

## Post-breeding movements of Wood Storks in Brazil and Argentina

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**ABSTRACT.** Seasonal migration and the dispersal of juvenile and adult Wood Storks (*Mycteria americana*) after breeding have been documented in the United States, but little is known about the post-breeding movements of Wood Storks in South America. Our objective was to identify the locations of post-breeding areas used by Wood Storks banded as nestlings in breeding colonies in Brazil by analyzing banding data. During the period from 1984 to 2007, 2543 nestlings were banded at breeding colonies in three regions of Brazil, with most (94%) banded in the Pantanal wetland in west-central Brazil. Seventeen bands were subsequently recovered, with most (14) recovered in southern Brazil and northern Argentina. The mean distance between banding and recovery sites was 1265 km. Our results suggest that Wood Stork movements from breeding areas in Brazil are, as also reported in the United States, in response to changing water levels. The rainy season begins at the end of the breeding season and, in apparent response to rising water levels, Wood Storks in our study moved to drier areas further south with shallower water where they can forage more efficiently. Because only a small percentage of the area where Wood Stork bands were recovered in our study is currently protected, measures are needed to prevent habitat destruction and preserve wetland habitats used by Wood Storks during the post-breeding period in southern Brazil and Argentina.

### **RESUMEN. Los movimientos después de la cría por *Mycteria americana* en Brasil y Argentina**

La migración estacional y la dispersión después de la cría por juveniles y adultos *Mycteria americana* ya se han documentado en los Estados Unidos, pero poco se sabe acerca de los movimientos después de la cría en América del Sur. Nuestro objetivo fue a identificar los lugares utilizados después de la cría mediante un análisis de datos de *M. americana*, lo cual que fueron anillados como polluelos en colonias de cría en Brasil. Entre los años 1984 - 2007, 2543 polluelos fueron anillados en las colonias de cría en tres regiones de Brasil, con la mayor parte (94%) de polluelos anillados ubicado en el humedal Pantanal en el centro-oeste de Brasil. Diecisiete bandas fueron recuperadas posteriormente; se recuperó la mayor parte (14) en el sur de Brasil y en el norte de Argentina. La distancia media entre los sitios donde se anillaron los polluelos y los sitios donde se recuperaron las bandas fue 1265 km. Nuestros resultados sugieren que los movimientos después de la cría por *M. americana* en Brasil son, como se informó también en los Estados Unidos, en respuesta a el cambiante nivel de agua en los humedales. La temporada de lluvias comienza a finales de la temporada de cría y, en aparente respuesta a la subida de los niveles de agua, *M. americana* en nuestro estudio se movieron al sur, a zonas más secas y con aguas menos profundas donde *M. americana* pueden buscar comida mas eficiente. Entre la zona donde se recuperaron las bandas de *M. americana*, sólo un pequeño porcentaje de la área esta protegida. Entonces, es necesario adoptar medidas para evitar la destrucción del hábitat y preservar los humedales en el sur de Brasil y Argentina, lo cual que son utilizados por *M. americana* durante el período después de la cría.

*Key words:* banding, conservation, dispersal, migration, *Mycteria americana*, recovery

Wood Storks (*Mycteria americana*) are widely distributed throughout the Americas from the southeastern United States to northern Argentina (Coulter et al. 1999). These storks are excellent bioindicators of wetland health due to their distribution and populations that are affected by habitat loss, change, and fragmentation. Seasonal migration and the dispersal of

juveniles and adults after breeding have been reported in the United States (Hylton 2004), with Wood Storks moving from areas where resources are scarce or unavailable to more favorable areas (Kushlan 1981, Coulter et al. 1999). These movements occur because Wood Storks are tactile feeders and depend on low water levels for efficient foraging (Herring and Gawlik 2011). Hylton (2004) reported that 82% of juvenile Wood Storks radio-tagged in southern Florida

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exhibited these circannual movements and the mean distance between natal colonies and their summer ranges was 388 km. In South America, Antas (1994) reported that Wood Storks banded at breeding colonies in the Pantanal wetland were later found in Argentina and southern Brazil (state of Rio Grande do Sul) in January and February, but no banding data were provided to support this statement. Thus, our objective was to analyze Wood Stork band-recovery data to examine the post-breeding movements of storks banded as nestlings in breeding colonies in Brazil.

### METHODS

Nestling Wood Storks were banded with numbered aluminum bands at nests in breeding colonies located in three regions of Brazil, including the Pantanal wetland in the states of Mato Grosso and Mato Grosso do Sul ( $N = 2398$  birds banded), coastal wetlands in the state of Amapá ( $N = 99$ ), and the northwestern portion of the state of Minas Gerais ( $N = 46$ ). The Pantanal wetland is an important conservation area in the Neotropics due to its central position in South America, its considerable biodiversity, and its role as a stopover and a breeding site for many birds (De Pinho and Marini 2012). This wetland is a periodically flooded savanna (Junk et al. 2014) covering  $\sim 140,000$  km<sup>2</sup> (De Pinho and Marini 2012).

Coastal wetlands in Amapá are floodplains located in northern Brazil near the equatorial region of South America, are influenced by predictable tidal flooded pulses, and serve as a stopover site for  $\sim 40$  species of migratory birds (Campos et al. 2008). The region surrounding the city of Vazante in the state of Minas Gerais (IBGE 2005) is tropical savanna (the *Cerrado*) that includes various types of vegetation, ranging from open grasslands to dense woodlands (Durigan and Ratter 2006).

We analyzed band recovery data provided by the National Center of Research and Bird Conservation (CEMAVE, ICMBio, Brazil). For each recovered band, we noted the banding date and banding location in Brazil (latitude and longitude), and the recovery date and location in Brazil or Argentina (latitude and longitude). Geographic coordinates were projected according to Albers projection (WGS 84 Datum) and distances were estimated using ArcGIS 9.3 (ESRI 2006).

### RESULTS

From 1983 to 2007, 2543 nestling Wood Storks (4–8 weeks old) were banded in three regions of Brazil, with most (94%) banded in the Pantanal wetland. From 1986 to 2008, only 17 bands were subsequently recovered (Fig. 1, Supplementary Table S1). Most bands ( $N = 14$ ) were recovered in southern Brazil and northern Argentina, and 10 bands (60%) were recovered during the austral spring/summer period (October–March) that follows the dry season in Wood Stork breeding areas in the Pantanal. Only one band of a Wood Stork banded in the Pantanal wetland was recovered north of the Pantanal (Fig. 1) and this bird was 2 mo old. Five bands were recovered in Argentina by hunters who killed the Wood Storks (two adult birds and three immature Wood Storks  $< 3$  yr old). The cause of death of the other 12 Wood Storks whose bands were recovered was not reported. Two bands were recovered  $< 20$  km from banding sites, including one adult (39 mo old) and one immature stork (15 mo old). The mean distance between banding and recovery sites was  $1265.1 \pm 895.2$  (SD) km (range = 0.03–3944.1 km). The greatest distance between banding and recovery sites (3944 km) was by a young stork banded in the state of Amapá and recovered 4 mo later in the Entre Rios province of Argentina.

### DISCUSSION

Most bands were recovered during the austral spring/summer (October–March), after the Wood Stork breeding period (July–October) that largely corresponds to the dry season in the Pantanal wetland (May–September) when water levels are low. Water levels increase during the rainy season (October–April) in the Pantanal (Junk et al. 2006) and, in response, Wood Storks leave the area because, as tactile feeders, they need areas with lower water levels to forage more efficiently (25 cm deep on average; Herring and Gawlik 2011). Movement by Wood Storks from breeding sites at the beginning of the rainy season in Pantanal is followed by the detection of storks in more southern areas. Similar movements have been reported in North America, with Wood Storks breeding in the Everglades during the dry season then moving to other wetlands in the southeastern United States where it is drier (Borkhataria et al. 2012). Junk

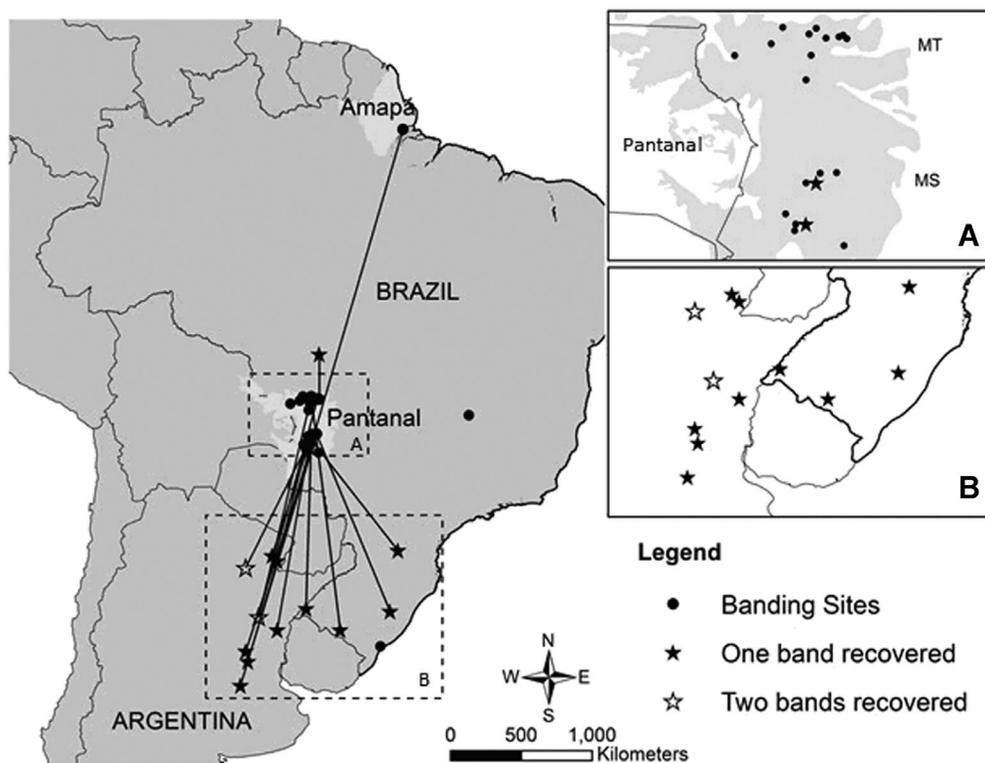


Fig. 1. Banding sites and sites where bands of Wood Storks ( $N = 17$ ) were recovered in Brazil and Argentina (MT, state of Mato Grosso; MS, state of Mato Grosso do Sul). Only 15 lines are shown because two Wood Storks had the same banding and recovery sites and one Wood Stork was recovered at the same site where it was banded 15 mo earlier.

et al. (2014) reported that rivers in west-central Brazil exhibited two “pulse” periods (rainy and dry), whereas rivers in more southern regions are more stable. Thus, when breeding, storks need more food and the Pantanal provides abundant fish and other prey items during the dry season. After breeding, Wood Storks move to more southern areas where they find shallower water.

Although based on a small sample size, we found little evidence of natal or breeding site philopatry (one immature and one adult Wood Stork were recovered <20 km from breeding sites). However, Coulter et al. (1999) reported similar results. Of 1589 color-marked nestling Wood Storks in Florida, only four 3-yr-old juveniles were subsequently observed in the breeding colony and three of these juveniles returned after 4 yr of age with adult plumage.

Wood Stork bands in our study were recovered in the Campos ecoregion of Brazil

(137,000 km<sup>2</sup>, with only 0.3% in conservation units) and in three Argentina ecoregions, including Pampa (351,330 km<sup>2</sup>, 1.0 % in conservation units), Chaco Húmedo (118,500 km<sup>2</sup>, 3.2% in conservation units), and Espinal (297,400 km<sup>2</sup>, 0.6 % in conservation units) (Burkart et al. 1999, Overbeck et al. 2007). Approximately 25% of the Campos biome in southern Brazil has been lost due to land use changes over the last three decades, mainly conversion to agriculture and forestry (Overbeck et al. 2007, Vélez-Martins et al. 2015). In Argentina, the Pampas ecoregion is the most populated and has been profoundly changed (Burkart et al. 1999). The Espinal ecoregion has a high rate of natural ecosystem replacement due to agricultural and livestock farming. The Chaco Húmedo ecoregion is the most conserved because only regions with higher altitude are occupied and wetland regions near the Paraguai and Paraná rivers are

preserved (Burkart et al. 1999). Neighboring regions in Paraguay and Uruguay on the border with northern Argentina and southern Brazil may also be used as post-breeding areas by Wood Storks because they belong to the Chaco and Pampa biogeographic provinces, and have similar biogeographic characteristics (Morrone 2006).

Of 10 bands recovered in Argentina, five were recovered by hunters in three provinces in Argentina (Chaco, Formosa, and Santa Fé). Argentine national law 22.421/1981 protects wild fauna in general, but each province can establish limitations on hunting to protect and conserve species. Hunting might be allowed in the provinces of Chaco, Formosa, and Santa Fé. Moreover, the Argentine Convention on the Conservation of Migratory Species of Wild Animals does not include Wood Storks on its list. In Brazil, hunting is prohibited by law.

Northern and central Argentine provinces where stork bands were recovered, excluding the Buenos Aires province (where one recovery was reported), have a population of approximately 6 million people, and Rio Grande do Sul state in southern Brazil, 11 million people (Burkart et al. 1999, IBGE 2010). Only a small fraction of the areas where Wood Stork bands were recovered is currently protected. We propose implementation of a collaborative educational program in these regions by the institutions that regulate bird banding, including the National Center of Research and Bird Conservation (CEMAVE) in Brazil and Centro Nacional de Anillado de Aves (CENAA) in Argentina. Changing the minds of hunters and those in local communities by education can be more effective than improving environmental laws.

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#### LITERATURE CITED

- ANTAS, P. T. Z. 1994. Migration and other movements among the lower Paraná River valley wetlands, Argentina, and the south Brazil/Pantanal wetlands. *Bird Conservation International* 4: 181–190.
- BORKHATARIA, R. R., P. C. FREDERICK, R. A. KELLER, AND J. A. COLLAZO. 2012. Temporal variation in local wetland hydrology influences post dispersal survival of juvenile Wood Storks (*Mycteria americana*). *Auk* 129: 517–528.
- BURKART, R., N. BÁRBARO, R. O. SÁNCHEZ, AND D. A. GÓMEZ. 1999. Ecorregiones de la Argentina. Cuarto Informe Nacional, Convenio sobre diversidad biológica, Secretaría de Ambiente y Desarrollo Sustentable, Administración Parques Nacionales, Buenos Aires, Argentina.
- CAMPOS, C., E. C. R. H. NAIFF, AND A. S. DE ARAUJO. 2008. Censo de aves migratórias (Charadriidae e Scolopacidae) da Porção Norte da Bacia Amazônica, Macapá, Amapá, Brasil. *Ornithologia* 3: 38–46.
- COULTER, M. C., J. A. RODGERS, J. C. OGDEN, AND F. C. DEPKIN. 1999. Wood Stork. In: *Birds of North America*, (Poole A. and F. Gill, eds.), No. 409: 1–28. The Birds of North America, Inc., Philadelphia, PA.
- DE PINHO, J. B., AND M. A. MARINI. 2012. Using birds to set conservation priorities for Pantanal wetland forests, Brazil. *Bird Conservation International* 22: 155–169.
- DURIGAN, G., AND J. A. RATTER. 2006. Successional changes in Cerrado and Cerrado/Forest ecotonal vegetation in western Sao Paulo state, Brazil, 1962–2000. *Edinburgh Journal of Botany* 63: 119–130.
- ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI). 2006. ArcGIS Professional: GIS for the desktop, version 9.3. ESRI, Redlands, CA.
- HERRING, H. K., AND D. E. GAWLIK. 2011. Resource selection functions for Wood Stork foraging habitat in the southern Everglades. *Waterbirds* 34: 133–142.
- HYLTON, R. A. 2004. Survival, movement patterns and habitat use of juvenile Wood Storks, *Mycteria americana*. M.S. thesis, University of Florida, Gainesville, FL.
- IBGE [online]. 2005. Fundação Instituto Brasileiro de Geografia e Estatística, dados referentes ao município de Vazante. <<http://www.cidades.ibge.gov.br/painel/painel.php?lang=&codmun=317100&search=minas-gerais|vazante|infograficos:-dados-gerais-do-municipio>> (Accessed 10 December 2014).
- . 2010. Fundação Instituto Brasileiro de Geografia e Estatística <[http://www.ibge.gov.br/estadosat/temas.php?sigla=rs&tema=sinopse\\_censodemog-2010](http://www.ibge.gov.br/estadosat/temas.php?sigla=rs&tema=sinopse_censodemog-2010)> (Accessed 20 July 2015).
- JUNK, W. J., C. NUNES DA CUNHA, K. M. WANTZEM, P. PETERMANN, C. STRÜSSMANN, M. I. MARQUES, AND J. ADIS. 2006. Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil. *Aquatic Science* 68: 278–309.
- , M. T. F. PIEDEDE, R. LOURIVAL, F. WITTMANN, P. KANDUS, L. D. LACERDA, R. L. BOZELLI, F.

- A. ESTEVES, C. N. DA CUNHA, L. MALTCHIK, J. SCHONGART, Y. SCHAEFFER-NOVELLI, AND A. A. AGOSTINHO. 2014. Brazilian wetlands: their definition, delineation, and classification for research, sustainable management, and protection. *Aquatic Conservation: Marine and Freshwater Ecosystems* 24: 5–22.
- KUSHLAN, J. A. 1981. Resource use strategies of wading birds. *Wilson Bulletin* 93: 145–163.
- MORRONE, J. J. 2006. Biogeographic areas and transition zones of Latin America and the Caribbean Islands based on panbiogeographic and cladistic analyses of the entomofauna. *Annual Review of Entomology* 51: 467–494.
- NORRIS, D. R., AND P. P. MARRA. 2007. Seasonal interactions, habitat quality, and population dynamics in migratory birds. *Condor* 109: 535–547.
- OVERBECK, G. E., S. C. MÜLLER., A. FIDELIS, J. PFADENHAUER, V. D. PILLAR, C. C. BLANCO, I. I. BOLDRINI, R. BOTH, AND E. F. FORNECK. 2007. Brazil's neglected biome: the South Brazilian Campos. *Perspectives in Plant Ecology. Evolution and Systematics* 9: 101–116.
- PARADIS, E., S. R. BAILLIE, W. J. SUTHERLAND, AND R. D. GREGORY. 1998. Patterns of natal and breeding dispersal in birds. *Journal of Animal Ecology* 67: 518–536.
- VÉLEZ-MARTINS E., C. H. ROCHA, C. BLANCO, B. O. AZAMBUJA, H. HASENACK, AND V. P. PILLAR. 2015. Conversão e Fragmentação. In: *Os Campos do Sul* (V. P. Pillar and O. Lange, eds.), pp. 123–132. UFRGS, Porto Alegre, Brazil

#### SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

**Supplemental Table S1.** Dates and locations where Wood Storks were banded and where bands were subsequently recovered.