palacios et al. 1986
17 Oct 1990	3 km W of Woodbridge Bay, DM	15°18.9'N 61°25.9'W	40	—	—	Sighting	This paper
18 Oct 1990	2 km WNW of Point Ronde, DM	15°32.5'N 61°30.5'W	2+	770 m*	—	Sighting	This paper
18 Oct 1990	1 km NNNW of Point Cabrier, DM	15°29.8'N 61°28.9'W	5+	817 m*	—	Sighting	This paper



TABLE 2. Continued.

Date	Locality	Latitude/longitude	No. animals	Depth	Temp	Event	Reference
21 Oct 1990	4 km S of Taron Point, DM	15°27.8'N 61°32.3'W	150	—	—	Sighting	This paper
12 Jun 1991	256 km NE of Mayaguana Island, BH	24°10.0'N 71°14.0'W	20	5300 m	27.5°C	Sighting	Jefferson and Lynn 1994
28 Jun 1991	9 km W of Pointe de la Batterie, MQ	14°40.0'N 61°15.0'W	40	2010 m	—	Sighting	Jefferson and Lynn 1994
1 Jul 1991	10 km W of Cap Enrage, MQ	14°38.0'N 61°15.0'W	30	2050 m	—	Sighting	Jefferson and Lynn 1994
10 Jul 1991	216 km N of Cabo de la Aguja, Santa Marta, CO	13°12.0'N 74°16.0'W	6	3915 m	—	Sighting	Jefferson and Lynn 1994
11 Jul 1991	273 km NNE of Punta San Blas, PA	11°50.0'N 78°05.0'W	2	3630 m	27.8°C	Sighting	Jefferson and Lynn 1994
12 Jul 1991	71 km NW of Punta Manzanillo, PA	10°05.0'N 79°58.0'W	50	1865 m	27.8°C	Sighting	Jefferson and Lynn 1994
13 Jul 1991	10 km SE of Kaap St. Marie, Curaçao, AN	12°08.0'N 69°00.0'W	1	—	—	Stranding	LeDuc et al. 1997
16 Jul 1991	143 km NNE of Cabo Falso, HN	16°20.0'N 82°38.0'W	4	50 m	—	Sighting	Jefferson and Lynn 1994
17 Jul 1991	117 km NNE of Isle Guanajas, HN	17°21.0'N 85°20.0'W	4	4875 m	—	Sighting	Jefferson and Lynn 1994
17 Jul 1991	148 km ENE of Turneffe Island, BZ	17°32.0'N 86°22.0'W	4	4100 m	27.8°C	Sighting	Jefferson and Lynn 1994
-- Aug 1991	Playa La Restinga, Isla Margarita, Nueva Esparta, VE	10°59.7'N 64°02.5'W	1	—	—	Stranding	L. A. Bermudez, unpubl. data
24 Oct 1991	3 km SW of Point Ronde, DM	15°30.9'N 61°30.5'W	12	—	—	Sighting	This paper
24 Oct 1991	5 km W of Cape Melville, DM	15°38.5'N 61°30.6'W	20	753 m*	—	Sighting	This paper
25 Oct 1991	1 km W of Point Ronde, DM	15°32.0'N 61°30.0'W	20	606 m*	—	Sighting	This paper
25 Oct 1991	4 km S of Taron Point, DM	15°21.0'N 61°25.6'W	25	536 m*	—	Sighting	This paper
26 Oct 1991	2 km SW of Point Cachacrou, DM	15°12.0'N 61°24.0'W	25	941 m*	—	Sighting	This paper
26 Oct 1991	4 km WSW of Cape Melville, DM	15°37.5'N 61°30.2'W	10-12	175 m	—	Sighting	Walkins et al. 1994
27 Oct 1991	4 km WSW of Cape Melville, DM	15°38.0'N 61°30.0'W	15	782 m*	—	Sighting	Watkins et al. 1997
18 Apr 1993	3 km WNW of Point Cabrier, DM	15°30.3'N 61°30.2'W	50+	—	—	Sighting	This paper
21 Apr 1993	7 km W of Taron Point, DM	15°22.8'N 61°29.9'W	—	1602 m*	—	Sighting	This paper
22 Apr 1993	9 km W of Point Cabrier, DM	15°30.4'N 61°33.6'W	30+	—	—	Sighting	This paper
26 Apr 1993	9 km WNW of Point Cabrier, DM	15°30.6'N 61°31.0'W	40+	—	—	Sighting	This paper
6 May 1994	3 km WNW of Point Ronde, DM	15°32.6'N 61°31.2'W	2+	1069 m*	—	Sighting	This paper
6 May 1994	2 km N of Point Ronde, DM	15°32.1'N 61°30.8'W	2+	606 m*	—	Sighting	This paper
6 May 1994	2 km W of Point Ronde, DM	15°32.2'N 61°30.8'W	2+	606 m*	—	Sighting	This paper
6 May 1994	3 km WSW of Prince Rupert Bluff, DM	15°34.5'N 61°31.1'W	6	1000 m*	—	Sighting	This paper
10 May 1994	3 km SW of Prince Rupert Bluff, DM	15°34.2'N 61°30.5'W	15	913 m*	—	Sighting	This paper
11 May 1994	6 km W of Woodbridge Bay, DM	15°18.9'N 61°27.5'W	4	1032 m*	—	Sighting	This paper
1 Mar 1995	24 km S of Cabo Beata, DO	17°23.0'N 71°27.0'W	12	640 m	26.7°C	Sighting	Roden and Mullin 2000
2 Mar 1995	66 km SSW of Cap Tiburon, HT	17°46.0'N 74°38.0'W	12	733 m	27.5°C	Sighting	Roden and Mullin 2000
2 Mar 1995	63 km SSW of Cap Tiburon, HT	17°46.0'N 74°33.0'W	12	725 m	27.4°C	Sighting	Roden and Mullin 2000
2 Mar 1995	62 km SSW of Cap Tiburon, HT	17°46.0'N 74°31.0'W	13	2430 m	27.3°C	Sighting	Roden and Mullin 2000
2 Mar 1995	43 km SW of Pointe a Gravois, HT	17°42.0'N 74°08.0'W	100	1540 m	27.2°C	Sighting	Roden and Mullin 2000
8 Mar 1995	95 km NNW of Grand Cayman Island, KY	20°07.0'N 81°52.0'W	23	1300 m	26.7°C	Sighting	Roden and Mullin 2000

TABLE 2. Continued.

Date	Locality	Latitude/longitude	No. animals	Depth	Temp	Event	Reference
26 Apr 1995	2 km WSW of Point Ronde, DM	15°31.3'N 61°30.6'W	15	872 m*	—	Sighting	This paper
1 May 1995	6 km WSW of Cape Melville, DM	15°37.4'N 61°31.2'W	1+	782 m*	—	Sighting	This paper
21 May 1995	8 km ESE of Punt Kanon, Curaçao, AN	12°01.0'N 68°40.0'W	50+	330 m*	—	Sighting	Debrot et al. 1998
14 Mar 1998	3 km S of Jan Thiel Baij, Curaçao, AN	12°03.0'N 68°52.0'W	15	1000 m*	—	Sighting	Debrot et al. 1998
14 Apr 1999	4 km WSW of Grand Caille Point, LC	13°51.0'N 61°07.0'W	20	1792 m*	—	Sighting	ECCN, unpubl. data
14 Apr 1999	15 km WNE of Grand Caille Point, LC	13°55.0'N 61°13.0'W	30-50	—	—	Sighting	ECCN, unpubl. data
17 Feb 2000	N coast of Tobago, Tobago, TT	—	20	—	—	Sighting	Carlson et al. 2000
19 Feb 2000	5 km WSW of Pointe Habitants, GP	16°03.0'N 61°49.0'W	11	915 m	26.7°C	Sighting	Swartz and Burks 2000
19 Feb 2000	6 km WNW of Pointe Colibris, GP	16°19.0'N 61°09.0'W	15	1190 m	26.1°C	Sighting	Swartz and Burks 2000
19 Feb 2000	5 km WNW of Pointe Habitants, GP	16°05.0'N 61°49.0'W	175	915 m	26.6°C	Sighting	Swartz and Burks 2000
22 Feb 2000	10 km NW of Grand Caille Point, LC	13°56.0'N 61°09.0'W	45	2507 m	26.6°C	Sighting	Swartz and Burks 2000
19 Mar 2000	9 km WSW of Moliniere Point, GD	12°04.0'N 61°51.0'W	5	1219 m	27.1°C	Sighting	Swartz and Burks 2000
19 Mar 2000	7 km W of Moliniere Point, GD	12°05.0'N 61°50.0'W	15	1215 m	27.3°C	Sighting	Swartz and Burks 2000
19 Mar 2000	7 km W of Moliniere Point, GD	12°06.0'N 61°50.0'W	20	1096 m	27.3°C	Sighting	Swartz and Burks 2000
20 Mar 2000	33 km SE of Galera Point, Trinidad, TT	10°39.0'N 60°40.0'W	15	49 m	27.4°C	Sighting	Swartz and Burks 2000
24 Mar 2000	18 km N of Pointe du Marigot, MQ	14°59.0'N 61°01.1'W	45	791 m	26.8°C	Sighting	Swartz and Burks 2000
25 Mar 2000	1-2 km W of Roseau, DM	15°16.5'N-	10-20	—	—	Sighting	A. Hill, pers. comm.
14 Nov 2000	31 km SE of Punta Garambeo, Isla la Trotruga, VE	10°39.8'N 65°07.7'W	30	800 m*	—	Sighting	ECCN, unpubl. data
16 Feb 2001	23.2 km W of Punta Guaniquilla, Cabo Rojo, PR	18°01.0'N 67°25.6'W	5	655 m	26.8°C	Sighting	This paper
18 Feb 2001	95.4 km NNE of Cabo San Juan, Fajardo, PR	19°14.7'N 65°27.6'W	18	7137 m	26.0°C	Sighting	This paper
28 Feb 2001	11.1 km SW of Punta Cucharas, Ponce, PR	17°52.6'N 66°43.1'W	2	1007 m	26.9°C	Sighting	This paper
28 Feb 2001	33.3 km SSW of Punta Brea, Guánica, PR	17°38.0'N 67°00.7'W	15	3038 m	25.5°C	Sighting	This paper
12 Nov 2001	35 km WSW of Punta Arenas, Sucre, VE	10°20.1'N 64°30.5'W	4	100 m*	—	Sighting	L. A. Bermudez, unpubl. data
9 Mar 2002	1-2 km W of Roseau, DM	15°16.5'N-	50-100	—	—	Sighting	A. Hill, pers. comm.
7 Mar 2003	1-2 km W of Roseau, DM	15°16.5'N-	30-40	—	—	Sighting	A. Hill, pers. comm.

BS = Bahamas, BZ = Belize, KY = Cayman Islands, CO = Colombia, CU = Cuba, DM = Dominica, DO = Dominican Republic, GD = Grenada, GP = Guadeloupe, HT = Haiti, HN = Honduras, JM = Jamaica, MQ = Martinique, AN = Netherland Antilles, PA = Panama, PR = Puerto Rico, LC = Saint Lucia, VC = Saint Vincent and the Grenadines, TT = Trinidad and Tobago, TC = Turks and Caicos, VE = Venezuela.

\*Calculated depth from nautical chart.

— (dash) Data not collected or available.

at Playa La Restinga on Isla Margarita, Venezuela in August 1991 and now catalogued in the Museo Oceanológico Hermano Benigno Román, Estación de Investigaciones Marinas de Margarita (EDIMAR) at Fundación La Salle de Ciencias Naturales, was identified by vertebral counts to be *S. attenuata* (J. Bolaños pers. comm., L. A. Bermúdez unpubl. data). Surveys conducted in 1995 aboard the NOAA Ship *Oregon II* off the West Indies and upper Lesser Antilles, documented pantropical spotted dolphins off the south coast of the Dominican Republic, south of the southern peninsula of Haiti and northwest of the Cayman Islands (Roden and Mullin 2000). Opportunistic sightings of *S. attenuata* were reported for Curaçao in 1995 and 1998 (Debrot et al. 1998), for Saint Lucia in 1999 and for Isla La Tortuga in Venezuela in 2000 by the Eastern Caribbean Cetacean Network (N. Ward pers. comm.).

A sighting of a pantropical spotted dolphin was reported during visual and acoustic surveys for cetaceans conducted off Tobago Island aboard the *Silurian* (Carlson et al. 2000). An earlier survey aboard the NOAA Ship *Gordon Gunter* in the Lesser Antilles and off the central and east coast of Venezuela in 2000 yielded nine sightings of *S. attenuata* in Guadeloupe, Martinique, Saint Lucia, Grenada, and Trinidad (Swartz and Burks 2000). Opportunistic sightings of pantropical spotted dolphins have been reported off Dominica during pelagic bird watching cruises in March 2000, 2002 and 2003 (A. Hill pers. comm.), and off the western part of the Paria Peninsula in Venezuela in November 2001 (L. A. Bermúdez pers. comm.).

No sightings or strandings were previously reported in waters of Puerto Rico or the Virgin Islands based on interviews with fishermen and boaters, or previous research efforts or surveys (Erdman 1970, Erdman et al. 1973; Levenson and Leapley 1978; Marion 1987; Mattila 1984, Mattila and Clapham 1989, Mattila et al. 1998; McLean 1983; Mignucci-Giannoni 1989, Mignucci-Giannoni 1998, Mignucci-Giannoni et al. 1993, Mignucci-Giannoni et al. 2000, Rodriguez-Ferrer 2001). Thus, the 2001 sight-

ings constitute the first records of *S. attenuata* for the Puerto Rican Bank.

*Zoogeographical review.*—Caribbean pantropical spotted dolphins were sighted in groups that varied between 2 and 400 individuals, with an average of 34.8 individuals per group (SE = 5.9,  $n = 87$ ). In the Gulf of Mexico, average group sizes were between 45.4 and 67.4 individuals (range 5-650, Davis et al. 2000), 71.8 individuals (range 7-186,  $n = 23$ , Mullin et al. 1994) and 47.2 individuals (range 3-180,  $n = 164$ , CV=0.20; K. D. Mullin pers. comm.). The average group size in the U.S. Atlantic was 77.5 (range 35-145,  $n = 6$ , Mullin and Fulling 2003).

Mixed-species sightings of pantropical spotted dolphins with other delphinids were reported in eight encounters in the Caribbean, including with Fraser's dolphins (*Lagenodelphis hosei* Fraser 1956, three encounters), striped dolphins (two encounters), spinner dolphins (*Stenella longirostris* [Gray 1828], one encounter), Atlantic spotted dolphins (one encounter), rough-tooth dolphins (one encounter), and common dolphins (*Delphinus* sp., one encounter). Two of these were three-species combinations: spinner, striped and pantropical spotted dolphins in Martinique, and Fraser's, striped and pantropical spotted dolphins in Dominica. Multi-species associations like these involving *S. attenuata* have been reported for the eastern tropical Pacific (Au and Perryman 1985) but not for the Gulf of Mexico (Mullin et al. 1994). Pantropical spotted dolphins were observed bowriding in 13.3 percent of the sightings recorded for the Caribbean.

The species was observed in all seasons, whether defined as winter (December-February), spring (March-May), summer (June-August) or fall (September-November), or as rainy (June-November) or dry (December-May) seasons, which is more appropriate for the Caribbean. Sightings were recorded during all months of the year except January and December, most probably due to lack of effort in those months. The highest number of sightings was during March, an artifact of winter surveys for humpback and sperm whale surveys in the area. There may be a slight in-

crease of sighting rate during the spring months, even if corrected for the increase in effort in March. Water temperature depends on season, although it varies little in the tropical Caribbean, ranging from a cold average of 26.2°C in February to a warm average of 28.8°C in October (Corredor and Morel 2001). Surface water temperatures taken with each sighting (during February, March, June, and July), varied from 25.5°C to 27.8°C (mean 27.0°C, SD = 0.6, SE = 0.13,  $n = 23$ ), similar to those encountered in the Gulf of Mexico (mean 25.0°C, range 24–27.5°C,  $n = 62$ , NMFS SEFSC unpubl. data). It appears from the 89 records with data on month of occurrence that pantropical spotted dolphins are year-round residents of the Caribbean. While the seasonality of the species in the Gulf of Mexico is still unresolved (K. D. Mullin pers. comm.), Mullin et al. (1994) and Davis et al. (2000) sighted the species during all seasons except winter, but mostly during the summer, and Hansen et al. (1996) observed the species in all seasons during more extensive seasonal surveys in the Gulf of Mexico. In the Southeastern U.S., it was recorded during aerial surveys in the winter (NMFS SEFSC unpubl. data) and along the U.S. mid-Atlantic

coast in July and August (Waring et al. 2002).

Caldwell et al. (1971), and later Taruski and Winn (1976), made distinctions between the distributions of *S. frontalis* and *S. attenuata* in the Caribbean, noting that *S. attenuata* was distributed around the Greater Antilles and that *S. frontalis* near the continents. Taruski and Winn (1976) supported this statement based on their loosely identified spotted dolphin data. Leatherwood et al. (1976) described the distribution of *S. attenuata* in the Caribbean as primarily near coastal areas and islands, e.g., the West Indies, and suggested that *S. attenuata* replaces *S. frontalis* around the West Indies. Based on the 96 records presented here, the pantropical spotted dolphin is distributed in all major areas of the Caribbean Sea (Fig. 3), including the eastern coast of Central America (5.2% of the records), the northern coast of South America (12.5%), the West Indies (17.7%), and more commonly in the Lesser Antilles (64.6%). Gaps in distribution, especially off Central America, are related to the lack of survey effort.

*S. attenuata* were commonly found in the Caribbean in oceanic waters, off the shelf

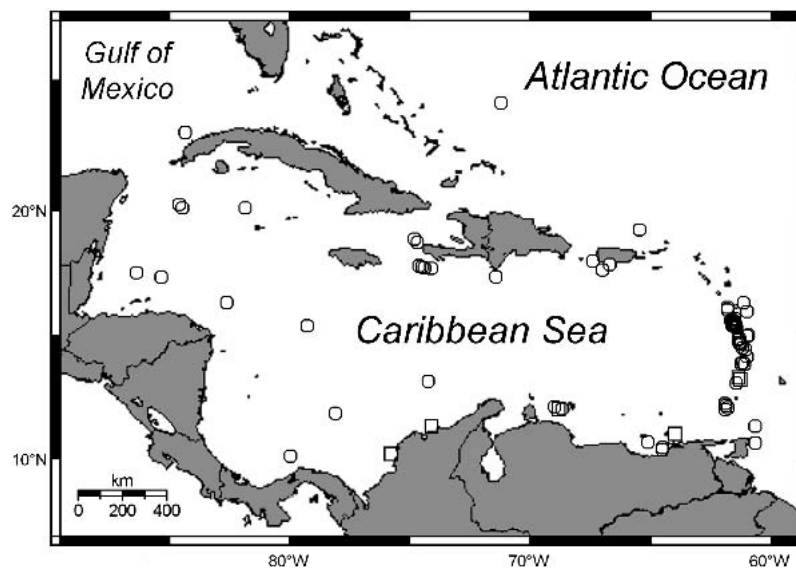


FIG. 3. Distribution of sighting and stranding records of the pantropical spotted dolphin (*Stenella attenuata*) for the Caribbean (circles = sightings, squares = strandings or captures).

edge. Depths at sighting locations ranged from 49 to 7137 m (27-3900 fathoms, mean = 1393.5 m, SE = 151.3,  $n = 70$ ), but pantropical spotted dolphins were found most commonly in areas with a bathymetry between 600 and 2500 m (328-1367 fathoms). One of the sightings was recorded over the Puerto Rican Trench, one of the deepest areas in the world. This is consonant with records in the Gulf of Mexico, where animals were well away from the shelf edge and the upper continental slope, throughout oceanic deep waters (Mullin et al. 1994; Davis et al. 2000; Baumgartner et al. 2001). Davis et al. (2000) reported that in the northern Gulf of Mexico, stenellids including *S. attenuata*, are frequently found in cyclonic, cold-core eddies and are less frequently encountered in anticyclone, warm-core eddies, but this has not been investigated for the Caribbean. Off the eastern U.S. seaboard, from Florida to Georges Bank, *S. attenuata* are found at the continental shelf edge and over continental slope areas (Waring et al. 2002). In the Gulf of Mexico, *S. attenuata* and *S. frontalis* are parapatric, occupying adjacent but not overlapping areas (Mullin and Hansen 1999). However, in the Caribbean, *S. frontalis* and *S. attenuata* are sympatric, occupying the same area, contrary to the assertion by Leatherwood et al. (1976) that they are parapatric.

Pantropical spotted dolphins are the most abundant cetacean in the oceanic northern Gulf of Mexico (Davis et al. 2000; Mullin and Hoggard 2000; Baumgartner et al. 2001) but not in the eastern U.S. Atlantic. Population estimates for the Gulf of Mexico are 91,321 (CV = 0.16, K. D. Mullin pers. comm.), while they were 12,747 (CV = 0.56) in the eastern U.S. Atlantic (Mullin and Fulling 2003). No estimates can be made for the Caribbean at this time, but based on the sighting records presented here, the Atlantic spotted dolphin is probably more common. Future aerial and ship surveys are needed to calculate abundance estimates for these and other cetacean species.

Future studies and surveys in the Caribbean should pay attention to pantropical spotted dolphin sightings and strandings to further document presence of this tropical

species in the Caribbean, its zoogeography and life history.

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## Response of the St. Croix Ground Lizard *Ameiva polops* to Severe Local Disturbance of Critical Habitat at Protestant Cay: Before-and-After Comparison

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The most recent survey (April-June 2002) of the endemic and endangered St. Croix Ground Lizard, *Ameiva polops* (Cope 1862), at Protestant Cay, a 1.2 ha islet in Chris-

tiansted Harbor off the northeastern coast of St. Croix, U.S. Virgin Islands, confirmed that this population (from only three) continues to decline (McNair 2003 and literature cited therein). Less suitable habitat is presently available because of landscaping practices such as raking and removal of leaf litter, removal of undergrowth and woody vegetation, and planting of exotic vegetation by hotel management on this highly developed cay. Disturbance can be negative, benign, or even positive such as enhancing habitat for *A. polops* by exposing more bare loose ground, increasing the amount of leaf fall or woody debris, or opening the undergrowth or canopy to improve the mixture of sun and shade. These positive changes within the context of *A. polops* at Protestant Cay, however, can now only occur in habitat that has already undergone major anthropogenic changes.

During late November 2002, following changes to critical habitat by Hotel on the Cay, we resurveyed areas where *A. polops* was present in an earlier survey to compare before-and-after species abundance and distribution, and seasonal effects of *A. polops* on Protestant Cay. We expected the population to decrease if deleterious landscaping practices prevailed as they have for the past 35 years. Our before-and-after survey comparison allowed us to assess whether or not this recent habitat change of general upkeep of the hotel grounds is a particularly threatening event, or only a milder event contributing to the long-term population decline of this species.

Survey methodology followed McNair (2003). Sampling units were the same habitat blocks (and one adjacent sampling unit, D) where *A. polops* was present during the spring survey. Time was fixed within each unit but varied between-units according to patch size and the difficulty of thoroughly searching the habitat. Sampling units were scored for habitat disturbance on a categorical scale from 1 (no change or negligible disturbance) to 5 (habitat completely removed; see Table 1). As before, we selected the maximum number of lizards from one of three replicated counts within each unit and summed these counts over all

units to obtain a minimum population estimate. For both survey periods we also visually estimated age-class (adults; juveniles < 50 mm snout-vent length [SVL]; Dodd 1980). This method produced higher counts than counts using the combined maximum number of lizards from both age classes, and allowed us to compare adult to juvenile age-ratios between the two survey periods (using a chi-square contingency test at  $\alpha = 0.05$ ). We also assessed the association between the net change in adults and juveniles counted during the two survey periods within sampling units to the degree of disturbance to critical habitat (Spearman rank correlation; one-tailed tests,  $\alpha = 0.05$ ).

The population estimate of *A. polops* during the new survey period for combined age classes was 36 animals, based on the sum of maximum counts in the 10 (43%) sampling units where lizards were present (Table 2, Fig. 1). *Ameiva polops* was concentrated in six contiguous units (A-E, S) of dry forest that contained 25 (69%) of the maximum number of lizards. Occupied habitat in unit D, a new area, was restricted to the border of adjacent occupied units. The two other occupied areas were disjunct (P-R, V), with beach habitat dominated by sea grape, *Coccoloba uvifera*. All but one *A. polops* were present in three contiguous units (P-R) where several animals were seen in tidal litter. *Ameiva polops* was not found in unit M – the most isolated area on the east side of the cay – where one individual was present during the spring survey (Table 1, Fig. 2c, d). It declined in the three (M, S, and V) most severely disturbed areas (Table 1, Fig. 2a, b). This species was absent from a large portion of unit S, but some were able to partially reoccupy habitat that was denuded of woody vegetation in late July 2002. No lizards were observed elsewhere on Protestant Cay during the new survey period (late December to mid-January).

Population estimates for each age-class were 20 adults/12 juveniles and 19 adults/21 juveniles for spring and winter surveys, respectively (Fig. 3). The difference in the proportion of the age-ratio between the two survey periods was not significant ( $\chi^2 =$



TABLE 1. Description of habitat disturbance and assigned scores on a categorical scale from 1 (no change or negligible disturbance) to 5 (habitat completely removed) in sampling units occupied by St. Croix Ground Lizards, *Ameiva polops*, at Protestant Cay during winter 2002-2003 or an earlier survey in spring 2002.

Sampling unit	Habitat disturbance	Score
A	Five trees and several shrubs removed; limbs removed on some other trees and several left on ground. Four large wood chip piles dumped along area border. Light increase in planted lilies.	3
B	One tree and several shrubs removed; some shrubs lightly pruned. Moderate increase in planted lilies.	2
C	One tree removed. Shrubs moderately pruned. Wood chips lightly scattered on portion of ground; one quarter of ground dusted with lime.	3
D	No change.	1
E	Moderate amount of litter removed. One tree and several shrubs removed; many other shrubs moderately pruned. Wood chips lightly scattered along area border.	3
M	Deposition of concrete rubble pile among excavation for pipeline obliterated occupied area.	5
P	Some limbs of one Sea Grape cut.	1
Q	Small wood chip pile and trash dumped along area border.	1
R	Light vegetation at one site removed for aquatic ski-doo parking area.	2
S	All woody and non-woody vegetation of ca. one-half of area removed (only Aloe left standing) and chips left on ground; groundcover and litter smothered. Large wood chip piles deposited along area border.	4
V	Woody vegetation (including Sea Grape), groundcover, and litter partially or completely removed from several sand mounds; soil disturbed in one area. Portion of woody debris (boards piled on ground) between sand mounds removed.	4

TABLE 2. St. Croix Ground Lizards, *Ameiva polops*, counted during winter 2002-2003 within sampling units at Protestant Cay where animals were present during an earlier survey in spring 2002.

Sampling unit	Duration of survey (min) <sup>1</sup>	Dates	Numbers per survey	Main habitat(s)
A	35	31 Dec; 10, 12 Jan	4, 10, 4	Dry Forest
B	20	31 Dec; 11, 17 Jan	2, 3, 4	Dry Forest
C	2	31 Dec; 5, 11 Jan	1, 0, 0	Dry Forest
D <sup>2</sup>	5	5, 11, 14 Jan	1, 1, 1	Dry Forest
E	15	31 Dec; 5, 11 Jan	1, 4, 3	Dry Forest
M	35	1, 11, 17 Jan	0, 0, 0	Dry Forest, Beach
P	30	1, 10, 12 Jan	4, 6, 5	Beach
Q	25	1, 5, 10 Jan	0, 1, 3	Beach
R	7	1, 10, 12 Jan	1, 1, 0	Beach
S	60	1, 11, 14 Jan	0, 0, 5	Dry Forest
V	25	31 Dec; 5, 10 Jan	0, 0, 1	Beach

<sup>1</sup>Duration of survey is the time spent in each sampling unit on each survey date.

<sup>2</sup>Lizards not detected in spring 2002.

1.09). The association between the net change in lizards counted during the two survey periods within sampling units to the degree of disturbance to critical habitat was significant for adults ( $R_s = -0.69$ ,  $P < 0.05$ ) but not for juveniles ( $R_s = -0.23$ ,  $P = 0.49$ ). The number of adults between the two survey periods declined in unit S, and

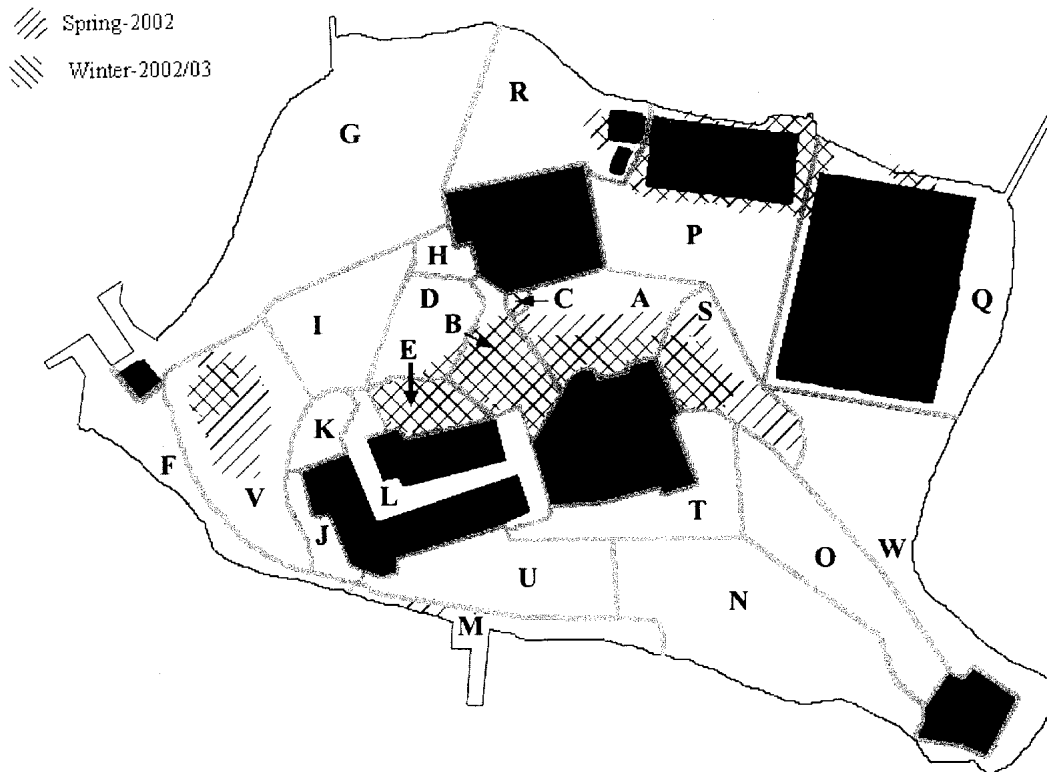


FIG. 1. Distribution of *Ameiva polops* before and after disturbance of critical habitat during spring 2002 and winter 2002-2003 in 23 sampling units (A-W) on Protestant Cay. Filled black areas are buildings or abandoned tennis courts (P, Q).

increased in the three nearest units (A, P, Q). Recruitment of juveniles was also greatest in units A and P.

Contrary to expectation, the overall population of *A. polops* did not decline but declines were observed in the three most severely disturbed sampling units. Though the long-term response to this perturbation is unknown, the number of adults was virtually identical between survey periods. Greater activity for this heliophilic animal is unlikely during winter when temperatures are 2.8-3.9° C cooler (Calvesbert 1970), but adult *A. polops* remained active during December and January, unlike most adults of three larger species of *Ameiva* in the northern Lesser Antilles and Puerto Rico (Rodriguez-Ramirez and Lewis 1991; Censky 1995). The possible reasons such as the smaller size of *A. polops* which may permit activity throughout the year, habituation to food obtained from human debris and

other human activities, or other factors need to be examined.

The only detected seasonal effect during the winter survey was greater juvenile recruitment, which was probably not confounded by differences in habitat during the two survey periods. The net change in the number of juveniles was not associated with the degree of disturbance to critical habitat (even though smaller individuals of *A. polops* were found in more exposed sites, whereas larger individuals were in canopied sites at Green Cay; Wiley 1982 unpubl. ms). Greater juvenile recruitment in winter than spring is consistent with a seasonal reproductive cycle or at least greater breeding activity in one season than another. At Green Cay, the mean size of *A. polops* in October was ca. 7 mm smaller than in April (Wiley 1982 unpubl. ms), suggesting more juveniles are present later in the year, data consistent with our results. The seasonal repro-



FIG. 2. a,b. Before (14 January 2002; top left) and after (20 February 2003; bottom left) photographs of habitat disturbance within unit V where *Ameiva polops* was formerly present. Concrete rubble now covers the site where an adult was seen near the largest shrub in foreground before disturbance. 2c,d. Before (27 February 2002; top right) and after (20 February 2003; bottom right) photographs of habitat disturbance within unit M where *Ameiva polops* was absent during the winter 2002-2003 survey. Note the virtual elimination of ground cover and litter on the sand mound, and disturbed soil in the foreground.

ductive cycles of *A. plei* in the northern Lesser Antilles and *A. exsul* and *A. wetmorei* in Puerto Rico, at similar latitudes and location to St. Croix, were more closely associated with daylength than with rainfall or temperature (reviewed in Censky 1995; also Rodriguez-Ramirez and Lewis 1991). Rainfall on St. Croix was ca. half of normal in 2002, so reproduction of *A. polops* on Protestant Cay was apparently not curtailed by the drought.

The distribution of adults changed in response to severe local disturbance to habitat even though the proportion of lizards in the two habitat types (dry forest, beach) was similar during the two survey periods (McNair 2003; this study). *Ameiva polops* re-occupied unit A where some disturbance was probably beneficial (i.e., cut limbs left

on the ground). Cattle Egrets (*Bubulcus ibis*) nested here during the winter survey but in much fewer numbers (3-8 pairs) than during spring when their predation temporarily eliminated *A. polops* from unit A (McNair 2003). Adult and juvenile lizards also increased in units P and Q which, in addition to unit A, were possibly individuals displaced from unit S. The decrease in the number of *A. polops* from unit S is probably even greater, as during a fourth replication conducted just after the spring survey ended (6 June) recorded eight adults here. The greater density of *A. polops* in the slightly larger occupied areas of units P and Q during the winter survey probably represents compensatory habitat use by animals moving in from unit S,

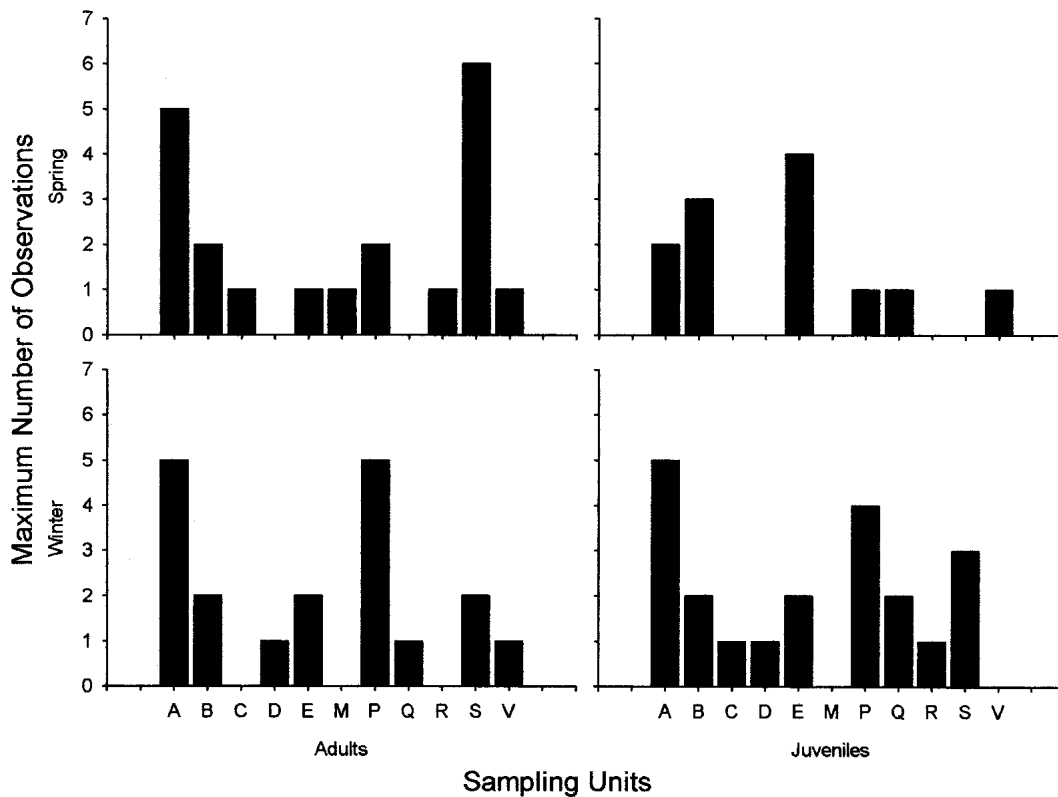


FIG. 3. Maximum number of adult and juvenile St. Croix Ground Lizards, *Ameiva polops*, counted during two survey periods (spring 2002, winter 2002-2003) within sampling units at Protestant Cay.

but some also may have been previously overlooked by chance (as in unit D). Severe disturbance to habitat also occurred in two disjunct sampling units (M, V) where the number of *A. polops* was also reduced or eliminated, but displacement of this species could not be detected in the nearest occupied sampling units. Even moderately disturbed sampling units (score of 3) retained *A. polops* (at least in the short-term), though adults are more sensitive to disturbance, as long as essential habitat components remained (e.g., a moderate amount of litter and some woody vegetation). These results augment the earlier conclusion (McNair 2003) that *A. polops* is resilient and pre-adapted toward disturbance because it occupies littoral habitat periodically disturbed by hurricanes.

Although severe local disturbance of critical habitat at Protestant Cay by owners

of Hotel on the Cay was inadvertent, it effectively removed some *A. polops* from these areas and thus constitutes a violation of the Endangered Species Act (1973). Subsequent to this inadvertent action and following recommendations in McNair (2003), for the first time owners of Hotel on the Cay have entered into a non-punitive agreement with the United States Fish and Wildlife Service (Partners with Wildlife program) in association with the Division of Fish and Wildlife of the territorial government to protect *A. polops*, which has included capture of a second small Indian mongoose on the cay in early January 2003 (cf., McNair 2003). This plan proposes to eliminate deleterious landscaping practices and minimize human disturbance of habitat and will include public use regulations. Improvement of the quality and amount of habitat for the benefit of *A. polops* should proceed, and possibly lead to

a reversal of the long-term population decline on Protestant Cay which will continue if earlier practices are not modified. Future surveys will determine the short- and long-term effects of disturbance at all sites. This study is one of few on the herpetofauna of the West Indies that focuses on a species in conspicuously disturbed habitats (Henderson and Powell 2001) as well as assesses the effects of degree of disturbance in these altered habitats (Germano et al. 2003).

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### *Hyla miliaria* (Anura: Hylidae) in Honduras, with Notes on Calling Site

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*Hyla miliaria* (Cope) is a huge (to 110 mm SVL; Duellman 2001) canopy dwelling fringe-limbed hylid that occurs in low and moderate elevations (20 to 1330 m) in humid forests from the Río San Juan region of southeastern Nicaragua to the central cordillera of Colombia (Duellman 2001; Ruiz-Carranza et al. 1996; Savage 2002). The species is extremely rare in collections; only 16 specimens are known (Savage, 2002). The calling site of this species is also poorly documented. Duellman (1970:354; reprinted 2001) presented circumstantial evidence of one calling "from a large oak tree in a *cafetal*." Savage (2002) presented circumstantial evidence that this species calls from tree holes. Savage (2002:335) stated "Michael Fogden reports hearing a call, later associated with this species, coming from high in a tree at night. The tree hole site was spotted during the day, but with no frog. Late in the afternoon Fogden waited on a ladder at the tree hole and captured the frog when it returned at dusk."

On the night of 29 May 2003 at Bodega de Río Tapalwás (14°56.140'N, 84°31.871'W), 190 m elevation, Gracias a Dios, Honduras, Tomás Manzanares Ruis and JRM traced a call of an unknown frog to a tree hole in a Santa María (Spanish) or Krasa (Miskito) tree (*Calophyllum brasiliense*). Climbing the tree to the hole revealed an adult male *Hyla miliaria* (UF 137207) sitting above the water line inside the upper edge of the tree hole. The opening to the tree hole was located 228 cm above the forest floor. The tree hole

opening measured 70 × 80 mm and had a depth of 200 mm. The tree was 44.5 cm in circumference at chest height. The frog has a SVL of 91.2 mm and agrees with the descriptions of the species provided by Duellman (2001) and Savage (2002). The call was a loud, booming single note repeated 12 to 15 times followed by 15 to 25 min of silence. The frog was first heard calling at about 1900 h and collected at 2250 h. The locality lies about 470 km N of the Río San Juan region of Nicaragua.

At the same locality on the night of 1 June 2003, Tomás Manzanares Ruis and JRM traced another calling male of *Hyla miliaria* to a Guácimo (Spanish) tree (*Luehea seemanii*). Because of the huge size of the tree and the height from where the frog was calling, we decided that it was too dangerous to climb the tree at night. We returned to the tree at about 1000 h the following day. A water-containing tree hole was found in the tree in the area from where the call was located the previous night. The hole contained an adult male *H. miliaria* (UF 137208; SVL 94.4 mm) sitting above the water line. The opening to the hole was 10.6 m above the forest floor and was 86 × 130 mm. The depth of the hole was estimated at 610 mm with a water depth of 460 mm. Circumference of the tree at chest height could not be measured because extensions of the tree buttresses reached heights of at least 2 m. The call of the second male seemed to be identical to that of the first male. The second call was first heard at about 1900 h and could still be heard at 2200 h before we walked out of hearing range. Both frogs were calling on nights in which there had been no rainfall for at least the previous 12 h. *Hyla miliaria* was not heard calling at this site on the nights of 30-31 May and 2 June when heavy rain showers fell either in late afternoon or early at night. Neither eggs nor tadpoles were present in either tree hole.

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### New Record of the Rare Emballonurid Bat *Centronycteris centralis* Thomas, 1912 in Costa Rica, with Notes on Feeding Habits

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The shaggy sac-winged bat, *Centronycteris centralis* (Chiroptera: Emballonuridae), occurs mainly in lowland forests from Veracruz, Mexico, to Peru, although it has been reported from elevations as high as 1450 m in Panama (Simmons and Handley 1998; Hice and Solari 2002). Most captures of the species are of single individuals, and throughout its distribution, this bat is rare and poorly-known (Emmons 1997; Reid 1997; Simmons and Handley 1998). *Centro-*

*nycteris centralis* generally has been assumed to be an aerial insectivore, capturing flying insects on the wing (Starrett and Casebeer 1968; Wilson 1973; Timm et al. 1989; LaVal and Rodríguez 2002). However, direct evidence supporting this trophic role has been lacking. Herein, I report on a specimen of *C. centralis* from seasonally-inundated swamp forest in the Caribbean lowlands of northeastern Costa Rica that provides valuable information on distribution, morphological variation, reproduction, and feeding habits of this species.

The specimen was captured during field work in April and May 2002 at Caño Palma Biological Station (10°36'N, 83°32'W), a ca. 40 ha reserve along the west bank of Caño La Palma, Barra del Tortuguero, Limón Province. The station is about 6.25 km NNE of Tortuguero in a region whose vegetation is generally mapped as Tropical Wet Forest under the Holdridge system of classification (Holdridge 1947; Tosi 1969). The seaward eastern bank of the *caño* (a natural waterway) typically remains above water throughout the year, whereas land on the western bank floods during the rainy season, when much of the reserve is beneath more than a meter of water. Apart from occasional, emergent hardwoods, such as *Pentaclethra*, the natural vegetation is dominated by abundant *Asterogyne*, *Raphia*, *Manicaria*, and other palms. The presence of howler monkey (*Alouatta palliata*), white-faced capuchin (*Cebus capucinus*), spider monkey (*Ateles geoffroyi*), and white-lipped peccary (*Tayassu pecari*) in the reserve and its surroundings testifies to the relative lack of human disturbance of the forest habitats in the immediate area.

Between 18:00 and 19:00 hours local time, on 29 April 2002, an adult female *C. centralis* (USNM 568525) was taken at about 2.5 m in a mist net set just off of a trail in moderately dense understory vegetation. The *C. centralis* was pregnant with a single embryo (crown-rump length, 20 mm). The digestive tract was removed and preserved in 70% ethanol for subsequent analysis of its contents. The same net captured *Artibeus literatus*, *Artibeus watsoni*, *Vampyressa nymphaea*, and *Carollia perspicillata* before midnight.

Other species caught in the net on other nights included *Glossophaga commissarisi* and *Vampyrum spectrum*. *Trachops cirrhosis* and *Ectophylla alba* were taken in other nets in the general vicinity.

*Centronycteris centralis* previously has been documented from only 36 specimens from 31 localities throughout its distribution. In Costa Rica, the species was represented by six specimens from five localities (Simmons and Handley 1998; Albuja 1999; Hice and Solari 2002). An individual was captured previously at Caño Palma and photographed (Simmons and Handley 1998: Fig. 7), but no specimen was preserved. The specimen I report provides the first verifiable record of the species from the northeastern coastline of Costa Rica.

Standard external measurements of the female from Caño Palma are comparable to those recorded for other members of the species (Table 1). Morphology of the cranium and mandible conforms closely to the description of *C. centralis* by Simmons and Handley (1998) and distinguishes it from the only other member of the genus, *C. maximiliani*. In particular, the basisphenoid pits are short, with an incomplete septum between the larger posterior and much smaller anterolateral portions; the postero-medial border of the ectotympanic is smoothly curved; in lateral view of the cranium, the rostrum tapers gradually from forehead to external nares; the nasals are unconstricted laterally; P1 is relatively large (39% the crown length of P4) and the

TABLE 1. External measurements of a sample of female *Centronycteris centralis* (after Simmons and Handley, 1998) and the Caño Palma specimen (USNM 568525). Statistics include mean and observed range, with sample sizes in parentheses.

	<i>Centronycteris centralis</i> (n = 5) <sup>a</sup>	USNM 568525
Total length	77, 70-93	72
Tail length	25, 20-40	22
Foot length		
(including claws)	8, 7-9 (n = 9)	8
Ear length	17, 11-20	17
Forearm length	45.9, 42.9-48.1 (n = 13)	45.2
Tibia length	18.5, 18.1-19.2	19.0
Weight (g)	5.7, 5.0-6.0 (n = 3)	6.7

<sup>a</sup>Except as noted.



diastema between P1 and P4 correspondingly short (20% the length of P1); the mandible is relatively slim, and the coronoid process rises at a steep angle. However, the posterolateral border of the palate is not as distinctly notched as illustrated by Simmons and Handley (1998: Fig. 4D).

What little is known about the natural history of *C. centralis* was summarized by Simmons and Handley (1998). Reproductive information is too scarce and too scattered geographically to determine any specific patterns with certainty. However, there may be a reproductive peak near the beginning of the rainy season. Pregnant females have been reported previously from March in Ecuador (Albuja 1999), from May in Costa Rica and Nicaragua (LaVal 1977; Greenbaum and Jones 1978), and from September in Peru (Hice and Solari 2002). A lactating female was taken in November in Peru (Hice and Solari 2002). Nonpregnant females have been found during August in Nicaragua (Baker and Jones 1971) and January in Panama (USNM 514956).

Inspection of the stomach contents of the individual from Caño Palma revealed finely chewed bits of chitin and soft tissues from relatively soft-bodied insects. The bulk of the identifiable remains represent plant hoppers (Fulgoroidea, Homoptera). In addition, there are remains of at least two different beetles (Coleoptera)—one of which is probably a leaf-beetle (Chrysomelidae)—and material tentatively identified as orthopteran. No scales or other evidence of lepidopterans are present. This analysis confirms the long-suspected insectivory of *C. centralis* and shows a distinct preference for plant hoppers, at least at this time of year in lowland swamp forest. Plant hoppers tend to rest in groups on branches, although they may fly between trees after dark and are attracted to electric lights (There were no lights near the site where the *C. centralis* was netted at Caño Palma). Many leaf-beetles feed on the surfaces of leaves, and many orthopterans rest on leaves. Both coleopterans and orthopterans tend to be relatively slow fliers. Based on the generalized behavior of these prey, *C. centralis* may feed by gleaning insects from the surfaces of leaves and branches, by tak-

ing slow-flying insects on the wing, or by using a combination of these two strategies. The flight of *C. centralis* was described as slow and “floppy” (Starrett and Casebeer 1968; Baker and Jones 1975) and “fluttering,” and these bats repeatedly fly the same path (Emmons 1997). Such slow, highly-maneuverable (Starrett and Casebeer 1968) flight patterns correspond well with a bat in pursuit of slow-flying insects or moving through heavy vegetation in search of resting prey. Floppy or fluttering flight might cause otherwise stationary and ultrasonically “invisible” insects to move or to become airborne, thereby making them easier to detect and capture.

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