Tim Morton

TRACKING PURPLE MARTIN MIGRATION TO BRAZIL, AND BACK!

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There is no doubt that Purple Martins are masters of the sky, plucking dragonflies out of the air with ease and then flying into the impossibly small hole of their nesting compartment at breakneck speed. Many martin landlords have spent a lazy evening admiring the acrobatics of their tenants who seem more at home in the air than they do on land. The martin's long tapered wings and streamlined body say it all – flying machine. In late summer when the nesting colony is strangely quiet, I often see martins flying overhead on migration and hear an occasional gurgling song. I can hardly believe these intrepid travelers are going all the way to Brazil.

We know that martins over-winter throughout much of South America where they spend their days feeding over tropical rainforests, rivers, and farmland and at night gather in large roosts. The PMCA has studied martin roosts in the deforested areas of southern Brazil, in São Paulo province, as well as roosts at an oil refinery in Manuas, on the Amazon River in northern Brazil. Though we know a lot about each end of the journey, we know next to nothing about how individual birds make such a marathon trip. How long does it take a martin to get to Brazil, how many stops does it make along the way, does it cross the Gulf of Mexico or go the long way around?

The details of the purple martin's amazing journey are no longer a secret to us. Until now it has been impossible to track individual songbirds to their wintering grounds and back. Larger birds, like eagles and falcons, have been tracked using satellite transmitters but these weigh far too much for a martin to carry. In the summer of 2007, we put tiny "geolocators" (**Fig. 1**) on Purple Martins nesting at the PMCA's Indianhead colony. These new devices, created by engineers at the British Antarctic Survey, detect light levels 24/7 and have a clock that keeps track of time. The timing of sunrise and sunset tells us where the bird slept each night (see sidebar). The geolocators are carried like a backpack, with the loops going around the legs, not the wings **(Fig.2)**, and weigh only 1.6 grams (less than a dime.)

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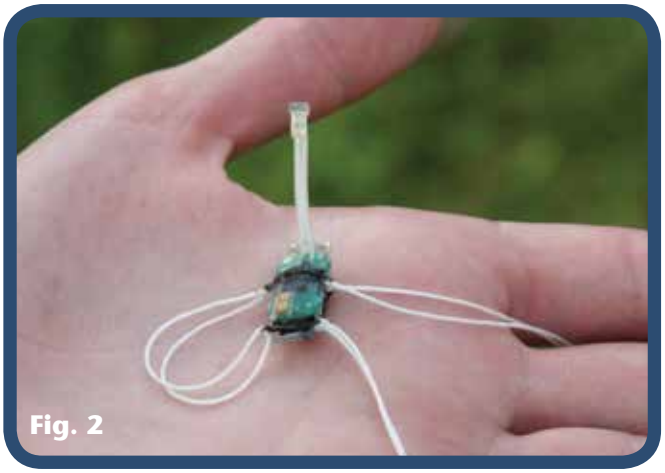

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Fig. 1. Miniature geolocator (MK15S, British Antarctic Survey) for tracking songbird migration; light detector is at at the end of the raised stalk. Fig. 2. The geolocator is attached like a backpack. The device nestles into the feathers with the raised stalk protruding above them. Fig. 3. A Purple Martin a with geolocator backpack ready for release.

To get any information at all, we have to catch the martin when it comes home in spring to retrieve the geolocator and download the light data onto a computer for analysis.

Our first step was to do pilot tests with dummy geolocators to make sure that martins were not bothered by the geolocator or harness. Our test birds continued to feed their nestlings as much as the other martins in the colony, and unless you looked closely you wouldn't even know they had a backpack. In July 2007, during two "martin mornings" at Indianhead when we had caught the sleeping martins with nest traps, we carefully attached real geolocators to twenty male and female ASY birds. Older birds have the highest survival and return rate in the colony, so were most likely to return after the winter. When we released our birds **(Fig. 3)** with their new backpacks the martins flew out over Edinboro Lake, gave themselves a few good shakes (sort of like a wet dog?) then, as we watched, started feeding high over the lake. All returned to their nests and fed their young, and over the next two weeks gradually left one by one from the colony after the young fledged.

Then began the long 10 month wait to see if our martins could carry the geolocators the entire 8,000 mile round trip to Brazil. Most landlords eagerly look forward to their first martins each spring, but we were on pins and needles

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Fig. 4. Migration routes and timing for ASY female martin (1631-65794). Locations are accurate to about 100 miles; dotted line is the likely migration route during the fall equinox. Blue: fall migration; Yellow: wintering ground movements; Red: spring migration.

waiting to see if Emily Pifer, the PMCA biologist, would spot one of our geolocators birds. The good news arrived on 30 April 2008 via an e-mail from Emily "Hi Everyone. Just wanted you to know I was down at Indianhead this morning doing some band reading and looking for geolocators. I saw a geolocator on an ASY-F….she is Yellow 2551. I saw her sitting on the porch at WH-44 for awhile." Emily was looking at the first migratory songbird, anywhere in the world, for whom we would know its arrival time on the wintering grounds, where it spent the winter, and how quickly it had just come home. As a bonus, Emily saw a second female carrying a geolocator a few days later at the colony. Both were caught, and the geolocators were retrieved.

How fast do you think martins can fly? I had always thought of martins as lazy when it comes to migration, though of course, the distance covered is impressive. Martins fly during the daytime and feed along the way, and they stop at night to gather in huge roosts. What's the hurry? There is plenty of food up for grabs in the warm southern states and roost sites have been mapped out using weather radar (Project Martin Roost) showing lots of martin "motels" along the way. I am in good company, since the official species account for the Purple Martin in the Birds of North America says "Probably follows typical swallow pattern of leisurely movement, with migration in both directions spanning several months."

To my astonishment our geolocator martins wasted no time flying south to Mexico once they actually began migration. Both birds stayed in the Erie area until late August, presumably using the Presque Isle Bay roost, and then without warning flew to the Gulf Coast states, crossed the Gulf of Mexico, and arrived at the Yucatan Peninsula near the city of Merida within 5 days of leaving Pennsylvania! **(Fig. 4, 5)**. The martins had somehow covered 1500 miles, including a 500 mile over-water flight, in less than a week. And I had worried the geolocators would slow them down!

One martin (Yellow 2551) spent its last night in Erie on 31 August. She stopped somewhere in north central Kentucky the first night **(Fig. 6)**, then spent two nights somewhere south of Montgomery, Alabama. Keep in mind that geolocators cannot pinpoint the exact location of the bird and on a given night could be off by 100 miles or so (see sidebar). Yellow 2551 then flew across the Gulf of Mexico and arrived near Merida, Mexico on the Yucatan Peninsula by 5 September. The other martin (1631-65794) left Erie on the 27 August and spent its first night somewhere in southern Ohio and the next two nights between Jacksonville and Tallahassee, Florida **(Fig. 6)**. Then, it too, took off across the Gulf of Mexico to Merida, Mexico. After this quick start, both birds put on the brakes and spent the next 2-3 weeks in the northern Yucatan.

Band recoveries give us a brief snap shot of migration movements and can tell us where a breeding population likely over-winters, and in rare cases reveal migration routes.

Though the PMCA has banded over 20,000 martins in northwestern Pennsylvania, very few of these banded birds have ever been seen or recovered in Central or South America. The first was a nestling (1681-29623) banded by the PMCA at Andy Troyer's Conneautville, PA martin colony on July 23rd, 2004. This bird was found dead in October, 2004, by Guillermo Castillo Vela at San Felipe, on the northern coast of the Yucatan Peninsula, Mexico. This single band recovery was suggestive of a Gulf crossing, and now our geolocator results confirm that martins from Pennsylvania routinely cross the Gulf of Mexico.

The migration map gets a little fuzzy in September because of the fall equinox. Geolocators use day length on a given date to figure out the north-south location (see sidebar) so during the weeks near the fall equinox we cannot estimate latitude from the light data during this period. If we assume the martins continued their journey over land we can get an idea of when they passed through the narrow east-west land bridge of Panama. Though the martins raced down to Mexico in less than a week, they did not cross into South America until 29 September and 4 October.

Fig. 5. Migration routes and timing for ASY female martin Yellow 2551 (1801-98551). Locations are accurate to about 100 miles; dotted line is the likely migration route during the fall equinox. Blue: fall migration; Yellow: wintering ground movements; Red: spring migration.

Both martins spent the winter in the forested Amazon basin in northern Brazil, and did not roost in São Paulo province, in southern Brazil. The famous particle-marking study at the São Paulo roosts in the 1980s, where martins at several roosts were sprayed with UV-colored microdots, showed that martins from the same roost later bred at colonies throughout the U.S., including Marysville in southeastern Pennsylvania. Nevertheless, our martins never made it into southern Brazil at all. Instead, Yellow 2551 stayed near the region of Manaus, Brazil, where martins are known to roost on the pipes in the oil refinery. I don't think she was actually roosting in the refinery, because her geolocator did not show artificial lighting at night. The other martin spent its first month in Brazil somewhere just southwest of Manaus, then flew some 800 miles farther south to the border of Bolivia and Brazil. She stayed in that region until late January then moved again; this time back north into the Brazilian Amazon.

Scout arrival times show that martins arrive along the Gulf coast states in January and February, though in Pennsylvania we do not see martins regularly until late April. Since there is enough food for locally breeding martins to live in Texas, Alabama and Florida in February and March, I had always wondered if our northern breeders get a head start on migration and then stall once they arrive in the southern U.S. The answer is clearly not for our birds!

Yellow 2551 spent her last night in Brazil on 12 April, and rocketed northward to arrive at her breeding colony by the night of 25 April. She flew about 4,400 miles in only 13 days (over 300 miles/day)!!!! It took her only 5 days to head north to the Yucatan Peninsula, near Merida again, where she spent two extra nights (a well deserved rest!). Then she crossed the Gulf of Mexico to make landfall somewhere in near the Texas-Louisiana border. She rested the next two nights

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Fig. 6. The fall migration tracks of Yellow 2551 (1801-98551) (left) and 1631-65794 (right.) No. 1631-65794 flew 600 miles in one day.

near New Orleans, then flew up the Mississippi river valley and stopped for a night in southern Illinois. The next night she was home in northwestern Pennsylvania. Her lightning fast trip home had been accomplished with only 9 flight days and four days of rest. Our second martin made a more leisurely spring trip, and returned from Brazil in 27 days.

If we assume that Yellow 2551 only flew during the daytime, and covered an average of 500 miles per flight day, then she was traveling at ground speed of about 40 miles/h. Radar tracking studies of barn swallows and house martins in Europe have clocked birds going an average of 30 miles/h over several miles. Purple martins are the world's largest swallow so can probably fly a good deal faster, as our geolocator data suggest.

Our two martins had an overall spring migration speed, start to finish, of 174 and 358 miles per day. During the first part of fall migration they flew about 500 miles per day for the first five days. How does this flight performance compare to other migratory songbirds? Previous studies have estimated migration speed from band returns of individuals re-captured hundreds of miles away within a few days. These events are very rare and even then there is no way to know the bird's actual departure and arrival times. Barn swallows migrating in fall across Britain and Ireland flew up to 120 miles per day. Average fall migration speed of songbirds in Sweden that exceeded 60 miles per day were considered exceptional. Spring migration is generally thought to be faster than fall migration, because birds are in a hurry to claim breeding territories and mates. Spring migration speed of five species of European warblers caught in Britain and Europe was as fast as 140 miles per day. In North America, radio-tagged thrushes followed by airplane flew at an overall migration rate of 70 miles per night during spring migration. Even our slow poke martin, who went "only" 174 miles per day during spring migration, flew faster than expected.

Seeing the migration maps for these two female martins raises intriguing questions. Do males, who are slightly larger, migrate even faster than these two females? Do ASY birds migrate faster than SY birds, and do they overwinter farther north so they can get home more quickly in spring to claim their nest sites? Under what circumstances do martins fly overland around the Gulf of Mexico instead of making the risky over-water crossing? Do all our martins in northwestern Pennsylvania spend the winter in northern Brazil, flying over rainforests every day? In 2008, the PMCA fitted 20 new martins with geolocators that will help us answer some of these other secrets about martin migration.

Tracking individuals to their wintering areas is important for understanding what threats martins face when away from their well-cared for nesting apartments. Martins that feed over agricultural fields in southern Brazil are undoubtedly exposed to dangerous pesticides that are used in large quantities throughout most of Latin America. Perhaps overwinter survival is highest for birds wintering in the forested regions of northern Brazil. There is great concern that climate change will hurt our migratory songbirds, but forecasting these effects is difficult because weather conditions vary so much over the winter range of our migrants. Northeastern South America is expected to get hotter and drier, but southern Brazil is expected to become wetter. Since martins depend on flying insects for their food supply, over-winter survival may differ for Purple Martins living in the northern versus southern parts of their winter range. Knowing where different breeding populations of martins spend the winter will help us protect our beloved martins for generations to come.

This spring, when the first scout arrives, circling our martin house and bubbling cheerfully, I'll run outside with a deepened sense of excitement and awe. Flying machine, indeed!

THE 'LOCATION' IN GEOLOCATORS

Geolocators record light levels every minute all day and night. Sudden changes in light level are usually due to actual sunrise and sunset (**see Figure 7**) and over weeks and months the raw data show the predictable up and down cycles of day and night wherever the bird was at that time.

The geolocator is tuned to low light levels, those when the sun is just below the horizon. Bright events at night, like a full moon, show up in the raw data as do heavy shading events during the day (entering a nest compartment).

As the bird travels east or west, the actual time of sunrise logged on the geolocators will be earlier or later the next day. A martin roosting on the Gulf Coast of the Florida panhandle will see the sunrise long before a martin that roosted under the Lake Ponchetrain bridge in New Orleans. This east-west location is measured by longitude.

Latitude is a bit harder to estimate, and is based on day length. During northern hemisphere summers, days get longer as you go farther north. In winter, however, days get shorter as you go north. As a martin travels south in fall, the days get shorter until it reaches the equator, and then the days get longer if the bird continues southward into southern Brazil.

Under perfect weather conditions, and assuming the martin is out in the open so nothing shades the geolocator, the accuracy is quite high. Rainy and cloudy days are common, of course, and somewhat obscure the actual timing of sunrise and sunset which lowers the accuracy.

In August, purple martins in Erie, Pennsylvania gather at a pre-migratory roost at the Presque Isle Peninsula on the shore of Lake Erie. To get an idea of the accuracy of our geolocators, we compared locations of our two martins using the light data with the actual location of the roost. The geolocators gave us average positions for August that were within 37 miles of the Presque Isle Roost. From one day to the next, our estimated locations were off by up to 110 miles in latitude and 40 miles in longitude.

The final glitch in geolocating using light levels is the awkward time of year when day length is equal everywhere on the planet, and latitude cannot be estimated. This is known as the fall (21 September) and spring (21 March) equinox, which most people mark on their calendars as simply an official change of season. The two weeks before and after the equinox is a "blackout" time for latitude but we can still estimate longitude (east-west position) and have some idea of what the birds are doing.

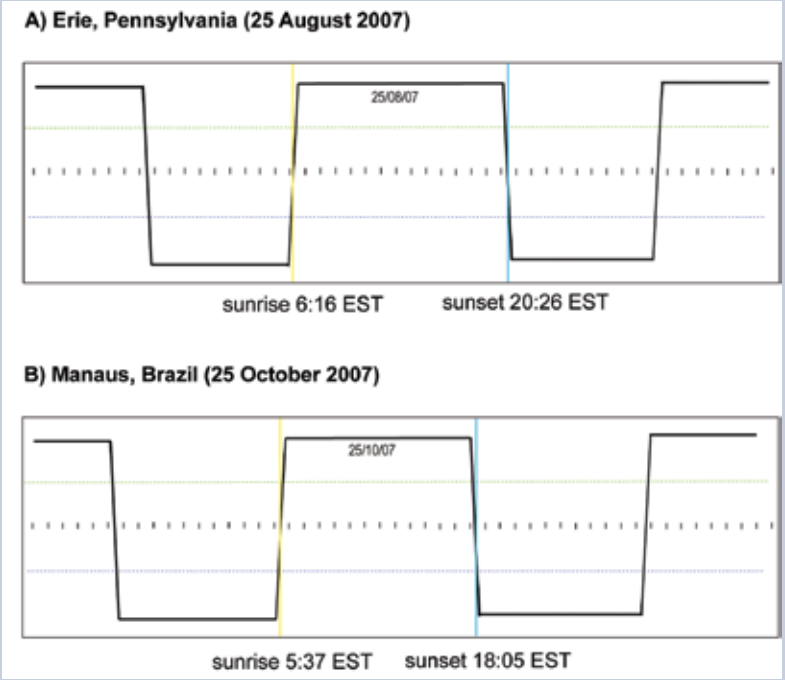

Figure 7. Light levels on two different days that were recorded by the geolocator carried by female martin Yellow 2551 (1801-98551). The midway point between the minimum and maximum reading at sunrise or sunset corresponds to the sun's position 4.5° below the horizon, when light levels change very rapidly with time. These "sunrise" and "sunset" times occur before true sunrise and after true sunset because the sun has dropped below the horizon. On August 25, Yellow 2551's geolocator detected "sunrise" and "sunset" times that correspond with Erie, Pennsylvania, showing she had not yet begun migration. By October 25, however, sunrise and daylength place her in northern Brazil (Table 1.)

	August 25th		October 25th		January 25th	
	rise	set	rise	set	rise	set
Erie,PA (42N 80W)	6:40	20:03	7:11	19:13	8:40	18:25
Manaus, Brazil (3S, 60W)	6:01	18:03	5:38	17:50	6:04	18:20

Table 1: Change in actual sunrise and sunset times (Eastern Standard Time) in Erie, Pennsylvania and Manaus, Brazil at different times of the year (www.timeanddate.com).