MOVEMENTS AND RESOURCE UTILIZATION OF FOUR SPECIES OF DUCKS CAPTURED IN THE MID-PARANA RIVER BASIN, CORRIENTES PROVINCE, ARGENTINA

FINAL REPORT OF RESEARCH STUDY

SUBMITTED BY

DON PABLO RESEARCH TEAM

MOVEMENTS AND RESOURCE UTILIZATION OF FOUR SPECIES OF DUCKS CAPTURED IN THE MID-PARANA RIVER BASIN, CORRIENTES PROVINCE, ARGENTINA

Final Report

Submitted to

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Sponsor of Research Study

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EXECUTIVE SUMMARY

During the period 2008-10, 100 implantable battery-powered satellite transmitters (PTT-100; Microwave Telemetry, Inc., Columbia, MD, USA) were deployed on five species of ducks on the Don Pablo Ranch, near Goya, Argentina. The species selected were the white-faced whistling duck (*Dendrocygna viduata*), black-bellied whistling duck (*D. autmnalis*), fulvous whistling duck (*D. bicolor*), rosy-billed pochard (*Netta peposaca*), and the South American comb duck (*Sarkidiornis melanotos*). All species are relatively large ducks and of compatible size to carry a 26-gram PTT-100 transmitter internally with an external (percutaneous) antenna.

Results from these studies indicate that ducks instrumented at the end of the hunting period (July-August) disperse to new areas up to 500 miles around the release site. Although there was a slight tendency for the ducks to move south, there was not the clear north/south movement that is seen with ducks in North America every spring and winter. The distribution of ducks in the spring (November-April) in South America may reflect less dependency on specific habitats for breeding or it could reflect that South America was less influenced by the ice age period than was North America. The common migrations seen in North America are believed to be the result of the glacial period, 10,000 years ago.

The ducks on the Don Pablo Ranch use a large proportion of anthropogenic habitats, including rice fields, rain-fed crops, and wetlands controlled by dams. The data obtained suggest that the rice fields are used throughout the year, but in a greater proportion during the summer.

The distribution of the instrumented ducks on the ranch during winter (May-October) seemed most influenced by the production and distribution of cultivated rice. Off the ranch the ducks seemed closely associated with river drainages that included areas where there were cultivated rice impoundments (Amaiden 2011).

MOVEMENTS AND RESOURCE UTILIZATION OF FOUR SPECIES OF DUCKS CAPTURED IN THE MID-PARANA RIVER BASIN, CORRIENTES PROVINCES, ARGENTINA

INTRODUCTION

Little was known about Argentine waterfowl or their habitat until a wealthy American businessman and duck hunter, Mr. Paul Tudor Jones, decided to sponsor a satellite tracking study on his ranch in Argentina. This report is a compilation of the work that was done over a three-year period (2008-2010) by a team of researchers. More technical manuscripts will be forthcoming and published in the scientific literature so that the larger group of wildlife professionals can become aware and knowledgeable concerning this unique study that has provided a tremendous amount of information about Argentine waterfowl.

Argentina is a popular destination for both North American and European waterfowl hunters due to large populations of ducks, a variety of species, and liberal bag-limits. A search of the world-wide web for duck-hunting outfitters produces hundreds of web-sites offering duck hunting opportunities in Argentina. A similar web-search for information on the biology, behavior, or management of ducks in Argentina produces meager results. However, whistling ducks (genus *Dendrocygna*) have received general attention from North American biologists concerning zoogeography, ecology, and anatomy (Bolen et al. 1983). Research on annual habitat use by ducks requires a practical and effective combination of satellite telemetry and remote sensing information and these techniques were used to collect data for this study.

The team of researchers assembled for the study included scientists from USGS Patuxent Wildlife Research Center (Patuxent) in Maryland, USA, and a professor and students from the University of Cordoba (Cordoba), in Cordoba Province, Argentina. Staff on the ranch in Argentina and biologists on the donor's staff in the United States were heavily involved with the study. In addition to field personnel, several persons worked on data analyses at Patuxent and Cordoba.

Although many species of ducks occur on the ranch, this study aimed at filling existing information gaps on four duck species common in the hunter's bag: the black-bellied whistling duck (*Dendrocygna. autmnalis*; BBWD), fulvous whistling duck (*D. bicolor*; FUWD), white-faced whistling duck (*D. viduata*; WFWD), and rosy-billed pochard (*Netta peposaca*; RBPO). While there are several other species equally common to the hunter's bag, these four species of ducks have a sufficiently large body mass (700g, 700g, 700g, 1000g, respectively) to successfully carry a radio transmitter.

OBJECTIVES

1. Describe the annual and seasonal movement patterns of the four duck species
2. Determine main habitat use patterns including both natural and agricultural areas.
3. Explore the existence of important nesting, molting, staging, and wintering areas.
4. Evaluate use of rice fields and other man-made habitats by the four duck species
5. Based on the above findings, identify and describe key management factors and resources important to the continued success of these four species.

BACKGROUND INFORMATION

In late 2007, a request was made to Patuxent Wildlife Research Center (Patuxent), Laurel, Maryland, to initiate a study on the movements of waterfowl on the Don Pablo Ranch in Argentina using satellite telemetry. Scientists at Patuxent had experience with satellite telemetry with seaducks in North America (Olsen et al. 2005, Perry et al 2006) and several other species in Europe, Africa, and Asia (Prosser et al. 2009).

It was decided early in the planning to collaborate with staff at Cordoba University, Cordoba, Argentina, and a graduate student under the direction of Dr. Enrique Bucher was obtained to assist with field work and to conduct analyses of satellite tracking data. Dr. Bucher's staff had unique experience analyzing remote sensing images of habitat in South America.

Microwave Telemetry, Inc., (Columbia, MD, USA) was selected to provide the satellite telemetry units due to the extensive previous contracting that Patuxent had with this company and the proven record they had with implantable units. At the time the study was initiated, no other company in the world had successfully created and deployed implantable telemetry units with a percutaneous antenna in waterfowl.

STUDY AREA

General Description:

This study was conducted on the privately-owned 6,300 hectares (15,750 acres) Don Pablo Ranch located near about 60 km southeast of the town of Goya, Corrientes Province, Argentina, at latitude -29.5448 and longitude -59.0382. Our study site was a wintering area for waterfowl in Corrientes Province, northern Argentina. The site is on the Corrientes River, a large river that drains the central portion of Corrientes Province, eventually joining the Paraguay River.

The ranch was previously used for cattle production and grazing until it was purchased 2008 by an American hunter, who converted the ranch to a wildlife management area. Hunting rights on the ranch had been purchased for two years previous to the purchase. All cattle were removed and cats and dogs belonging to ranch employees were also removed over a two-year period. Intensive management began in 2007, which included creation of impoundments and flooding of fields for rice production.

Although the instrumentation of the ducks occurred on the ranch the data came from the total area that the study ducks used while transmitting**.** It stretched from 27° to the 38º S latitude and from the 56° to the 63° degrees longitude, and included the southeast region of Paraguay, southwest region of Brazil, Northwest of Uruguay, and East of Argentina.

Climate:

The study area covered part of the wetland regions, so-called Cuenca del Plata, Chaco, and Pampas (Canevari et al. 1998). The Plata Basin comprises the basin of the Paraná River and its delta, the Uruguay and Río de la Plata. To the North, the climate is tropical and in the South, subtropical temperate. The climate varies from the hot and dry areas of the West, then less so in the mountain foothills, and becoming more benign towards the East. The area reaches the maximum rainfall in the headwaters of the coastal tributaries of the Paraná, the Uruguay and the other tributaries of the Iguazu river network. Wetlands are associated with the floodplains and surrounding areas of the Parana and Uruguay Rivers.

Chaco. It is a vast semi-arid plain, which includes part of Argentina, Bolivia, and Paraguay. The Chaco is located within a region that ranges from a semi-arid to a semi-humid climate, resulting from a rainfall gradient that goes from one 450 mm annually in the southwest to 1,200 mm per

year in the East. The rain regime is strongly seasonal. Elements of the Chaco climate have a wide variability. Temperatures decrease from North to South; the annual average varies between 19° C and 24° C.

Pampas. It comprises the eastern plains of the Argentina between 33° to 39° degrees latitude approximately. The climate is temperate pampas in most of its territory, and temperate oceanic or tempered transition in the coastal South region. It rains throughout the year; rainfall decreases from North to South and East to West, from about 1200 to 600 mm per year. The average annual temperature varies between 13° and 17° C. The pampean lakes are typical aquatic environments and unique to this region.

Hydrology:

The Don Pablo Ranch is in the Parana River and Corrientes River watersheds. The Parana River and its major tributary, the Paraguay River, comprise the second largest river system in South America (Bonetto 1986; Arduino 1990). A diversity of wildlife uses the rivers and the wetlands in the adjacent uplands for nesting, brood rearing, resting, and feeding (Bucher et al. 1993). The rivers and the wetlands near the rivers have unique floating vegetation that is used by numerous wildlife species, especially birds seeking refuge from the numerous predators in the wetlands, especially broad-snouted caimans (*Caiman latirostris*).

Land Use:

Wetland impoundments on the Don Pablo Ranch were created by constructing dikes with bulldozers and draglines from soil on the construction site. Water was pumped to the impoundments from channels that were dredged from the Parana River to inland sites to facilitate water availability. The first impoundment was called Airport Wetland and was planted with rice in early 2007 and flooded in July 2007. This site was heavily used by waterfowl and was a main site used for trapping ducks during this study in 2008 and 2009. There are presently a total of 12 impoundments of approximately 110 hectares (275 acres) that are managed annually with planting of rice and flooding with pumped water. In addition to the flooded impoundments there are 1500 hectares (3750 acres) of natural wetlands on the ranch that are used by waterfowl and other wildlife.

Each year upland sites are planted with approximately 28 hectares (70 acres) of sorghum, 24 hectares (60 acres) of corn, 4 hectares (10 acres) of white clover, 2 hectares (5 acres) of sunflower, and 16 hectares (40 acres) of oats. These sites are managed mainly for pigeons and doves, but are also used by numerous other wildlife species.

A small number of domestic cattle (500-750) and water buffalo (25-35) are maintained to graze about 700 hectares (1750 acres) of natural grassland and avoid invasion of woody plants. These natural grassland areas also have 40 kilometers (25 miles) of plowed strips (roads) that are maintained annually to provide additional habitat for 2 species of perdix (partridge, *Nothura* spp.). These areas are used for dusting and foraging on insects.

Approximately 3900 hectares (9750 acres) are in shrub or tree vegetation with about 10 hectares (25 acres) in planted eucalyptus trees. Although not intensively managed these woody vegetation sites provide good habitat for roosting doves and pigeons as well as many other wildlife species, especially passerine birds. The result of the management program and policy changes on the ranch was the creation of an area with high waterfowl use and high populations of many other wildlife species. This area is a showplace for successful management of land to benefit wildlife populations, especially birds (Appendix 1).

Duck Species Diversity:

Eleven species of ducks were recorded on the ranch during this 3-year study (Appendix 1). The whistling ducks (Tribe Dendrocygnini) constitute the most numerous ducks on the ranch

and the white-faced whistling duck is the most common of the group. Rosy-billed pochards were the most numerous of the divers. One stifftail the masked duck (*Oxyura dominica*), in the Tribe Oxyurini, occur on the ranch, but not in large numbers, and the was seen twice on different ponds.

Among the puddle ducks (Tribe Anatini), the Brazilian duck (*Amazonetta braziliensis*) and the ringed teal (*Callenetta leucophrys*) were the most common on the ranch and were commonly captured, while focusing on whistling ducks and pochards. The black-headed duck (*Heteronetta atricapilla*) is a parasitic nester and was unique to the area, but only seen once. Other waterfowl recorded was the coscoroba swan (*Coscoroba coscoroba*), which was seen one year. No geese species were seen during the study.

TECHNIQUES

Capture:

Ducks were captured at various locations on the Don Pablo Estancia near Goya, Argentina, within the floodplain wetlands of the Corrientes River in Corrientes Province during August 2008, 2009, and 2010. The Corrientes River flows into the Parana River producing a very large watershed. Because these wetlands of the Corrientes and Parana River are popular hunting sites for commercial hunting outfitters, capture efforts were delayed to the end of the traditional hunting season. Capture sites were pre-baited with commercial rice to attract feeding ducks, and when ducks were attracted to the wetland, the site was equipped with walk-in funnel traps. The traps were modified to be swim-in traps in deeper water when predation by foxes became a problem. The funnel and surrounding areas in and out of the trap were continually baited during the trapping period. Traps were closed at sunset and opened at sunrise.

Ducks selected for instrumentation were all adults (with the exception of the comb duck) and were the heaviest and healthiest available during capture of each day. Age and sex of all ducks were determined by cloacal examination, with size of penis being main determinant of age in males and size of bursa being main determinant of age in females. Additional ducks that were captured during the trapping effort were taken to the surgery area where weights (g) and measurements (mm) of culmen, tarsus, wing chord, and 9th primary were recorded. Measurements followed protocols established by Baldwin et al. (1931). Weights were taken with a simple spring scale, whereas linear measurements of body parts were taken with calipers (culmen and tarsus) and a centimeter ruler (9th primary and wing chord).

Four major duck species used with satellite telemetry study.

Telemetry:

The techniques used for satellite transmitter implant work have evolved in the last two decades (Korchgen et al. 1984, 1996; Esler et al. 2000). Researchers at the USGS Patuxent Wildlife Research Center developed a technique for implanting transmitters in ducks and completed a study of almost 300 of canvasback during 1987-89 (Olsen et al. 1992, Haramis et al. 1993). This original work was done with VHF transmitters, but the techniques were applied to

satellite transmitters when the latter were developed several years later (Petersen et al. 1995, 1999). All transmitters on the study in Argentina used 26-gram PTT-100 implantable transmitters with an external antenna (percutaneous). Transmitters were purchased from Microwave Telemetry, Inc., Columbia, Maryland, USA.

Nylon Mesh Bags

A problem with some transmitters shifting position in the coelomic cavity (Olsen et al. 2005) resulted in the antenna not remaining vertical, but rather falling laterally to 45° or greater. This can decrease signal strength, especially if the antenna tip drags in the water. This shifting in position may also interfere with normal flight. Two techniques have been developed to stabilize the transmitter in the coelomic cavity. The first utilizes suture material such as PDS II or Ethilon (Ethicon, Inc., Johnson and Johnson Company, Somerville, New Jersey, USA) to form a harness to hold the transmitter in position against the lateral body wall. The second technique uses 100% nylon mesh to form a vest or bag partially or completely surrounding the transmitter. The mesh is attached with surgical silicon adhesive or, in the case of the bag, no additional adhesive is needed. Two simple interrupted sutures (PDS II) are used to hold the transmitter in position against the body wall. We used the mesh on all transmitters except those for the black-bellied whistling ducks, where suture material alone was used to hold the transmitters in place in the coelomic cavity. The different technique used on black-bellied whistling ducks was due to the slightly smaller coelomic cavity of this species.

The antenna cuff of felt material around a flexible plastic core (Kendall Quinton Felt Cuff, Tyco Healthcare Group LP, Mansfield, Massachusetts, USA or similar product) is placed at the base of the antenna on each implantable transmitter. The cuffs are used for indwelling peritoneal catheters in human medicine. The cuff was retained in position with an additional layer of heat shrink tubing.

However, attachment to the heat shrink wrap on the transmitter antenna has proven problematic. The original technique involved using adhesive silicon, as recommended by the cuff manufacturer. The cuff would eventually work loose from the antenna using this technique. The latest technique, developed with the assistance of Microwave Telemetry (Dr. Paul Howey, pers. comm.) has been to glue the cuff to the antenna and then heat shrink using Locktite 410 glue (Henkel Corporation Engineering Adhesives, Rocky Hill, Connecticut, USA). This is allowed to set for 24 hours then an additional 1.5 cm piece of heat shrink tubing is placed above

the cuff to further anchor the cuff in position. These techniques were used to help stabilize the transmitter in the coelemic cavity (Mulcahy and Esler 1999, Mulcahy et al. 1999, 2007).

Transmitter Sterilization

To prevent infections, the transmitters were disinfected using ethylene oxide gas to completely sterilize the outside of the transmitters before implantation. Gas sterilization using ethylene oxide (Anprolene, Andersen Sterilizers, Inc., Haw River, North Carolina, USA) has become the normal and accepted method for sterilizing the coelomically implanted transmitters (Burger et al. 1994, USGS 2006). Transmitters are placed in a bag permeable to the gas, but not permeable to bacteria. These bags are then placed in a special ethylene oxide sterilizing container in a well-ventilated area, such as a fume hood. The bagged transmitters are exposed to the ethylene oxide gas for 12 hours. This is followed by a 12-24 hour period when the bags and contents are placed on open shelving and allowed to "de-gas" before surgical implantation. All sterilization and transmitter preparation procedures were conducted at Patuxent Wildlife Research Center, Laurel, Maryland. A small magnet taped to each unit prevented transmission.

Anesthesia

Techniques for conducting the surgery have improved over the years. Isoflurane anesthesia (Isoflurane, USP, Hospira, Inc., Lake Forest, Illinois 60045 USA or other generic equivalents) with a bupivacaine local at the surgery site was used for each implant surgery in 2008 and 2009. Isoflurane anesthesia is a useful anesthetic for waterfowl, but requires compressed oxygen for vaporization of the liquid isoflurane. Lightweight oxygen cylinders (E-size cylinders) are available in many areas of the world, and can be purchased or rented for field work. However, either the cylinders need to be refilled or multiple cylinders need to be rented or purchased. In addition, the compressed oxygen cylinders can be an explosion hazard in some situations in vehicles, and transport on aircraft in most countries is highly restricted, often to freight-only aircraft.

Oxygen concentrators are commercially available in many parts of the world. These can be battery powered, powered from local household current, or run off of a portable electrical

generator. The units can often be rented for much less than the cost of the traditional oxygen cylinders, and are being used often for home oxygen therapy, and in human hospitals and remote human medical outposts (Shrestha et al 2002).

Isoflurane for induction was delivered by face mask. A small animal face mask or a special duck face mask constructed from a 35 or 60 ml plastic syringe case was used for induction. The narrow end is cut off to form a tight fit with the end of the tube delivering the oxygen/isoflurane mix. The wide end is covered with Micropore tape to cushion the edges and a flat area of a surgical glove is stretched across the opening and held in place with more tape. The flat surface of the glove is then slit and the duck bill is placed through the slit for induction.

Induction is started slowly with just oxygen at first then 1 % isoflurane, gradually increasing every 30-60 seconds until the duck is anesthetized. Regardless of anesthetic type, ducks are always intubated. The endotracheal tube is taped to the bill, usually the lower bill, to allow passage of the esophageal cardiac monitor (Audio Patient Monitor, A. M. Bickford Inc. Wales Center, New York 14169). Oxygen was delivered at a flow rate of 0.5 to 1.0 l/minute from either conventional oxygen tanks (E-tanks) or from an oxygen concentrator Model NewLive (AirSep Corporation – Industrial and Medical Air Separation Equipment, Buffalo, New York).

A respiratory monitor, Breathe Safe, was attached inline to the intubation tube to allow monitoring of the respiration. A pulse oximeter (Nelcor N-20, Nellcor Incorporated, Pleasanton, California 94588) was used to monitor cardiac rate and oxygen saturation by attaching the sensor to the webbing of the duck's foot.

In 2008, some ducks were anesthetized with propofol (10 mg/ml, Hospira, Inc., Lake Forest, Illinois 60045 USA, or Abbott Laboratories, North Chicago, Illinois 60064 USA) given intravenously, usually using the medial tarsal vein on the leg. A 25 gauge ¾ inch winged infusion catheter (Surflo, Terumo Corporation, Tokyo, 151-0072, Japan, or Standard Infusion Set, Abco Dealers, Inc. Milwaukee, Wisconsin 53218) was placed in the vein to deliver the propofol. The catheter is taped to the foot using adhesive tape. For many duck species it is helpful to trim the wings of the catheter to the size of the leg to which it is to be taped.

In 2010, an experiment was conducted to test if differences existed between groups of ducks receiving oxygen from an oxygen concentrator compared with those ducks receiving oxygen from the more typical oxygen cylinders. Our hypothesis was that the oxygen

concentrator would deliver oxygen in sufficient quality and quantity for use in isoflurane general anesthesia of ducks, and that there would be no differences noted in the surgeries or any of the measured parameters between ducks receiving oxygen from either the oxygen concentrator or from standard oxygen cylinders.

Surgery

Each duck had a surgical procedure to implant a PTT 100 satellite transmitter (Microwave Telemetry, Inc., Columbia, Maryland USA). The duck was placed on its back and the surgical field was prepared. The feathers on the ventral abdominal midline were parted and held back using water soluble ointment of hydroxyethylated amylopectin (Facilitator, Blue Ridge Pharmaceuticals, Greensboro, North Carolina 27410) or hydroxypropyl methylcellulose (HR Lubricating Jelly, Carter Products Division of Carter-Wallace, Inc., New York, New York 10105). Paper tape (Micropore Surgical Tape, 3M, St. Paul, Minnesota 55144) was used to further hold the feathers out of the surgical field. The skin was disinfected with dilute chlorhexadine diacetate solution (Nolvasan, Fort Dodge Laboratories, Fort Dodge, Iowa 50501). Local anesthesia (Bupivacaine HCl, Abbott Laboratories, North Chicago, Illinois 60064, USA) was infiltrated into the incision site. The total dose should not exceed 1.5-2.0 mg/kg of bupivacaine HCl. The bupivacaine HCl provides long-term (24-48 h) analgesia.

A midline ventral abdominal incision starting just caudal to the end of the sternum and extending 3.3 to 4.0 cm (1.4-1.6 in) caudally was made using a #15 scalpel blade. The right caudal abdominal air sac is opened, and if necessary, especially in very obese ducks, space is created for the PTT by blunt dissection. Before the PTT is placed in the coelomic cavity, the exit hole for the antenna is created.

Two techniques were used for passing the antenna through the body wall. The first technique uses a blunt stainless steel trochar to penetrate the dorsal abdominal wall into the coelomic cavity (Mulcahy and Esler 1999, Elser et al. 2000, USGS 2001). The antenna is threaded into the lowest hole in the trochar, and the trochar with the antenna is pulled back through the abdominal wall.

In the second technique, developed at Patuxent, we use a 3/32 inch diameter Steinman intramedullary pin cut in half, with the sharp end slightly dulled and a sleeve of 3 mm (1/8 in) outside diameter aluminum tubing to make a trochar and sleeve combination. The trochar and sleeve were positioned inside the coelomic cavity and then penetrated the abdominal wall from

the inside, instead of the outside, caudal to the pubic bone on the right side. The duck was raised slightly off the table and the assistant pulled the trochar from the sleeve. The PTT was placed in the coelomic cavity and the PTT antenna was passed out through the sleeve. The sleeve is then also removed by the assistant, while also pulling on the antenna to keep transmitter in place. Placement of the transmitter follows and was the same in either the first or second case.

The felt cuff glued to the base of the antenna and the mesh bag was sutured to the body wall to help stabilize the PTT. There are two alternatives for anchoring the cuff in place: a) A single suture is run externally from the dorsal caudal lumbar area through the skin and body wall into the antenna collar. Note, this suture is usually placed in position after the abdominal cavity has been closed in step 5 below. b) A single suture is placed in the antenna collar and body wall internally as the PTT is being positioned in the coelomic cavity. Note, it sometimes helps to preposition this suture, position the PTT in the coelomic cavity and then tie the suture.

The abdominal body wall was closed with a single line of simple continuous suture material. Likewise, the skin was closed with another single line of simple continuous suture material. Suture material used throughout the procedure was absorbable 3-0 PDS II (Ethicon Inc., Sommerville, New Jersey 08876 USA), Vicryl (polyglactin 910, Ethicon Inc., Sommerville, New Jersey 08876 USA).

Sterilized 26 g PTT with magnet in place

PTT 100 with mesh bag and felt cuff

In addition to a general anesthesia, various types of analgesics or pain-relieving medications to reduce complications from post-operative pain were used. Strict aseptic surgical techniques were also adhered to including using all sterile instruments, sterile surgeon's gloves, and surgical gowns. Recently, experiments were conducted at Patuxent with various regimes of post-operative care of captive ducks, including supplemental feeding and various feather cleaning techniques (Olsen et al. 2010). The research showed that survival was improved by not giving supplemental feeding and releasing ducks as soon as possible to avoid feather problems, which were the procedures used in Argentina.

Each surgery took approximately 60 minutes, including preparation and post-surgical monitoring. Lactated Ringer's solution was given subcutaneously, usually 15 to 30 ml/kg, as a single bolus or divided into two boluses. We wrapped the duck in a towel and carefully monitored its recovery until fully awake, able to hold its head erect, and stand or sit in an upright position. At this point the duck was returned to the portable kennel or other cage and placed in a dark quiet area. Ducks were released 3-4 hours after surgery during daylight hours at capture site. Ducks having implant surgery in the late afternoon or evening were released early the next morning to avoid flushing other ducks from the ponds at night and to avoid numerous nocturnal predators.

Satellite Telemetry Tracking

Satellite tracking (ARGOS) began immediately following surgery and ducks were released back onto the wetlands of the Don Pablo Ranch within the Corrientes River watershed.

Telemetry data were filtered to eliminate unlikely positions and errors using the filtering algorithm Douglas version 7.02 (U.S. Geological Survey - Alaska Science Center - Biology - GIS - Spatial Tools 2010). Filtered data were plotted in a Google Map for initial analysis, and later processed in a special routine in ArcView GIS, where each position datum was located in Landsat satellite images (the closest in data for the available sets). Location data were posted monthly on a bi-lingual Spanish-English website. An Argentine researcher was responsible for data analyses and maintenance of the website with assistance from USGS personnel. During the second and third years of the study, locations determined from the satellite telemetry were analyzed for habitat type. Some location sites were visited on the ground and the nature of the natural resources described to better understand the habitat used by the ducks.

Satellite data were initially processed at USGS Patuxent Wildlife Research Center and shared with researchers in Argentina. Analyses of the habitat used by the ducks (based on locations) during the three years following release were conducted in Argentina by graduate students at the University of Cordoba. In addition to the wealth of new movement and habitat data that were generated, an added advantage of this study was the collaboration between North and South American researchers.

Terminology Used:

Position. Followed by individual location. Each received position was assigned to one of two defined categories: isolated positions and positions in the group. Positions in Group ("clusters" in English nomenclature) were called as a set of positions consecutive, near each other and equal or exceeding three, within a circle imagination with no more than 25 km radius. Their positions were all position out of a group.

Flights. Called short flights to those less than 100 km from a position to the next, and that they did not belong to group positions. Long flights are considered to those equal to or greater than 100 km from a position to the next.

Total distance traveled. Path of the duck since release until the last detection of the same individual.

Total time of follow-up. Since the release of the duck up to last detection.

Daily turnover rate. Ratio between distance traveled and duration of follow-up.

Habitat. Site specific for a given position.

Catch and release site. Area comprising an imaginary circle of 25 km of radio signals.

Data Analyses:

In ongoing studies of duck migration in Argentina, we worked with a software system that fulfills the role of a practical and effective combination of satellite telemetry and remote sensing information. The software includes the following components. First, a filter (developed by the U.S. Geological Survey) eliminates erroneous coordinates in the raw data sent by the satellite, due to transmission problems or other artifacts. Second, a program organizes the filtered database and displays data on Google maps, allowing rapid visualization of ducks movements for both research and educational purposes (such as web pages, for example). The third component integrates the coordinate-filtered database with a satellite image database of the study that includes as many different dates of acquisition as available for each path-row intersection. If needed, images may be improved by selecting optimal band combinations to increase key habitat features. Finally, the program automatically associates a given duck position with the closest in time satellite image. The sequential use of the listed software components allows rapid and error-free manipulation of a large amount of remote sensing data for habitat use studies. To show major uses of areas in the various countries we used the Kernel Density tool in Spatial Analyst in ArcMap (ArcGIS Desktop 10. Redlands, CA: Environmental Systems Research Institute).

Statistical analyses of morphometric data included a standard analysis of variance (SAS 2008) comparing differences among years, species, age, and sex. Only groups of ducks with sample sizes of 5 ducks or more were used for statistical analyses. Differences were considered to be significant at the < 0.05 level of probability.

RESULTS

Banding and Morphometrics:

During August of 2008, 2009, and 2010, a total of 943 ducks of eight species were captured and banded at the Don Pablo Ranch near Goya, Argentina. The white-faced whistling duck was by far the species most commonly caught (Table 1). Capture rates for the species at Don Pablo Ranch appeared closely correlated to the abundance of the species on the ranch and not to differences among the species in regard to ease of capture. However, no population data

were available to make this correlation. One duck that was banded, but not instrumented in 2008, returned to the ranch and was captured in 2009. Two banded ducks were shot by hunters.

Sex ratio of captured ducks was skewed towards females with BBWD and WFWD, but five species had more males than females (Table 1), which more commonly occurs with North American ducks. Duck species captured and banded that were not part of the telemetry study included 23 Brazilian ducks (BRDU), 7 red shovelers (*Anas platalea*; RSHO), and 27 ringed teal (*Callonetta leucophrys*; RITE). Only one South American comb duck (*Sarkidiornis melanotos*; COMB) was captured and it was a male. The comb duck was instrumented.

Table 1. Banded ducks at Don Pablo Ranch in 2008, 2009, and 2010.

Species	Total Banded	Total Males	Total Females	Not Sexed
BBWD	22	7	14	1
FUWD	159	84	75	
WFWD	680	144	229	307
RBPO	26	14	10	2
BRDU	23	17	6	
RSHO	7	5	2	
RITE	27	15	12	
COMB	1	1		
TOTALS	943	285	348	310

Annual variations were not detected ($P>0.05$) for body weight for each of the four age and sex classes for WFWD, and so analyses among the age and sex classes for this species were combined across years. No differences ($P<0.05$) in weight could be detected among adult male, adult female and immature male for WFWD, but immature female body weights were different from the other age and sex groups for this species ($P>0.05$).

Weight was obtained on 21 of the 22 BBWDs that were captured at Don Pablo Ranch. Only 3 adult males BBWDs were captured and their mean weight was appeared less than the adult females. Immature male BBWDs were heavier than immature females (Appendix 2).

Weight data of FUWDs showed that adult and immature males were heavier than adult and immature females, respectively. The RBPOs were the largest of the species captured at Don Pablo Ranch and the only diving duck species captured. Males were clearly heavier ($P<0.05$) than females among the adults, but unfortunately only one immature female was captured during the 3-year period, so comparisons could not be made for young RBPOs (Appendix 3 and 4). No differences were detected between weights of adult female and immature males RBPOs.

Samples of ducks of each of the four target species were selected for measurements (mm) of body parts, which included length of culmen, tarsus, 9th primary, and wing chord (Appendix 3 and 4). Most measurements were taken in 2008, some in 2009, but none in 2010. Annual variations could only be tested for WFWD between 2008 and 2009 as sample size was too small or incomplete for other species. No difference ($P<0.05$) could be detected for any of the four body part measurements for WFWD between 2008 and 2009.

Measurements of culmen, tarsus, 9th primary, and wing chord of BBWD males in each age classes were equal or larger than for females. This preliminary analysis indicates that size was not the only factor relating to in heavier females than males for BBWDs and other factors such as condition or reproductive stage could result in these differences. However, a larger sample size is needed to make more conclusive assessments.

All four measurements showed that males were also larger than females, indicating that larger weights for males were not related to greater fat levels, but was related to larger structure (Appendix 2 and 3). FUWDs were slightly larger than the other two species of whistling duck species. Sample sizes for WFWDs were the largest of all species captured and interestingly the measurements were most similar between males and females for both adult and immature ducks in comparison to other species (Appendix 2 and 3). It would have been beneficial to get more weights and measurements from the other species to see if this also might have been true with them if a larger sample size had been obtained.

No differences in culmen measurements could be detected between adult male and adult female of all three whistling duck species (Appendix 2). Immature female WFWD had a smaller ($P<0.05$) culmen than the other three age sex groups of WFWDs. Culmen length was greater in adult and immature male RBPOs than in the adult females. Only one culmen of an immature female RBPO was obtained so no analyses were performed.

Measurements of the tarsus of BBWDs, FUWDs, and WFWDs showed that immature females had a shorter mean tarsus measurement than adult males, adult females, and immature males (Appendix 2). Only one tarsus measurement was obtained for immature female RBPO and it is very large and considered to possibly be in error.

Lengths of 9th primary and wing chord were not different ($P<0.05$) among adult male, adult female, and immature male, but all were different from immature females for all three species of whistling ducks (Appendix 3). Adult male RBPOs had longer ($P<0.05$) 9th primary and wing chord than adult female and immature male. Unfortunately only one immature male was measured so no comparison can be made.

A smaller sample of Brazilian ducks and ringed teal were captured and measured. Among the BRDU adults, males were heavier and larger than females for all measurements except culmen (Appendix 4). Mean weight of 6 adult male ringed teal was 408 grams and 4 adult females 392 grams. Sample size of immature RITE was too small to make comparisons between ages and sexes for weights and linear measurements (Appendix 4).

Oxygen Concentrator Study – 2010:

In 2010, an experiment was conducted to test if differences existed between groups of ducks receiving oxygen from an oxygen concentrator compared with those ducks receiving oxygen from the more typical oxygen cylinders. This separate study was conducted due to the problems at some field locations in obtaining concentrated oxygen in cylinders. Potential results from this experiment could have important consequences for other field studies. All statistics were done using a program called Statistix 8 using the ANOVA for random samples.

No differences ($P > 0.05$) were detected between the two groups concerning heart rate based on analyses of variance, chi square analyses tests, and Cochran's Q test (Table 2). Mean heart rate for all ducks in both groups combined was 189.08 (CV 12.67) beats per minute (b/m).

Table 2. Mean and statistical comparisons for heart rate between two groups of ducks on study using oxygen concentrator or oxygen cylinder during anesthesia.

	N	Mean (b/m)	SE		
O_2 Concentrator	21	188.67	5.2287		
O_2 Cylinder	17	189.59	5.8114		
ANOVA					
Source	**DF**	**SS**	**MS**	**F**	**P**
VO15	1	8.0	7.979	0.01	0.9068
Error	36	20,668.8	574.133		
Total	37	20,676.8			
CHI SQUARE					
Chi Square	DF	P			
0.71	1	0.3992			
Cochran's Q	0.6011				

No differences (P > 0.05) were detected between the two groups concerning the oxygen concentration (%) based on analyses of variance chi square analyses tests, and Cochran's Q test (Table 3). Mean oxygen concentration for all ducks in both groups combined was 96.892 (CV 4.45) percent.

Table 3. Mean and statistical comparisons for oxygen concentration (%) between two groups of ducks on study using oxygen concentrator or oxygen cylinder during anesthesia.

	N	Mean (%)	SE		
O_2 Concentrator	21	97.550	0.9642		
O_2 Cylinder	17	96.118	5.8114		
ANOVA					
Source	**DF**	**SS**	**MS**	**F**	**P**
VO19	1	18.8530	18.8529	1.01	0.3208
Error	35	650.715	574.133		
Total	36	669.568			
CHI SQUARE					
Chi Square	DF	P			
0.71	1	0.3996			
Cochran's Q	0.6009				

No differences (P > 0.05) were detected between the two groups concerning the isoflurane concentration (%) based on analyses of variance, chi square analyses tests, and Cochran's Q test (Table 4). Mean oxygen concentration for all ducks in both groups combined was 96.892 (CV 4.45) percent.

Table 4. Mean and statistical comparisons for isoflurane concentration (%) used in surgery between two groups of ducks on study using oxygen concentrator or oxygen cylinder during anesthesia.

	N	**Mean** (%)	**SE**		
O_2 Concentrator	22	3.0682	0.0865		
O_2 Cylinder	18	3.2222	0.0957		
ANOVA					
Source	**DF**	**SS**	**MS**	**F**	**P**
VO17	1	0.23491	0.23491	1.43	0.2398
Error	38	6.25884	0.16471		
Total	39	6.49375			
CHI SQUARE					
Chi Square	DF	P			
7.71	1	0.0074			
Cochran's Q	0.7895				

No differences (P > 0.05) were detected between the two groups concerning the body temperature (^{0}C) based on analyses of variance, chi square analyses tests, and Cochran's Q test (Table 5). Mean body temperature (^{0}C) for all ducks in both groups combined was 40.612 (CV 2.72) ^{0}C.

Table 5. Mean values and statistical comparisons for body temperature (^{0}C) between two groups of ducks on study using oxygen concentrator or oxygen cylinder during anesthesia.

	N	Mean (^{0}C)	SE		
O_2 Concentrator	22	40.468	0.2358		
O_2 Cylinder	18	40.789	0.2607		
ANOVA					
Source	**DF**	**SS**	**MS**	**F**	**P**
VO18	1	1.0182	1.01824	0.83	0.3673
Error	38	46.4855	1.22330		
Total	39	47.5038			
CHI SQUARE					
Chi Square	DF	P			
0.07	1	0.7949			
Cochran's Q	0.5303				

No differences (P > 0.05) were detected between the two groups concerning the body weight (g) based on analyses of variance, chi square analyses tests, and Cochran's Q test (Table 6). Mean body temperature (^{0}C) for all ducks in both groups combined was 921.50 (CV 10.83) g.

Table 6. Mean values and statistical comparisons for body weight (g) between two groups of ducks on study in 2010 using oxygen concentrator or oxygen cylinder during anesthesia.

	N	Mean (^{0}C)	SE		
O_2 Concentrator	22	893.18	21.284		
O_2 Cylinder	18	956.11	23.530		
ANOVA					
Source	**DF**	**SS**	**MS**	**F**	**P**
VO08	1	39205	39204.9	3.93	0.0546
Error	38	378705	9965.9		
Total	39	417910			
CHI SQUARE					
Chi Square	DF	P			
0.40	1	0.5249			
Cochran's Q	0.5743				

Tracking:

During August, 2008, 20 ducks were instrumented and in 2009 and 2010, 40 ducks were instrumented each year. Only healthy ducks in good body condition were used for telemetry implantation. Body condition assessment was based on body weight and body index, which measures size of breast muscle. One South American comb duck was also captured and instrumented. It transmitted for four months with last transmission received on November 28, 2009. Instrumentation was done with the use of an improvised indoor surgery and holding facility. Ducks not instrumented were banded and released. The white-faced whistling ducks were the most commonly caught in all three years of the study.

Ducks were tracked and data mapped with Google Earth to determine locations of the four species during the post hunting season. Mortality of instrumented ducks was low (<5%) following release and within six months following instrumentation ranged from approximately 17% for rosy-billed pochard to 26% for black-bellied whistling ducks (Table 7; Appendix 5). A small number of duck transmitters were not transmitting after several months and based on body temperature it appeared that ducks were alive. Although the cause was undetermined it possibly was related to transmitter malfunction or battery failure.

Satellite Transmission:

Each duck transmitted a signal for 4 hours and then was off for 60 hours (2.5 days). More than 2.5 days without signal was interpreted to mean that the duck missed satellite recognition or had technical malfunction. Location classes identified as "3" are most accurate, followed by "2," and then "1." Classes of "0," "A," "B," and "Z" are not as precise and need further information before interpretation. Only location class of 3, 2, and 1 were used in mapping for this study. A detailed analysis of the frequency of location classes is presented in Appendices 5 and 6.

Mortality during the first 6 months of deployment each year was relatively small and did not appear to vary by year or species of ducks (Table 7). Mortality is determined by the temperature of the duck going below normal when transmitter is still transmitting. Overall, mortality across years and species was 15 percent. This mortality of ducks instrumented with implantable satellite transmitters is lower that mortality experienced with seaducks in North America (Olsen et al. 2005, Perry et al. 2006).

Potential transmitter failure during the first six months following deployment of the 100 instrumented ducks was estimated at 31 percent. This category of "failures" is defined in a broad way, however, and includes possible unknown reasons like abrupt end of transmission that could be from transmitter being under water for various reasons.

Table 7. Transmitter status within six months by species for 2008, 2009, and 2010 deployments.

		BBWD	FWDU	WFWD	RBPO	COMB
2008	Deployed	3	2	8	7	0
	Deceased in six months	1	1	2	1	-
	Transmitter malfunction*	0	0	1	1	-
2009	Deployed	10	9	10	10	1
	Deceased in six months	2	1	3	1	0
	Transmitter malfunction*	5	2	2	6	1
2010	Deployed	3	20	17	0	0
	Deceased in six months	0	1	2	-	-
	Transmitter malfunction*	1	8	4	-	-

* transmitter failed within first six months of transmission.

Transmission time in days for 2008-2010 varied from a mean of 268 days for BBWD to 351 for WFWD. FUWD had a mean transmission time of 273 days and RBPO for 277 days. All mean transmission days are within the anticipated range for this type of implanted battery-operated PTT and is considered acceptable (Table 8). The maximum days of transmission for all species were more than expected, however, and approaching two years.

Table 8. Mean and range transmission time in days for each species deployed and tracked in 2008, 2009, and 2010.

	BBWD	FWDU	WFWD	RBPO
Number Ducks	16	31	35	17
Mean Days	268	273	351	277
Range Days	44-580	7-641	11-668	87-608

Cumulative distance (km) tracked in past 1 and 7 days was based on hybrid-filtered locations. When an animal is relocated several times within a single general locale, the cumulative 24-hour distance will tend to be inflated due to location error. The 7-day total distance is meant to highlight potential mortality, but the distance is strongly affected by the number of locations and their quality.

The average distance traveled by the ducks was greatest (102.0 km) for fulvous whistling ducks during the period September 2008 to March 2012. The shortest average distance traveled during this same period was 37.5 km for rosy-billed pochards (Table 9). The greatest mean distance traveled for 8 instrumented white-faced whistling ducks for the period August 2008 to August 2009 was during the month of April 2009 when movements exceeded 300 kilometers on average (Appendix 7). October 2008 was the month with the second highest mean distance traveled (Amaiden 2011).

Table 9. Mean distance traveled (km) by species tracked from September 2008 to March 2012.

	BBWD	FWDU	WFWD	RBPO
Number Ducks	14	29	34	16
Mean Distance (km)	74.3	102.00	51.2	37.5
Range Distance (km)	1.1-266.0	5.1-850.3	4.4-190.4	3.4-195.0

The mean distance traveled for all four species that were tracked from September 2008 to March 2012 was greater for females than males in all species. The differences between the sexes among the four species were greatest for black-bellied whistling ducks (99.6 vs. 36.4) and rosy-billed pochards (48.0 vs. 20.2) that averaged over twice the distances in both species (Table 10). White-faced whistling ducks had the least differences between the sexes for mean distance traveled. (Table 10).

Table 10. Mean, maximum, and minimum distance traveled (km) by sex tracked from September 2008 to March 2012.

	Species	Sex	n	Mean	Max	Min
Tracked (Sep 08-Mar 12)	Fulvous whistling duck	Female	14	117.5	850.3	5.1
		Male	15	87.5	189.7	15.0
	Black-bellied whistling duck	Female	9	99.6	266.0	15.7
		Male	5	36.4	77.3	1.1
	White-faced whistling duck	Female	18	58.5	143.6	4.4
		Male	17	43.0	190.4	8.3
	Rosy-billed pochard	Female	10	48.0	195.0	3.4
		Male	6	20.2	50.5	3.7

Flight speed for instrumented ducks cannot be determined accurately for ducks on the duty cycle used during this study as location data are not determined frequently enough. However, the data on flight speed in Table 11 represent a minimum speed during the period September 2008 and March 2012. These flight speeds are much lower than the known flight speed of ducks in North America and don't represent the actual speed as much as the relative speed among species. Based on data from Table 11, it would appear that rosy-billed pochards are the slowest flying duck among the four instrumented species, but this difference was not obvious in casual field observation. Typically diving ducks fly faster than puddle ducks.

Table 11. Average flight speed (km/h) by species, 2008-2012.

	BBWD	FWDU	WFWD	RBPO
Number Ducks	14	19	34	16
Mean Speed (km/h)	7.7	9.5	11.7	7.0
Range Speed (km/h)	2.9-14.3	1.4-47.8	2.4-40.6	1.0-20.1

Results from the preceding work indicate that ducks instrumented at the end of the hunting period distribute to new areas up to 850 km (538 miles) around the release site. Although there was a slight tendency for the ducks to move south, there was not the clear north/south movement that is seen with ducks in North America every spring and winter (Figure 1; Appendices 8-12).

Although Argentina was expected to be the major country where satellite telemetry locations of the ducks would occur, it was interesting to note that Brazil was also a country where locations for FUWD were documented (Table 12). However, these analyses were based

mostly on data in 2008 with a very small sample size and in later years the percentage of locations in Argentina increased dramatically (Appendix 8). In 2008, approximately 3% of the locations of rosy-billed pochards were recorded in Paraguay, which was the most of any species instrumented and showed a movement to more northern areas for RBPO than for other instrumented species.

All species of whistling ducks and rosy-billed pochards seemed to be closely associated with the Corrientes and Parana River and the surrounding wetlands in the river drainages (Appendices 8-12). Coastal estuarine lagoons in Brazil near Porto Alegre (Figure 1) were used by black-bellied and fulvous whistling ducks (Appendices 9 and 10), but were not used by white-faced whistling ducks. There was one coastal area in southern Uruguay near Montevideo (Figure 1) that was, however, frequented by white-faced whistling ducks (Appendix 11). The rosy-billed pochard seemed to have the most dispersed distribution, and interestingly did not seem to be associated with the estuarine lagoons of the coast (Appendix 12). The rosy-billed pochard was recorded in four South American countries (Table 7).

Table 12. International movement by species as defined by percentage of total location 3, 2, or 1 satellite fixes for discrete days during specified transmission period[1].

Species	COUNTRY			
	Argentina	Brazil	Uruguay	Paraguay
Black-bellied whistling duck	87%	7%	6%	0%
Fulvous whistling duck	91%	8%	0%	0%
White-faced whistling duck	82%	13%	1%	4%
Rosy-billed pochard	91%	3%	2%	4%

[1]Percentages based on the following number of fixes:
BBWD = 735; FUWD = 1757; WFWD = 2522; RBPO = 764

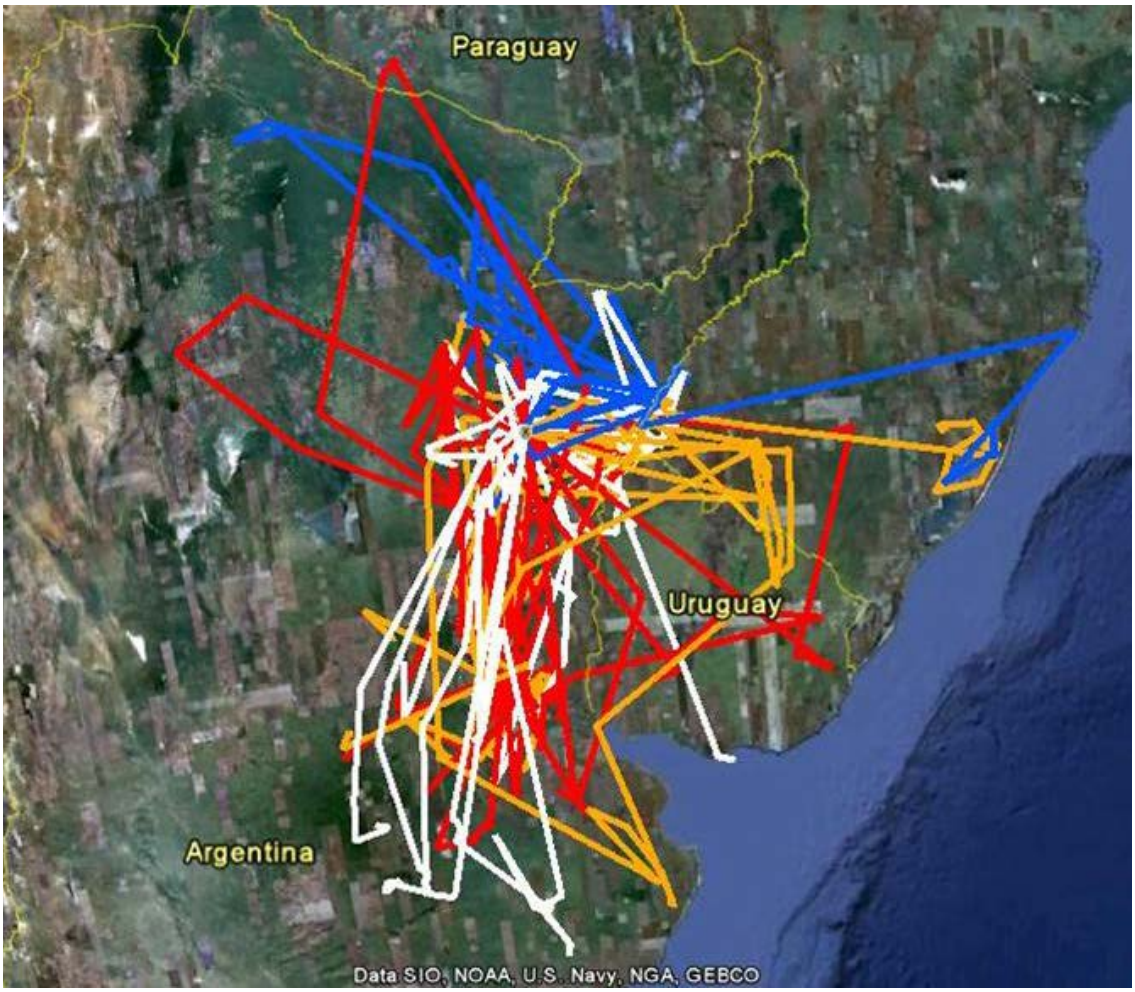


Figure 1. Combined tracking results of four species showing track lines combined for 2008-2010 as displayed on Google Earth map. Blue=BBWD; Yellow=FUWD; White=WFWD; Red=RBWD.

Habitat:

Extensive habitat data was accumulated on the instrumented ducks by graduate students at the University of Cordoba in Argentina for WFWD (Table 13) and by separate analyses conducted at Patuxent for all four instrumented species during August 2008 to June 2009 (Appendix 13). The direction of distribution of ducks that left Don Pablo Ranch seemed random seasonally, but duck distributions were most associated with commercial rice fields. Main habitat types used by ducks were natural wetlands and cultivated areas. Among natural wetlands, predominant subtypes used by WFWD during 2008 and 2009 included isolated small ponds, rivers, and creeks in the Pampas region and riverine wetlands along the Parana, Paraguay, and Uruguay Rivers (Table 13). Rice fields were the predominant areas used among cultivated fields.

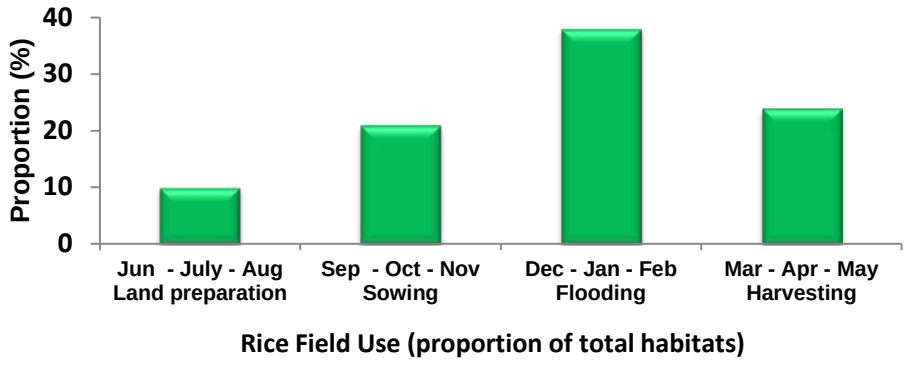
Table 13. Habitat use of white-faced whistling ducks based on data from 2008 to 2009 (Amaiden 2011).

Habitat	Quantity (ha)	Proportion
Dry Cropland	182	39
Rice Fields	108	23
Wetlands	76	17
Rivers and Creeks	57	12
Dams and Reservoirs	32	7
Small Pampas Ponds	10	2

Preliminary data on the white-faced whistling duck indicate that 70% of all recorded duck locations were on rice fields or on nearby cultivated areas. Our results confirm previous observations suggesting that white-faced whistling duck populations are heavily dependent on cropland habitat, particularly rice fields. This high use of cultivated rice fields in South America by the four species of ducks in this study is probably increasing due to the increasing areas of rice that are being sown during the period 1969 to 2009 (Appendix 14).

Specific analyses of white-faced whistling ducks that were instrumented showed that rice fields were used throughout the year, with the lowest (10%) visit rate to rice fields was observed in June-July-August (preparation field stage) and with a peak (35%) in summer months (December to February), at the time when rice fields are flooded (Figure 2; Amaiden 2011). These findings, based on satellite telemetry fixes throughout South America, are to be expected and were commonly observed on Don Pablo Ranch during three years of the study.

Figure 2. Use of Cultivated Rice Fields by White-faced Whistling Duck



In another analysis conducted at Patuxent, when species are compared with each other it appeared that grassland habitat and lakes were used by fulvous whistling ducks more that other species (Table 14; Appendix 13). Black-bellied whistling ducks were more closely associated with wetland forest than other species (Table 14; Appendix 13). Rosy-billed pochards were least associated with grasslands and most associated with wetland ponds and lakes in combination with forested areas (Table 14; Appendix 13). Casual observation on Don Pablo Ranch indicated that RBPO were closely associated with the deeper ponds, which is typical for diving duck species. It is not clear if there is a direct correlation with forest areas and RBPO or if this is an anomaly of the data analyses. Analyses showed great variation within species of WFWD and RBPO for individual ducks instrumented (Appendix 13).

Table 14. Species habitat preferences for four species of ducks defined by percentage of total location 3, 2, or 1 satellite fixes for days during transmission period August 2008 to July 2009.

Species	HABITAT						
	Wetlands	Grass-lands	Forests	Wetland Forests	Rivers	Lakes	Sandy Dunes
BBWD	41%	6%	7%	20%	18%	7%	2%
FUWD	15%	25%	0%	0%	11%	44%	5%
WFWD	75%	7%	1%	0%	14%	3%	0%
RBPO	31%	4%	21%	6%	19%	20%	0%

DISCUSSION

This study was initiated to learn more about duck movements in Argentina and more specifically on the Don Pablo Ranch near Goya, Argentina. Information on the movements of ducks in Argentina were very scarce and, in fact, scientists in Argentina did not know for sure if there was a migratory pattern of movements as is seen in North America and well understood by most biologists on that continent. Because the instrumentation of ducks was conducted in August, which is near the end of winter in Argentina, there was an expectation that ducks would leave the wintering area and move to breeding areas. The actual direction of movements was speculated to be south towards the South Pole, if breeding habitat for ducks had been influenced by glaciers as is the predominant theory for North American duck movements.

The random distribution of ducks in the spring in South America that was observed in this study may reflect less dependency on specific habitats for breeding or it could reflect that South America was less influenced by the ice age period as was North America. The common migrations seen in North America are believed to be the result of the glacial period, 10,000 years ago. South America was less influenced by the ice age presumably due to the smaller land mass near the pole than in North America and the moderating effect on temperature due to the large ocean mass on both sides of the southern portion of South America. The more temperate climate in Argentina and the high manipulation of habitat by commercial rice plantations could also be a factor influencing duck movements.

The high use of cultivated rice fields throughout South America documented in this study with satellite telemetry tracking supports the observations made at Don Pablo Ranch. The mean distances flown by the instrumented ducks from Don Pablo Ranch was greatest for the rosy-billed pochards (350 km), but only averaged 250 km for all four species combined. The maximum distance was over 1000 km for RBPO, but the three species of whistling ducks were all less than 1000 km for their maximum distance flown. These distance figures over a one-year period are far below the approximate 2400 km that ducks in North America fly twice a year during their spring and fall migrations.

The important factor is the dependency that the South American ducks seem to have on cultivated rice and possibly other plants and animal organisms associated with the rice fields. Ducks in the temperate zone of Argentina are probably not required to seek distant areas for food resources if the resources are locally available. However, young ducks cannot be raised on rice seeds and are dependent on a high protein diet that most typically would be invertebrates. The role that invertebrates play in duck, and especially duckling, nutrition during the breeding season is poorly understood in Argentina and probably throughout South America.

Migratory movements – white-faced whistling ducks:

Movements of white-faced whistling ducks show great variability in individual direction, time of flight, and distance (Amaiden 2011). No defined pattern of migration was detected. While some individuals stayed around the capture site, others moved in East-West direction and others in a North-South direction. The rate of daily movement also showed a large swing between the individuals studied (0.13 to 9.09 km/d). Our findings contrast with those observed

in reports of white-faced whistling ducks marked in South Africa (Petrie and Rogers 1997), which moved from an agricultural landscape in winter to the flood plain of the River Nyl, used as a reproductive area. On the contrary, the observations of Argentina match the movements observed in another anatid (*Anas gracilis*) in semi-arid Australia areas (Roshier et al. 2006). These authors using 17 marked individuals also found great individual variation in the same variables analyzed in this study.

A possible hypothesis to explain these differences is based on a greater unpredictability of rainfall in South America and Australia compared to the other environments considered, which may be reflected in the abundance, distribution and seasonality of the availability of habitats preferred by the duck. Verification of this hypothesis would require the simultaneous availability of information on ground conditions and presence-absence of ducks in one sufficient number of cases and a suitable statistical analysis. This implies a very significant demand for information and of technology, which has not been achieved so far, according to the literature available.

Our study also showed a great individual variation in the use of the habitat and patterns of activity. While some ducks moved long distances (up to 800 km in a week), others stayed most of the time in a restricted area. Likewise, also we observed alternation of long flights with a series of short flights, restricted to a small area. These local movements in restricted areas coincide with similar observations in this species in South Africa (Petrie and Rogers 1997) and with *Anas gracilis* in Australia (Roshier et al. 2006), and in waterfowl of the northern hemisphere (Perry et al. 2006, Knoche et al. 2007, Chubbs et al., 2008, Robert et al. (2008).

Grouped movements may reflect reproductive activity. Petrie and Rogers (1997) determined through field observation that this type of displacement occurred when the individual duck being studied was moving. For several waterfowl species of the North temperate regions, breeding areas are known. These movements (positions in restricted areas) are associated with some of these activities according to the date and the area where the movements are located (see Perry et al. 2006, Knoche et al. 2007, Chubbs et al. 2008, Robert et al. 2008). It is also possible that the alternation between long flights of short duration (weeks) and long stops (positions, grouped for months) is a strategy used by this species to recover the energy consumed during long flights similar to findings in Japan for *Anas platyrhynchos* (Yamaguchi et al. 2008). The

results of this study could indicate similar situations. However, detailed field information is required and currently nonexistent in Argentina, to verify these assumptions.

Differences between the sexes:

The movements of the individual ducks studied reflected differences between sexes. Of the eight marked white-faced whistling ducks, females moved on average three times more than males (Amaiden 2010). In turn, the males remained in restricted areas (positions in group) longer than females. This observation is questionable due to the small size of the sample. A conclusion must wait to have a larger number of marked individuals in order to permit a statistical analysis. In South Africa, tracked male and a female white-faced ducks showed that there was no difference between their movements. Other authors suggest a similar pattern of movements between the sexes (Petrie and Rogers 1997). For other groups of ducks, it is known that reproductive females have different distributions than males during part of the annual cycle. Once the incubation period begins, the males moved away from females, and met again in molting sites. During the non-breeding season, males often moved with the females to areas with lower quality and quantity of food (Baldassarre and Bolen 2006).

Seasonal variations in movements:

Our data suggest that there are seasonal variations in movements of the white-faced whistling ducks, with a maximum in spring and autumn. Most of the long flights (greater than 100 km) were observed in spring and autumn (19 of 30 long flights; 63%). In addition, at least one marked individual (# 29) made movements towards the South in spring and North in the autumn. These results coincide in part with banding data available on this species. Some data show that white-faced whistling ducks perform displacement towards the North in autumn and winter and it has been seen in huge flocks moving at the beginning of September in south-southeast direction (Capllonch et al. 2008). It is likely that climatic variables also influence movements, since it is possible that this species tends to move in in relation to the availability of water and food (Canevari et al. 1991).

In addition, our data support the existence of shared stocks between Brazil, Argentina, and Uruguay (Blanco et al. 2002), and the hypothesis of Antas et al. (1996) as regards that, at least in certain years, the white-faced whistling duck movements occur between the Valley of the

River Paraná and Rio Grande do Sul. For example, an individual (# 16) traveled to the Western region Rio Grande do Sul (Brazil), conducting several movements back and forth between this State and province of Corrientes, and another duck (# 18) reached the Southwest River Grande do Sul and Northwestern Artigas (Uruguay).

Habitat Use:

The information obtained in this study confirms that the wetlands in the basin region of Cuenta del Plata are important habitats for the population of white-faced whistling ducks in the central eastern Argentina area. Marked individuals moved along the river systems of the rivers Parana and Uruguay, and 70 per cent of the positions were registered in wetlands of this region. According to Capllonch et al. (2008), the great migratory flow in this region is due to various causes, including the presence of large rivers and wetlands that act as true migration corridors. Within this macro-region, our data confirm that the white-faced whistling duck uses a large proportion of rice fields and other habitats of anthropogenic origin, to the point that the majority (70%) of the locations were registered in rice fields, crops of water from rain and dams. These data support what was observed by several authors in different parts of the world, for this and other species of waterfowl. For example, *Anas gracilis* used 30 artificial wetlands of agricultural origin (water storage tanks) in Australia (Roshier et al. 2006) and the white-faced whistling duck used small dams and foraged in agricultural fields (Petrie and Rogers 1997) in South Africa. Various South American authors have reported the use of rice by the white-faced whistling duck or other waterfowl, in some areas including Brazil (State of Rio Grande do Sul) (Crozariol 2008), Uruguay (Rodriguez et al. 1998) Blanco et al. (2006), and Argentina (Zaccagnini 2002, Blanco et al. 2006).

Individuals marked in this study used rice paddies year-round although higher during the summer. This probably indicates reproductive activity of the white-faced whistling duck in these habitats of agricultural origin, which has been reported by several authors (Zaccagnini 2002, Dias and Burger 2005, Rodriguez and Tiscornia 2008). Dias and Burger (2005) postulated that the white-faced whistling duck would have adjusted to ecological circumstances imposed by this crop and would be favored by the high availability of grain in the region. The results of this study support that hypothesis. It also is a highlight that marked individuals showed a high use of rain-fed crops in addition rice paddies. These habitats could be used for foraging, according to

that postulated in South Africa for this species (Petrie and Rogers 1997) or in order to perform other activities such as resting or grooming.

To better understand the South American distribution of ducks in the spring and the factors related to the distribution, we propose to conduct further satellite telemetry studies with other puddle ducks in 2012. Since the project began, new transmitters and attachment techniques have been developed that allow the use of smaller duck species for satellite telemetry studies using solar-powered transmitters.

It now appears appropriate to initiate another phase of waterfowl studies in Argentina on the Estancia Don Pablo to instrument smaller ducks. Species of special concern for instrumentation should be focused on ringed teal and integrated with the ongoing study with the nesting of teal on Don Pablo Ranch in artificial nest boxes. The nest box study has demonstrated the value of providing nesting habitat and that several species are using this artificial habitat. A key question to determine in the future is whether the ducklings produced in these boxes are able to find suitable feeding habitat on the wetlands of Don Pablo, so that the area can be as good in producing ducks in the breeding season as it is in maintaining ducks during the winter period.

Although movement data should be the principal focus for any new studies, it is suggested that movement data be also assessed in relation to food habits of the ducks and food availability in the wetland areas where the ducks are located. By determining invertebrates available and utilized by ducklings during the breeding season managers will have better capabilities to manage habitats to optimize for invertebrate production to benefit duckling growth and survival and subsequently increase duck populations.

This study in a major waterfowl area of Argentina has provided an outstanding opportunity to begin to assess waterfowl population biology in an area that has been poorly studied in the past. Hopefully, more analyses of our data and additional data on duck movements and locations will provide the information necessary to manage sustainable duck populations well into the future so the species can be maintained and continue to provide outstanding recreational opportunities for sportsmen in the future.

The added benefit of this study with the movements of ducks in Argentina was that there was an opportunity to test some of the techniques used to instrument ducks with implanted satellite transmitters. Because this technique is needed for diving ducks it was used in Argentina as the rosy-billed pochard is a diving duck and was a focus duck for the Argentina study. Also,

because of the remote location of Don Pablo ranch and the subsequent difficulties in obtaining oxygen cylinders for the surgery, the location became a good place to test the feasibility of using an oxygen concentrator during anesthesia.

The results of this side study indicate no significant differences in any of the measured parameters between ducks receiving anesthetic using traditional oxygen tanks or using the new oxygen concentrators. This is as we hypothesized. The advantages of the oxygen concentrator are its ease in being carried and the safety in transporting it to remote locations. As there is no oxygen in the unit except when actually running, there is no fire or explosion hazard associated with it as there is with the traditional oxygen tanks. One oxygen concentrator allows the surgeon to perform unlimited numbers of surgeries, whereas the tanks are limited in the number of surgeries that can be performed, and often multiple tanks are needed to complete a project. We used propofol for some surgeries at the start of this project in 2008, but found isoflurane easier to use and obtain locally. In the United States, at least, propofol may soon fall under the regulations of the Drug Enforcement Agency, making obtaining it for surgery in remote locations problematic, though this currently is not the situation.

The oxygen concentrator method does have some disadvantages. It requires an electrical power source. This can be regular electrical current if available. Alternatively, an electrical generator can be used. In our studies in Argentina, the location is somewhat remote, but the facility has an electrical generator on site to provide all necessary electricity for lights, refrigeration, cooking, etc., and we were able to use this as our electricity source. The concentrator does not use large amounts of electricity, so running on a generator is feasible. It may even be possible to run the concentrator from a converter attached to the power outlet of an automobile or truck, though we have not tried that.

We would recommend the use of an oxygen concentrator for field work where an electrical power source is readily available. This is a safer alternative than transporting oxygen tanks to remote sites. We have even started using the oxygen concentrator as our primary oxygen source in our veterinary hospital at our research center.

CONCLUSIONS

1. Instrumented ducks on the Don Pablo Ranch in Argentina dispersed to new areas up to 500 miles around the release site. Although there was a slight tendency for the ducks to move south, there was not the clear north/south movement that is seen with ducks in North America every spring and winter.
2. There are seasonal variations in the duck populations in the Corrientes Province area. The available data suggest that the peaks of movements occur in spring and autumn, although at present there is not sufficient data to arrive at definitive conclusions.
3. White-faced whistling ducks in the Corrientes Province population have great individual variability in their movements in regard to location, time of flight, and distance traveled. Movements include East of Argentina, southwest of Brazil and Northwest Uruguay; particularly along the rivers Parana and Uruguay.
4. The three species of whistling duck use large proportions of anthropogenic habitats, including rice fields, rain-fed crops, and dams. The data obtained suggest that the rice fields are used throughout the year in a greater proportion during the summer.
5. There was greater mobility of females as compared with males for rosy-billed pochards.

MANAGEMENT RECOMMENDATIONS

The technique of marking with satellite transmitters combined with the analysis of satellite images has proven to be of great utility and potential, so it is important to continue with this methodology, extending it to other species of waterfowl in Argentina.

It is also very important to develop studies in the field to advance the understanding of the factors associated with the use of the habitat of rice paddies by wild ducks, using techniques of adequacy of habitat or similar procedures.

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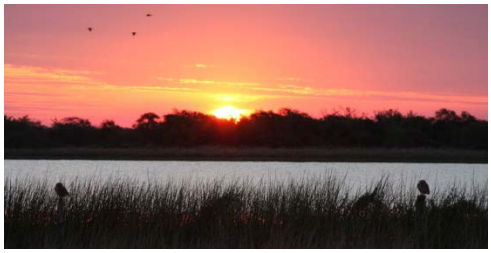


APPENDICES

Appendix 1. Birds recorded from Don Pablo Ranch 2008, 2010, and 2012.

Appendix 2. Mean weight (g±SE) and culmen and tarsus measurements (mm±SE) of four species of ducks in Argentina, 2008-2010.

Appendix 3. Mean measurements (mm±SE) of 9th primary and wing chord of four species of ducks in Argentina, 2008-2010.

Appendix 4. Mean weight (g±SE) and culmen, tarsus, 9th primary, and wing chord measurements (mm±SE) of ringed teal and Brazilian ducks in Argentina, 2008-2010.

Appendix 5. Transmission data (as of July 5, 2009) for all 20 Argentina ducks instrumented August 2008.

Appendix 6. Deceased ducks and/or ducks that have stopped transmitting.

Appendix 7. Monthly mean distance (95% conf. limits) flown by 8 white-faced whistling ducks.

Appendix 8. Locations of all four duck species of in three years (2008, 2009, 2010). Red are BBWD, Green are FUWD, Red are WFWD, and Yellow are RBPO.

Appendix 9. Locations of black-bellied whistling ducks for three years (2008, 2009, 2010).

Appendix 9a. Locations of black-bellied whistling ducks for three years (2008, 2009, 2010), based on kernel analyses.

Appendix 10. Locations of fulvous whistling ducks for three years (2008, 2009, 2010).

Appendix 10a. Locations of fulvous whistling ducks for three years (2008, 2009, 2010), based on kernel analyses.

Appendix 11. Locations of white-faced whistling ducks for three years (2008, 2009, 2010).

Appendix 11a. Locations of white-faced whistling ducks for three years (2008, 2009, 2010), based on kernel analyses.

Appendix 12. Locations of rosy-billed pochards for three years (2008, 2009, 2010).

Appendix 12a. Locations of rosy-billed pochards for three years (2008, 2009, 2010), based on kernel analyses.

Appendix 13. Habitat preferences as defined by percentage of total location 3, 2, or 1 satellite fixes for discrete days during specified transmission period.

Appendix 14. Area in square hectares sown with cultivated rice in three countries (1969-2009).

Appendix 15-18. Species accounts – BBWD; FUWD; WFWD; and RBPO.

Appendix 1. Birds of Don Pablo Ranch – August 17-28, 2008, Aug 2010, and April 9-18, 2012[1].			
	2008	**2010**	**2012**
Greater Rhea	X	X	X
Red-winged Tinamou		X	X
Spotted Nothura	X	X	X
Great Grebe		X	
Pied-billed Grebe	X		X
White-tufted Grebe		X	
Least Grebe			X
Anhinga			X
Neotropic cormorant	X		X
White-necked Heron	X	X	X
Rufescent Tiger-heron	X	X	X
Whistling Heron	X	X	X
Pinnated Bittern	X		
Great Egret	X	X	X
Snowy Egret	X	X	X
Cattle Egret			X
Black-crowned night-Heron	X		X
American Wood Stork			X
Maguari Stork	X	X	X
Jabiru	X	X	
Green Ibis	X	X	X
Bare-faced Ibis	X	X	X
White-faced Ibis	X	X	
Roseate Spoonbill	X	X	X
Chilean Flamingo		X	
Southern Screamer	X	X	X
Comb Duck	X		
Fulvous Whistling-duck	X	X	X
Black-bellied Whistling-duck	X	X	X
White-faced Whistling-duck	X	X	X
Coscoroba Swan		X	
Red Shoveler	X		
Silver Teal	X		X
Ringed Teal	X	X	
Rosy-billed Pochard	X	X	
Brazilian Duck	X	X	X
Black-headed Duck	X		
Masked Duck	X		
Black Vulture	X	X	X
Lesser Yellow-headed vulture	X		X
Turkey Vulture	X	X	X
Black-crested Buzzard eagle			X
Great Black Hawk	X		

Bay-winged Hawk	X		
Snail Kite	X		X
Long-winged Harrier	X		X
Cinereous Harrier	X		
Roadside Hawk	X	X	X
White-tailed Hawk	X		
Black-collared Hawk			X
Savanna Hawk	X	X	X
Southern Crested-caracara	X	X	X
Chimango Caracara	X	X	X
Yellow-headed Caracara			X
Aplomado Falcon		X	X
American Kestrel	X	X	X
Chaco Chachalaca	X	X	X
Giant Wood-rail	X	X	X
Ash-throated Crake	X		
White-winged Coot	X		X
Common Gallinule	X	X	
Wattled Jacana	X	X	X
Limpkin			X
Southern Lapwing	X	X	X
South American Stilt	X	X	X
Collared Plover	X		
Lesser Yellowlegs	X		
Common Snipe	X		X
Snowy Crowned Tern			X
Large-billed Tern	X		X
Picazuro Pigeon	X	X	X
Spot-winged Pigeon		X	
Eared Dove	X	X	X
Picui Ground Dove	X	X	X
Ruddy Ground-dove		X	
White-tipped Dove	X	X	X
Blue-crowned Parakeet		X	
Monk Parakeet	X	X	X
Guira Cuckoo	X	X	X
Smooth-billed Ani		X	X
Burrowing Owl	X	X	X
Nacunda Nighthawk			X
Band-winged Nightjar	X		
Scissor-tailed Nightjar		X	X
Gilded Sapphire	X		X
Ringed Kingfisher		X	X
Green Kingfisher		X	
Field Flicker	X	X	X
Golden-breasted Woodpecker	X	X	X

White Woodpecker	X	X	X
Narrow-billed Woodcreeper		X	X
Rufous Hornero	X	X	X
Lark-like Brushrunner		X	X
Firewood-gatherer			X
Great Antshrike			X
White Monjita	X	X	X
Rufous-backed Negrito		X	
Spectacled Tyrant	X	X	X
White-headed Marsh-tyrant	X	X	
Cattle Tyrant	X	X	X
Great Kiskadee	X	X	X
Vermilion Flycatcher	X		
White-rumped Swallow	X	X	X
Blue-and-white Swallow	X		
Plush-crested Jay		X	X
White-banded Mockingbird	X	X	X
Chalk-browed Mockingbird	X	X	X
Creamy-bellied Thrush		X	X
Rufous-bellied Thrush	X	X	X
Masked Gnatcatcher			X
Golden-billed Saltator	X	X	
Green-winged Saltator		X	X
Grayish Saltator		X	
Red-crested Cardinal	X	X	X
Yellow-billed Cardinal	X	X	
Rusty-collared Seedeater		X	
Red-crested Finch	X		
Rufous-collared Sparrow	X	X	X
Epaulet Oriole	X		
Screaming Cowbird	X	X	
Shiny Cowbird	X	X	
Bay-winged Cowbird	X	X	
Chestnut-capped Blackbird	X	X	X
Yellow-winged Blackbird			X
Yellow-rumped Marshbird		X	
White-browed Blackbird	X	X	X
Scarlet-headed Blackbird (Federal)			X

[1]A complete bird list was not maintained in 2009. The bird list maintained in 2012 is presented here to give a more complete understanding of the birds using the Don Pablo Ranch.

Appendix 2. Mean weight (g±SE) and culmen and tarsus measurements (mm±SE) of four species of ducks in Argentina, 2008-2010.

Species	Year	Mean Weight (g±SE)				Mean Culmen (mm±SE)				Mean Tarsus (mm±SE)			
		Ad-M	**Ad–F**	**Im–M**	**Im-F**	**Ad-M**	**Ad–F**	**Im–M**	**Im-F**	**Ad-M**	**Ad–F**	**Im–M**	**Im-F**
BBWD	Number	3	7	4	7	3	7	3	5	3	7	3	5
	2008	770/21	830/0			49/0	49/0			57/0	55/2		
	2009	750	826/17	823.3/24	784/16	50	47/0	47/1	47/0	60	54/1	56/1	53/0
	2010				835/60								
	Mean	763/11	827/10	825/14	798/12	49/0	48/0	47/1	47/0	58/1	54/1	56//1	53/0
FUWD	Number	30	29	54	46	2	10	3	5	2	10	3	5
	2008	935/11	715/53		600/64	49/1			45/2	56/2			54/0
	2009		917/11	907/30	990/4		47/0	48/1	46/0		54/0	57/1	55/0
	2010	951/3	888/5	928/2	891/2								
	Mean	950/3	885/4	926/2	887/2	49/1	47/0	48/1	46/0	56/2	54/0	57/1	54/1
WFWD	Number	94	89	47	127	54	55	25	65	54	55	25	65
	2008	842/1	845/2	811/4	755/1	49/0	48/0	48/0	48/0	58/0	56/0	58/0	56/0
	2009	834/10	876/3	884/6	878/3	48/0	48/0	50/0	46/0	57/1	58/0	58/0	56/0
	2010	900/14	830/5	849/5	772/2								
	Mean	845/1	851/1	835/2	789/1	49/0	48/0	49/0	47/0	58/0	57/0	58/0	56/0
RBPO	Number	6	9	7	1	6	8	7	1	6	8	7	1
	2008	1102/16	1070/18	925/60		63/0	60/1	59/0		44/0	44/0	42/0	
	2009	1250	1102/33	1136/25	930		58/0	65/1	49	44	42/0	44/0	68
	2010												
	Mean	1126/15	1087/14	1076/22	930	63/0	59/0	63/1	49	44/0	43/0	43/0	68

Appendix 3. Average measurements (mm±SE) of 9th primary and wing chord of five species of ducks in Argentina.

Species	Year	Mean 9th Primary (mm±SE)				Mean Wing Chord (mm±SE)			
		Ad-M	Ad-F	Im-M	Im-F	Ad-M	Ad-F	Im-M	Im-F
BBWD	**Number**	**3**	**7**	**3**	**5**	**3**	**7**	**3**	**5**
	2008	148/1	148/1			240/4	234/5		
	2009	154	147/1	153/2	144/2	247	242/2	247/2	232/2
	2010								
	Mean	150/1	147/1	153/2	144/2	242/2	240/1	247/2	232/2
FUWD	**Number**	**2**	**10**	**3**	**5**	**2**	**10**	**3**	**5**
	2008	145/1			126/7	230/3	215		209/6
	2009		134/1	134/1	135/3		223/1	231/5	231/3
	2010								
	Mean	145/1	134/1	134/1	131/2	230/3	222/1	231/5	222/3
WFWD	**Number**	**54**	**55**	**25**	**65**	**54**	**55**	**25**	**65**
	2008	142/0	141/0	140/0	138/0	231/0	232/0	227/1	227/0
	2009	137/1	142/0	141/1	139/1	231/2	237/0	238/1	235/1
	2010								
	Mean	142/0	141/0	141/0	139/0	231/0	233/0	231/0	229/0
RBPO	**Number**	**6**	**8**	**7**	**1**	**6**	**8**	**7**	**1**
	2008	150/3	147/1	153/2		238/2	236/1	237/4	236
	2009		139/3	140/2	142	252	234/3	239/2	
	2010								
	Mean	151/2	142/1	144/2	142	240/2	235/1	238/1	236

Appendix 4. Mean weight (g±SE) and culmen, tarsus, 9th primary, and wing chord measurements (mm±SE) of ringed teal and Brazilian ducks in Argentina, 2008-2010.

Species	Year	Mean Weight (g±SE)				Mean Culmen (mm±SE)				Mean Tarsus (mm±SE)			
		Ad-M	Ad–F	Im–M	Im-F	Ad-M	Ad–F	Im–M	Im-F	Ad-M	Ad–F	Im–M	Im-F
RITE	Number	6	4		3	1				1			
	2008					38				31			
	2009												
	2010	408/6	392/8		342/7								
	Mean	408/6	392/8		342/7	38				31			
BRTE	Number	11	4			10	4			10	4		
	2008	561/5	548/14			39/0	40/0			37/0	35/0		
	2009												
	2010	530											
	Mean	558/4	548/14			39/0	40/0			37/0	35/0		

Species	Year	Mean 9th Primary (mm±SE)				Mean Wing Chord (mm±SE)			
		Ad-M	Ad-F	Im-M	Im-F	Ad-M	Ad-F	Im-M	Im-F
RITE	Number	1				1			
	2008	122				180			
	2009								
	2010								
	Mean	122				180			
BRTE	Number	11	4			11	4		
	2008	130/0	124/0			204/1	190/2		
	2009								
	2010								
	Mean	130/0	124/0			204/1	190/2		

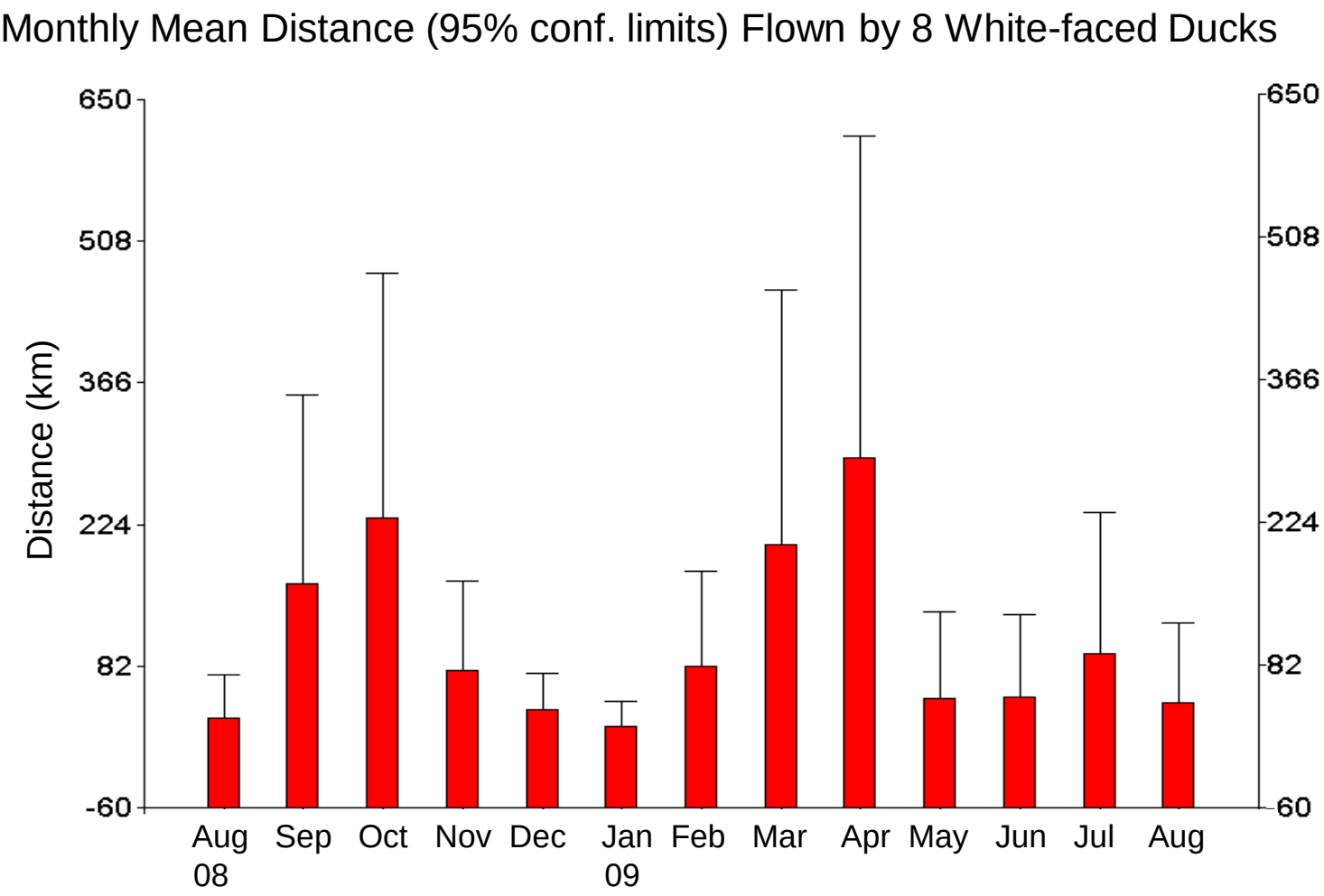
Appendix 5. Transmission data (as of July 5, 2009) for all 20 Argentina ducks instrumented August 2008.

Species	PTT No.	Sex	Deployment Date	Approx. No. of Days at Large	No. of Days Transmission Signal	Date Last Location Transmission	Days Since Last Trans.	Total Trans Since Deployment	% Trans. Location Class 3,2,1
BBWD	26	F	8/20/08	34	44	10/3/08	275	131	57.25%
	27	M	8/20/08	317	317	7/3/09	2	397	62.97%
	28	M	8/20/08	317	317	7/3/09	2	432	58.80%
FUWD	20	F	8/20/08	315	315	7/1/09	4	380	66.58%
	24	F	8/20/08	6	282	5/29/09	37	232	38.36%
WFWD	15	M	8/20/08	316	316	7/2/09	3	446	62.33%
	16	F	8/20/08	318	318	7/4/09	1	464	62.07%
	17	M	8/20/08	49	241	4/18/09	78	63	4.76%
	18	F	8/20/08	198	262	5/9/09	57	318	63.21%
	21	F	8/20/08	63	63	10/22/08	256	175	53.71%
	22	M	8/20/08	76	317	7/3/009	2	292	53.08%
	23	F	8/20/08	317	317	7/3/09	2	420	52.38%
	29	F	8/20/08	318	318	7/4/09	1	402	67.16%
RBPO	19	F	8/20/08	0	0	8/20/08	319	2	0.00%
	25	M	8/20/08	139	319	7/5/09	0	388	77.32%
	30	F	8/20/08	319	319	7/5/09	0	454	55.95%
	31	M	8/20/08	9	270	5/17/09	49	217	50.23%
	32	M	8/20/08	98	318	7/4/09	1	358	65.08%
	33	M	8/20/08	160	280	5/27/09	39	333	65.47%
	34	F	8/20/08	232	232	4/9/09	87	352	72.44%
Mean				**180**	**258**		**60**	**312**	**54.46%**

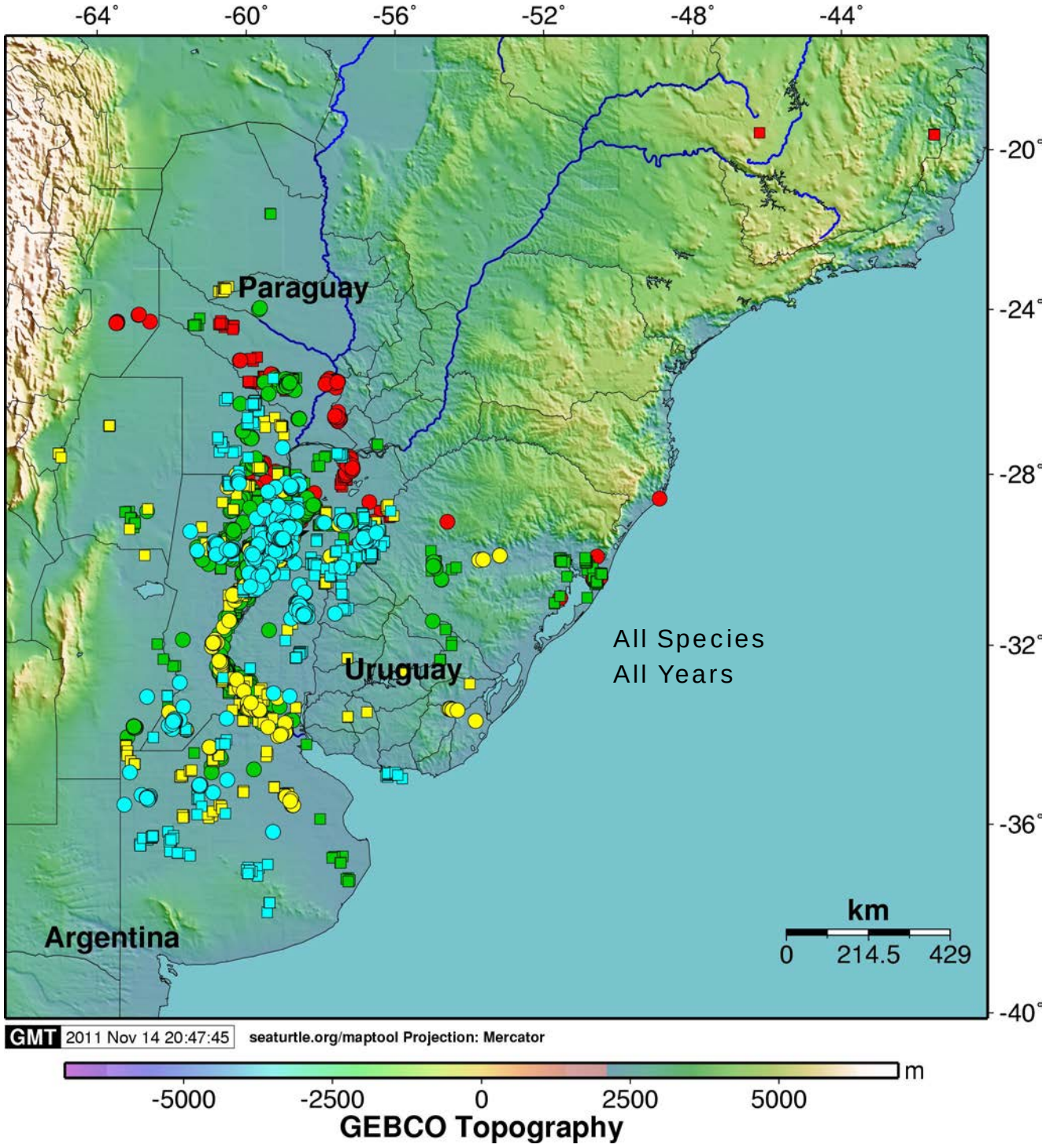
Appendix 6. Deceased ducks and/or ducks that have stopped transmitting.

Species PTT #	Approx. date of death	Unexplained distance traveled since death (km) (using all location classes)	Unexplained distance traveled since death (km) (using only 3,2,&1 location classes)	Last date of transmission	Last fix of location class 3,2,&1
BBWD 26	9/19/08-9/23/08	1589.28	0.00	10/3/08	9/18/08
FWDU 24	8/21/08-8/26/08	1306.31	89.93	5/29/09	5/8/09
RBPO 25	1/1/09-1/6/09	2287.44	60	7/5/09	7/5/09
RBPO 31	8/29/08	5171.62	75.15	5/17/09	5/12/09
RBPO 32	11/26/08	922.76	43.66	7/4/09	7/4/09
RBPO 33	1/28/09-2/1/09	1048.68	6.18	5/27/09	5/27/09
WFWD 17	8/20/09-10/9/08	8013.60	5.65	4/18/09	12/31/08
WFWD 18	3/6/09	402.12	193.17	5/9/09	4/23/09
WFWD 22	11/5/08	5692.19	19.23	7/3/09	6/28/09
RBPO 19	N/A	N/A	N/A	8/20/08	none
RBPO 34	N/A	N/A	N/A	4/9/09	4/9/09
WFWD 21	N/A	N/A	N/A	10/22/09	10/22/09

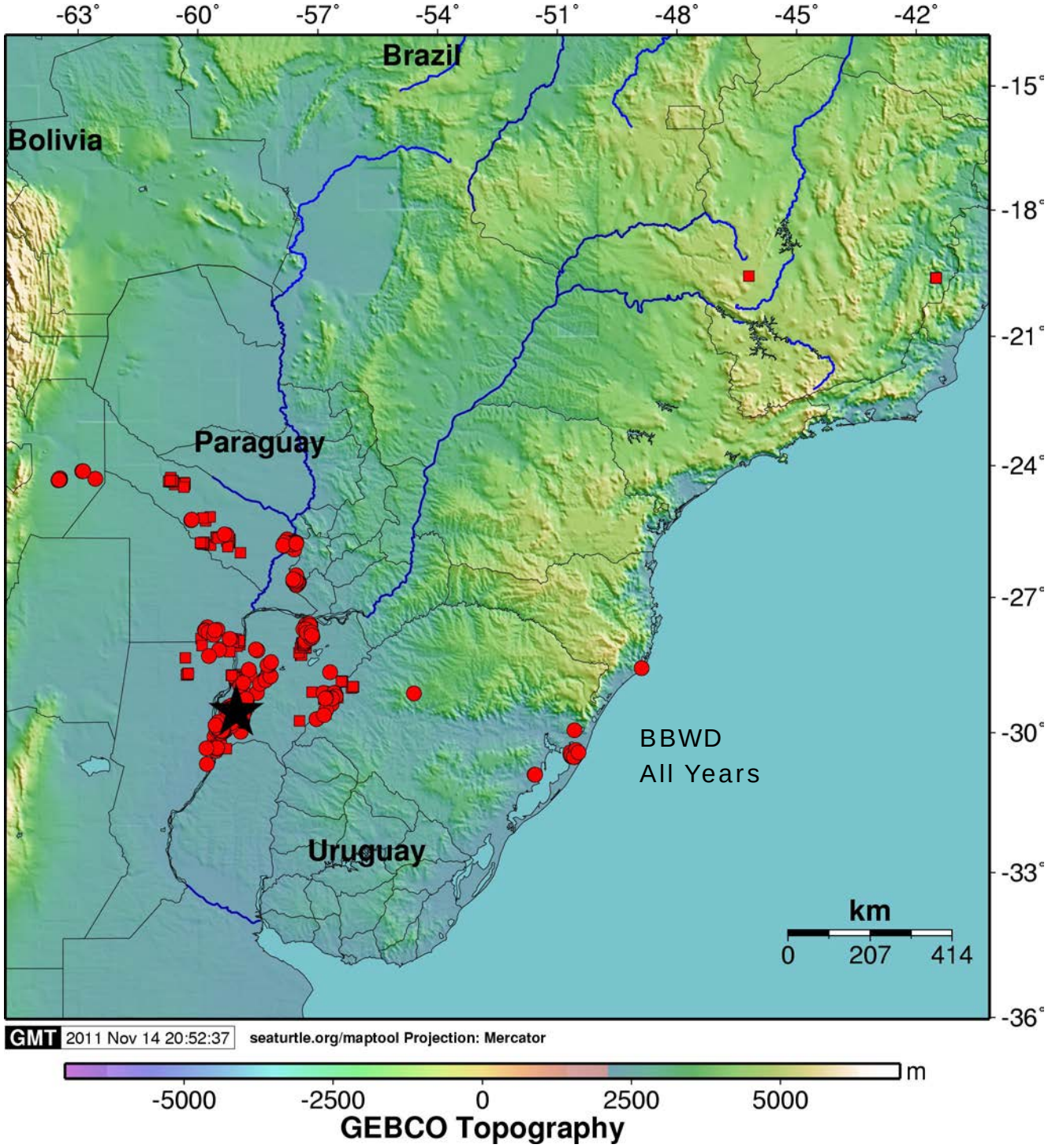
Appendix 7. Monthly mean distance flown by 8 white-faced ducks instrumented at Don Pablo Ranch, Argentina.



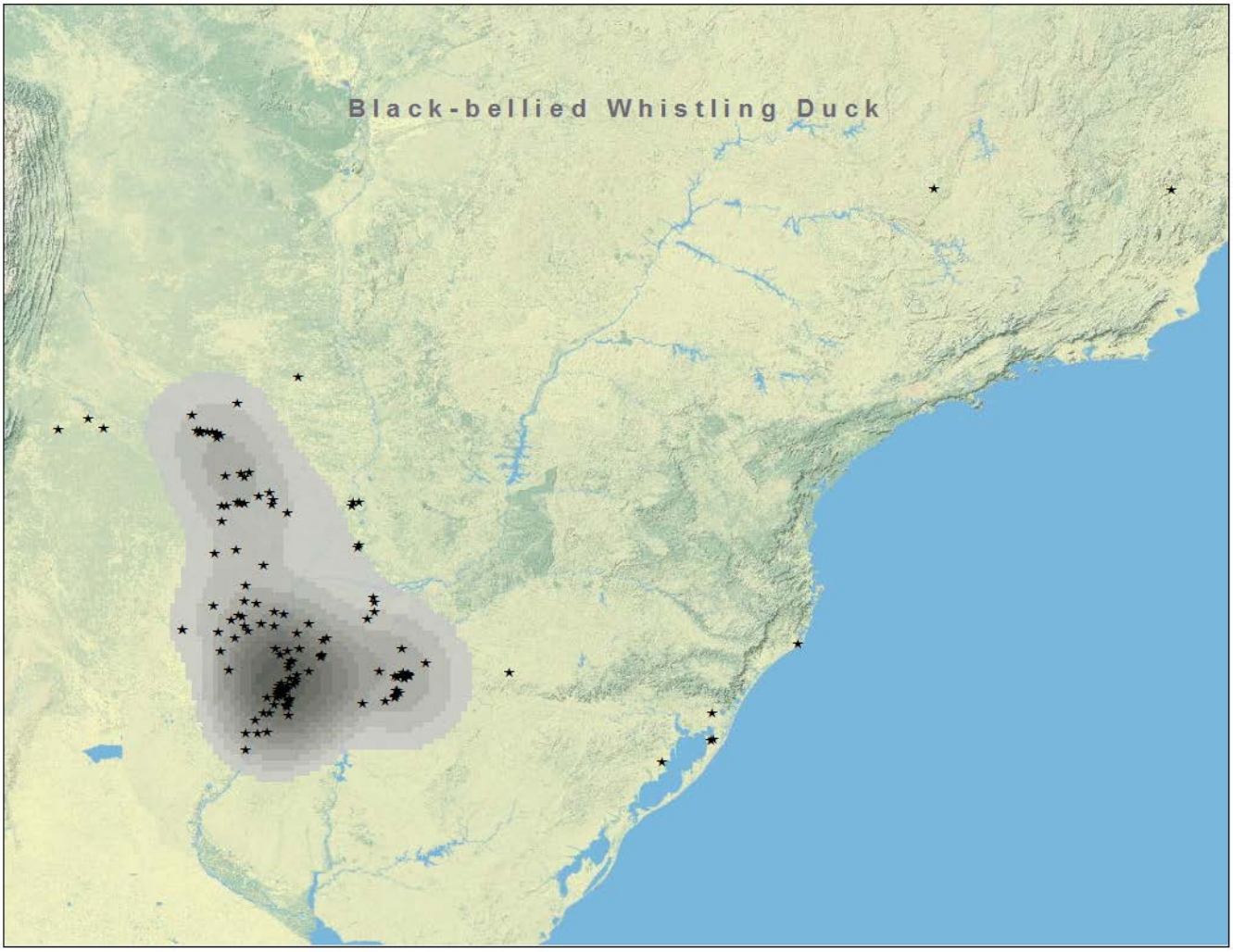
Appendix 8. Locations of all four duck species of in three years (2008, 2009, 2010). Red is BBWD, Green is FUWD, Red is WFWD, and Yellow is RBPO.



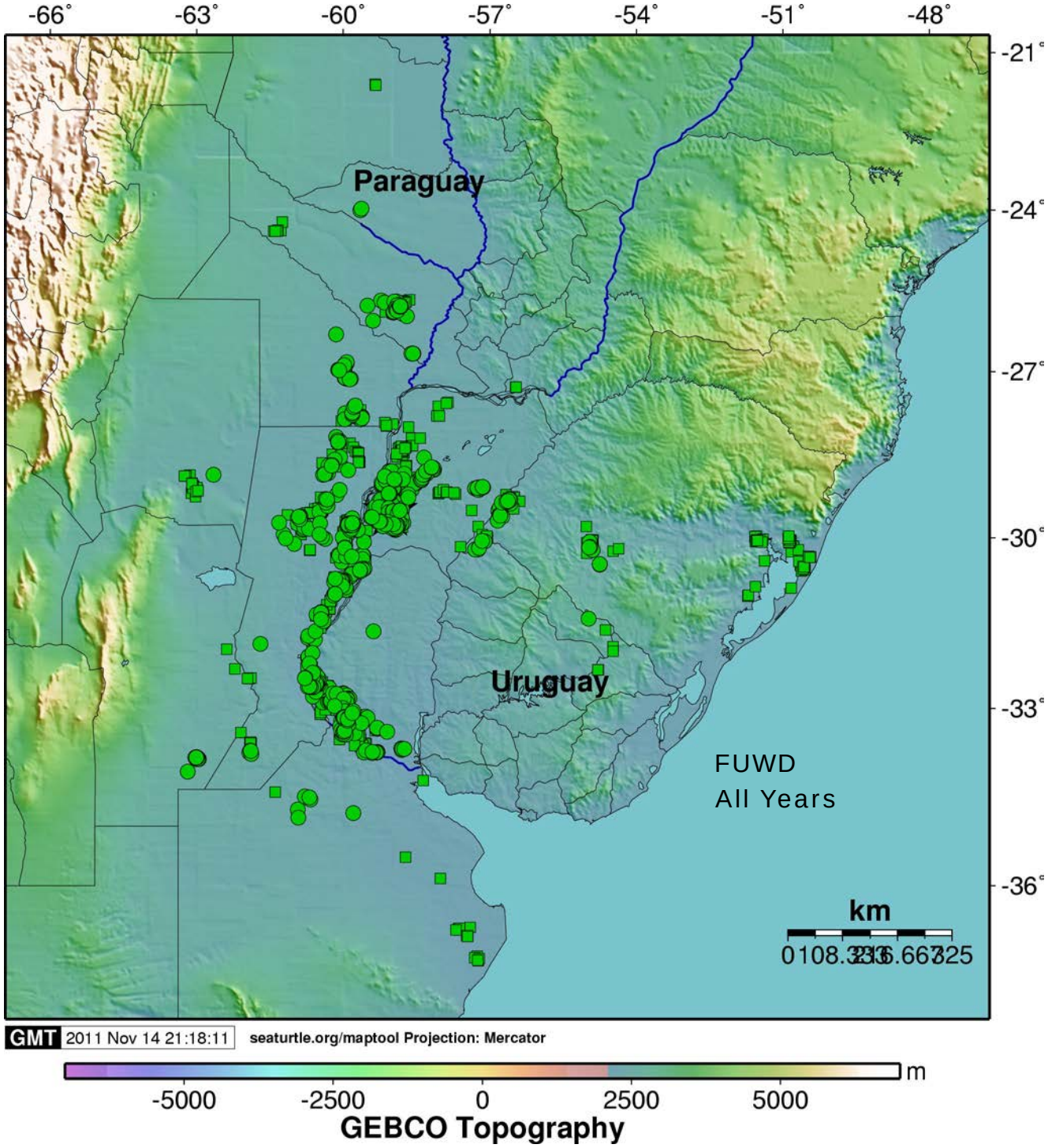
Appendix 9. Locations of black-bellied whistling ducks for three years (2008, 2009, 2010).



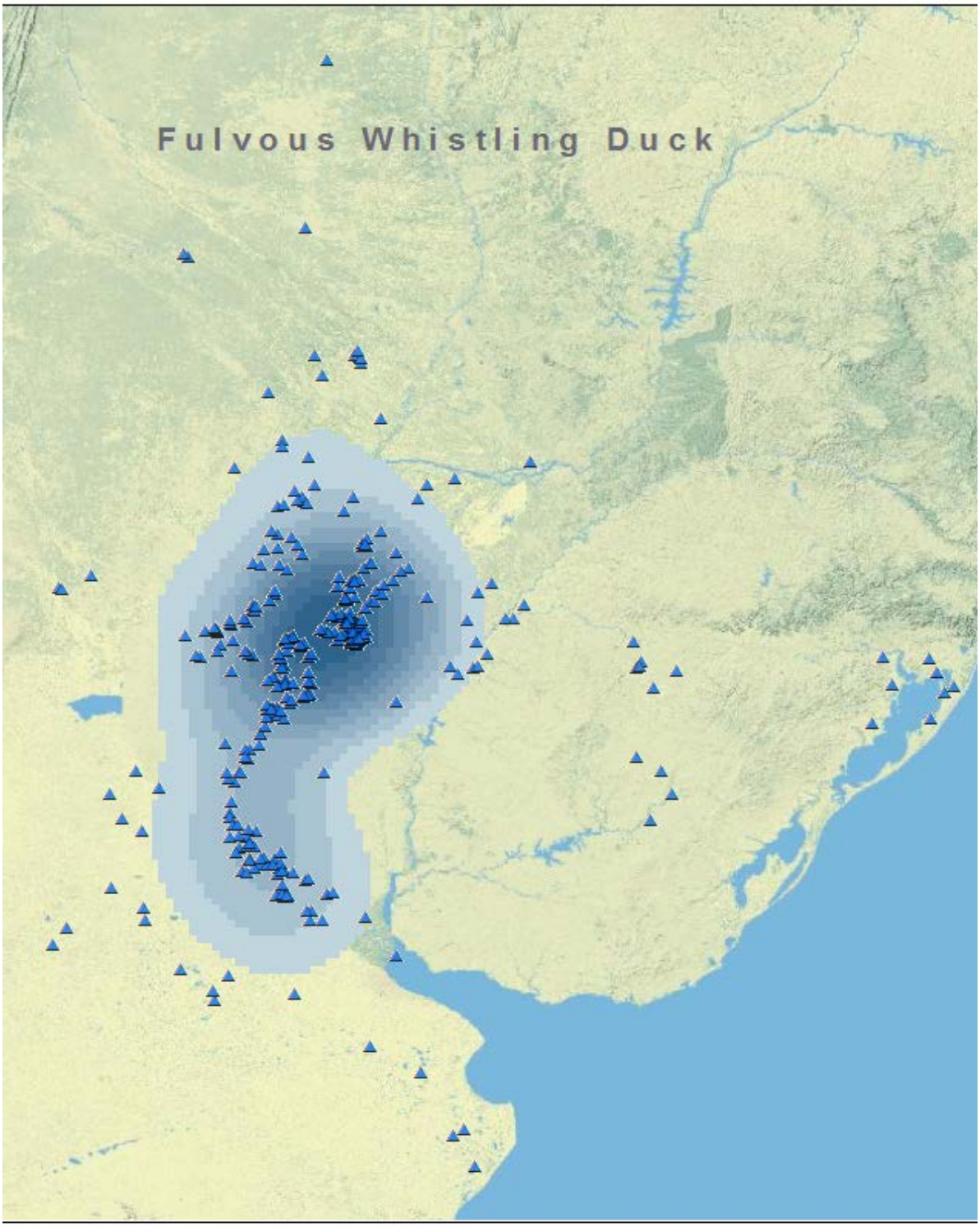
Appendix 9a. Locations of black-bellied whistling ducks for three years (2008, 2009, 2010), based on kernel analyses.



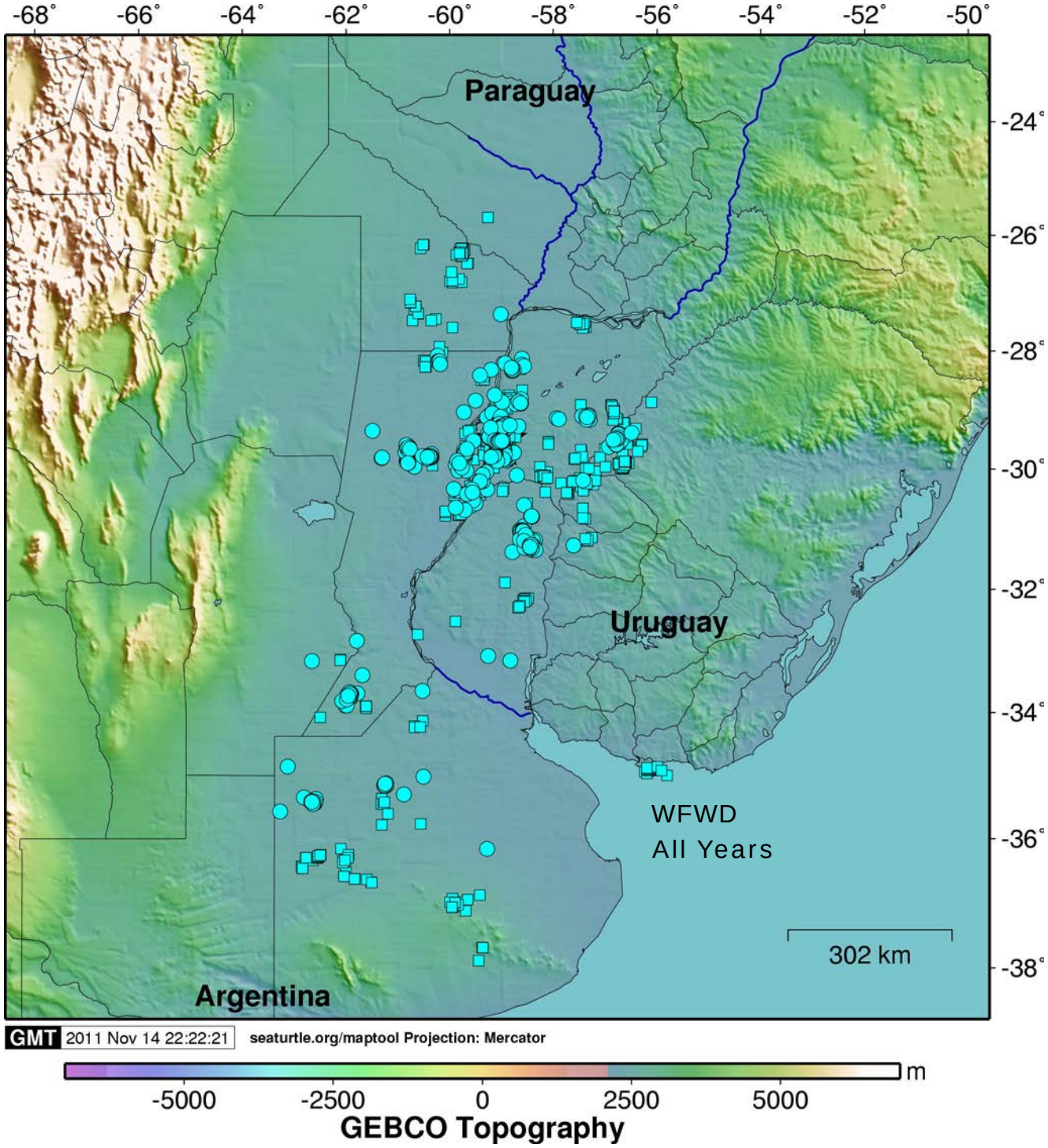
Appendix 10. Locations of fulvous whistling ducks for three years (2008, 2009, 2010).



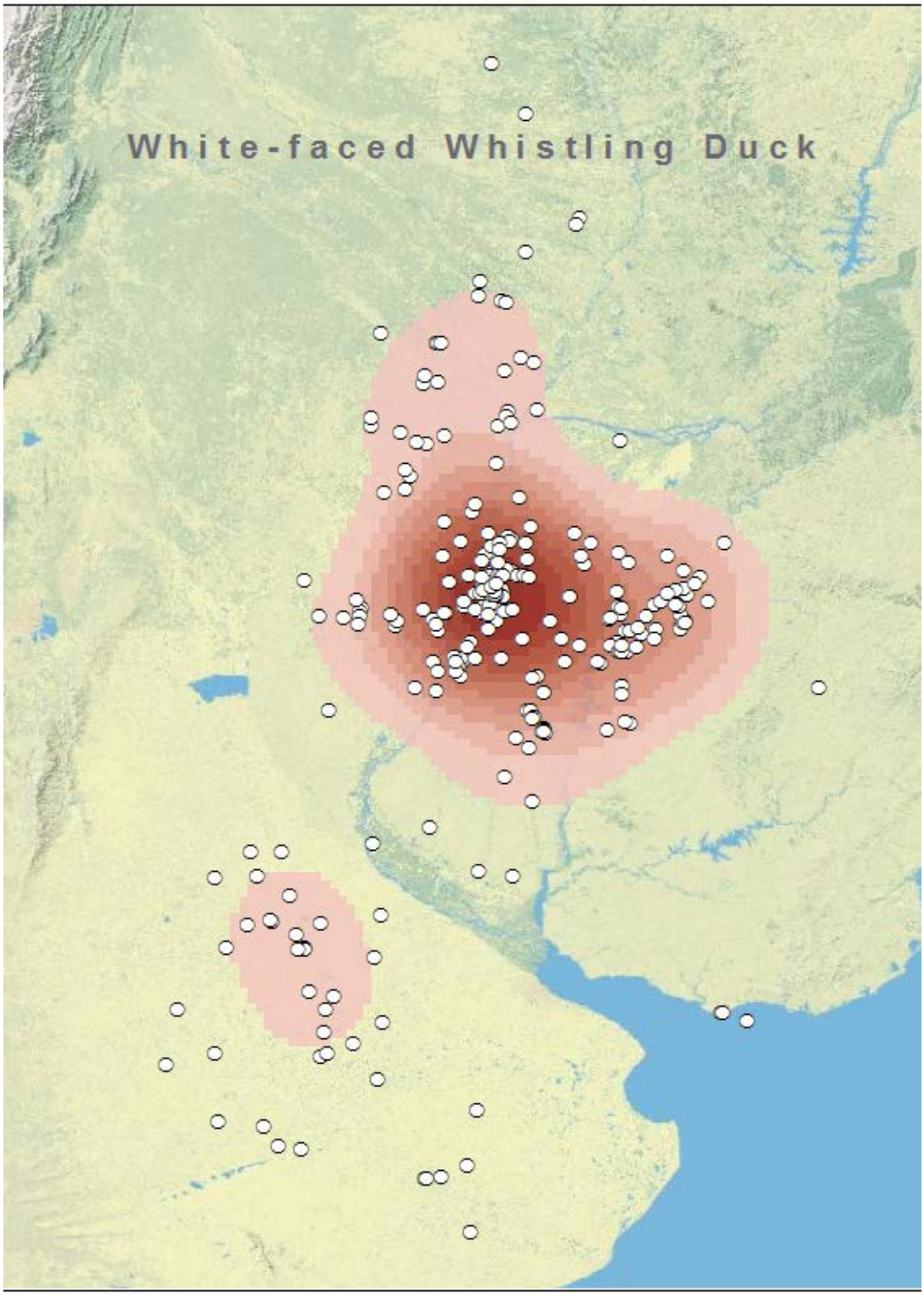
Appendix 10a. Locations of fulvous whistling ducks for three years (2008, 2009, 2010), based on kernel analyses.



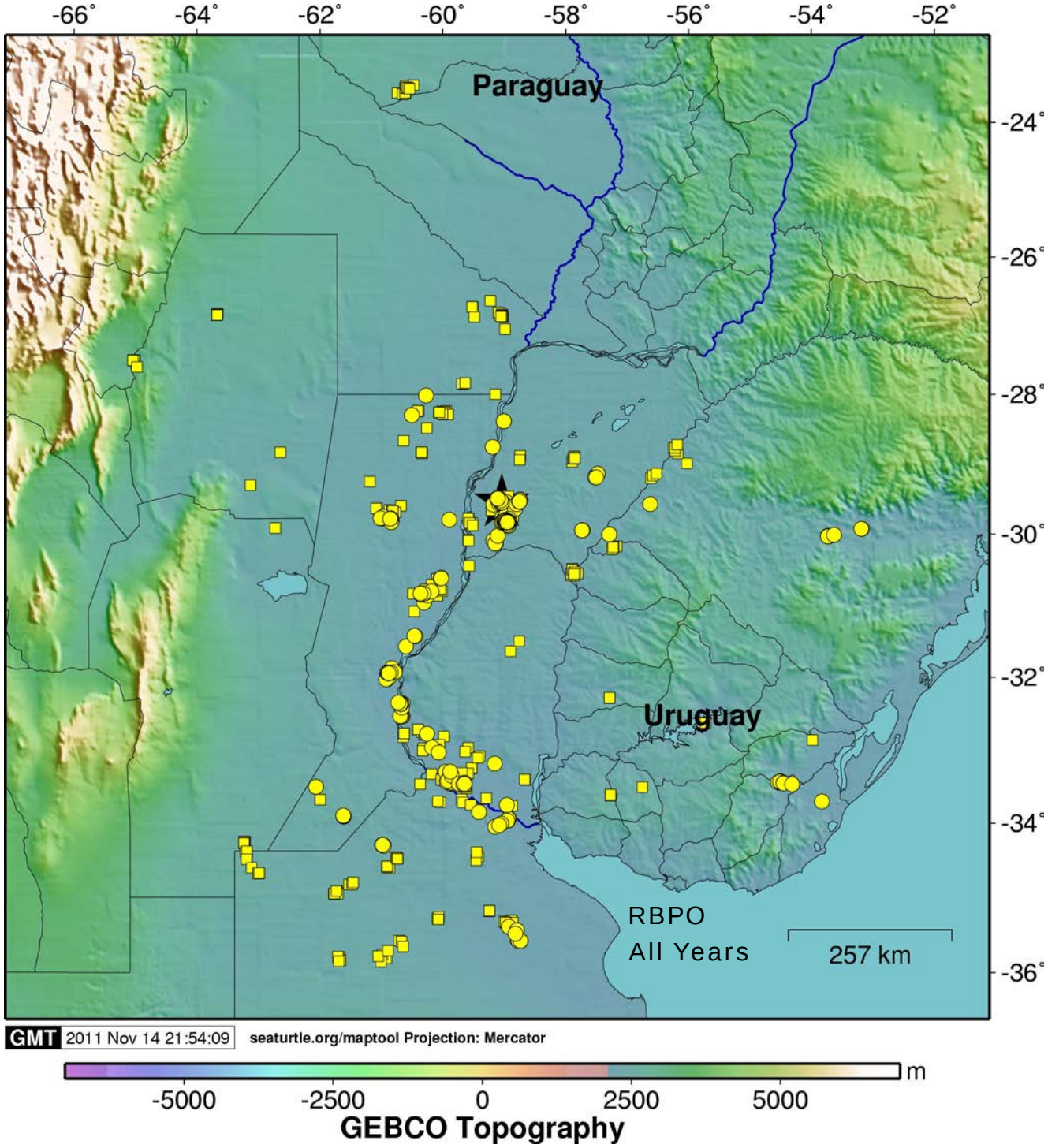
Appendix 11. Locations of white-faced whistling ducks for three years (2008, 2009, 2010).



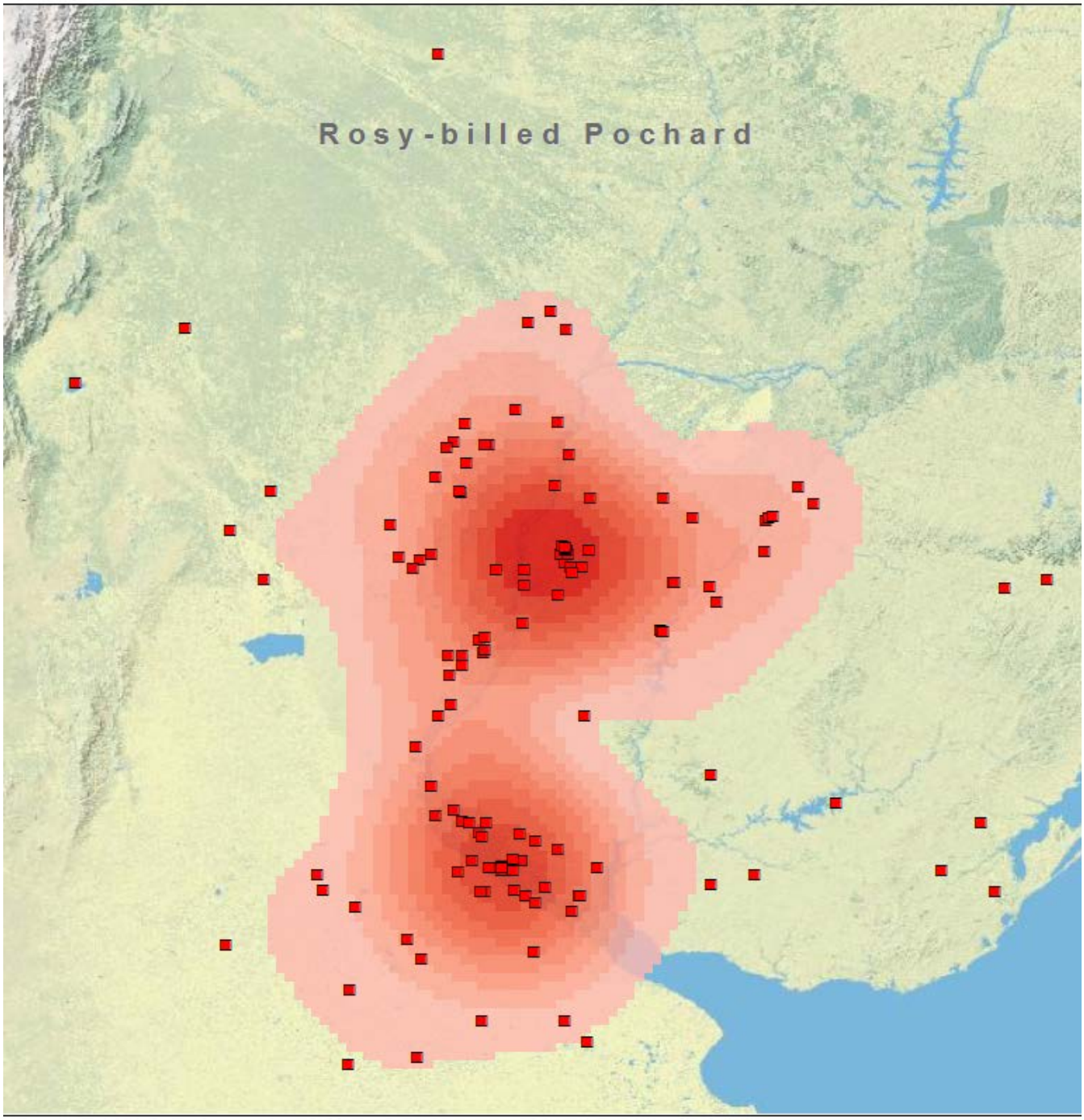
Appendix 11a. Locations of white-faced whistling ducks for three years (2008, 2009, 2010), based on kernel analyses.



Appendix 12. Locations of rosy-billed pochards for three years (2008, 2009, 2010).



Appendix 12a. Locations of rosy-billed pochards for three years (2008, 2009, 2010), based on kernel analyses.



Appendix 13. Habitat preferences for individual instrumented ducks as defined by percentage of total location 3, 2, or 1 satellite fixes for discrete days during specified transmission period.

Species	No.	Transmission Period	Total Satellite Fixes*	HABITAT						
				Wetlands	Grasslands	Forest	Wetland Forests	River	Lake	Sandy Dunes
BBWD	27	Aug-June	55	40%	9%	0%	4%	29%	15%	4%
	28	Aug-June	52	42%	2%	13%	36.50%	6%	0	0
FUWD	20	Aug-June	55	15%	25%	0%	0%	11%	44%	5%
WFWD	15	Aug-June	55	92%	2%	0%	0%	2%	4%	0%
	16	Aug-June	51	88%	6%	0%	0%	6%	0%	0%
	18	Aug-Apr	33	0%	82%	0%	0%	18%	0%	0%
	22	Aug-Oct	14	86%	0%	0%	0%	7%	7%	0%
	23	Aug-June	53	72%	8%	0%	0%	13%	8%	0%
	29	Aug-June	56	43%	16%	5%	0%	32%	4%	0%
RBPO	25	Aug-Dec	24	29%	0%	0%	38%	21%	13%	0%
	30	Aug-June	50	38%	10%	33%	6%	13%	0%	0%
	32	Aug-Nov	17	29%	6%	0%	0%	18%	47%	0%
	33	Aug-Jan	29	58%	0%	0%	0%	6%	37%	0%
	34	Aug-Mar	40	0%	0%	40%	2%	33%	25%	0%

*each fix is location class 3, 2, or 1 and represents a discrete day

Habitat Description:

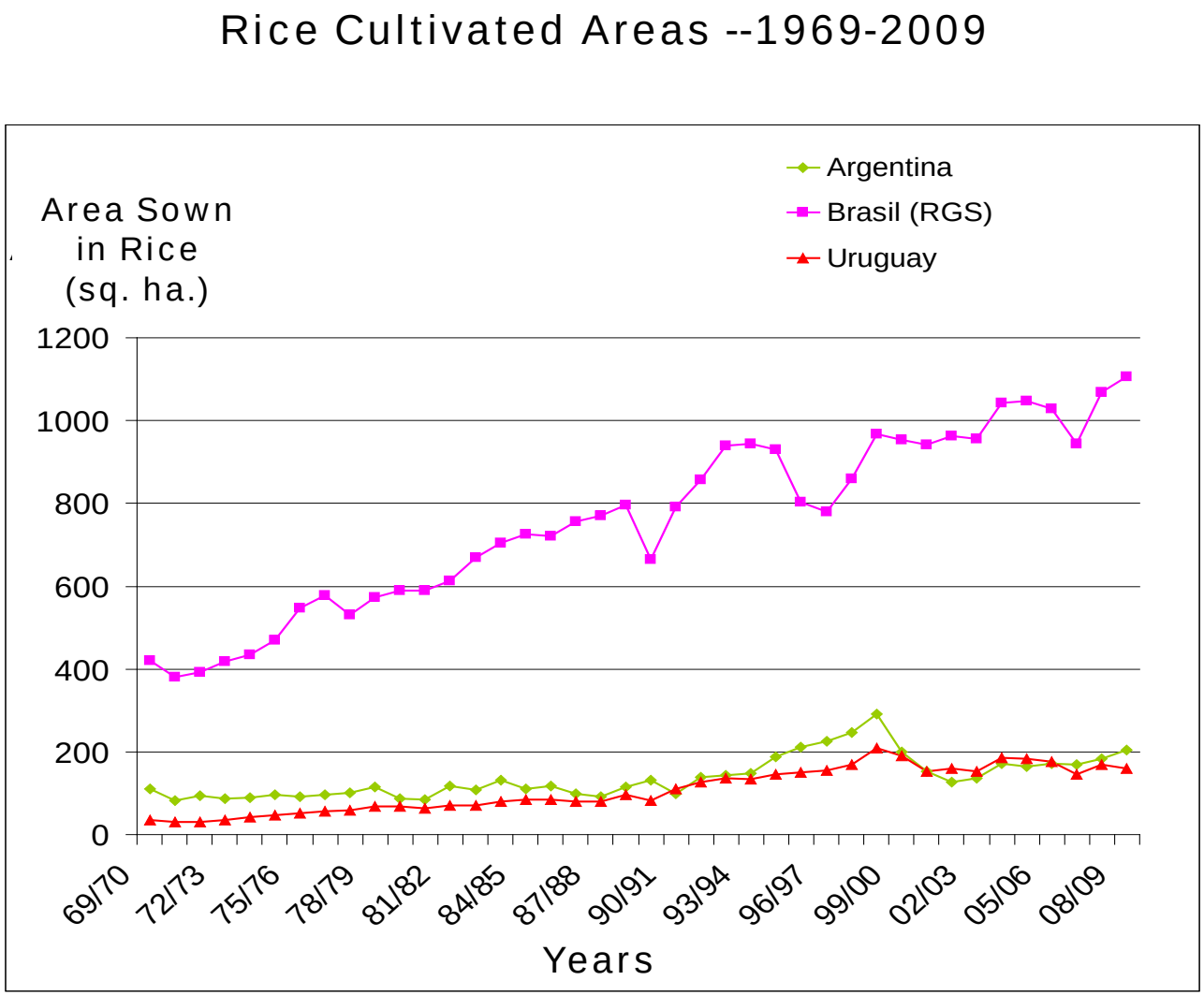
Wetlands: Flooded grasslands. Characterized by an abundance of ponds, lakes, streams, tributaries, or rivers.

Grasslands: generally dry grasslands with low lying shrubs and vegetation. May experience some seasonal flooding depending on region.

Forest: Dry, broadleaf forests.

Wetland Forest: "Gallery forests" characterized by an abundance of water in the soil.

Appendix 14. Rice cultivated areas that were sown in three countries from 1969 to 2009.



Appendix 15.

Black-bellied Whistling Duck (BBWD)

Scientific name: *Dendrocygna autumnalis*
Common names: *sirri vientre negro (Argentina and Uruguay); marreca cabocla, marreca asa branca (Brazil)*

Distribution: Two subspecies: *D. a. autumnalis* in south-east Texas to central Panama and *D. a. fulgens* in East Panama and South America down to northern Argentina and southern Brazil (Figure 1).

Figure 1. Distribution range of the BBWD in South America

Conservation status: **L**east concern, lowest risk (UICN).
Feeding: **V**egetarian, basically leaves and seeds(grain). Also small invertebrates (molluscs, insects). Feeds mainly on ground by grazing or in shallow waters by wading and dabbling.
Movements: Considered partially migratory.
Breeding: In loose groups: nests are usually in tree cavity, occasionally on ground. Incubation 26-31 days, fledging 53-63 days.
Habitat: Tropical lagoons with some tree cover on margins. Often found in vicinity of agricultural land.

Movements in South America

Limited information is available. The species was first mentioned in Brazil in 1994, when 220 individuals were recorded in the southern state of Rio Grande do Sul. In August 2000, 3,130 individuals were counted in an aerial census in the same region (Menegheti and Dotto 2008). No banding recoveries of this species are available.

Results

Operational Life Span of Transmitters

A total of 16 BBWD were implanted (Table 1). Mean duration of transmitter reception was 246 days, with a maximum of 602 days and a minimum of 26 days (Table 1).

Table 1. Duration of transmitter activity (days) in BBWD, according to sex.

BBWD	All	Females	Males
Mean	246	259	229
SD	182	210	153
Max	602	602	369
Min	26	26	38
N	16	9	7

Distance Flown

Total distance flown by each duck ranged between 17 km and 3,513 km (Table 2). Mean daily distance was 7.50 km. Mean values of males and females did not differ from the total average ($p<0.05$). In these calculations individuals with less than 30 days of survival (#27) were not included. Two ducks did not move from the release point (Don Pablo Ranch during the entire transmitting period) (#26 and #47).

Table 2. Average daily distance flown by BBWD according to sex.

BBWD	All	Females	Males
Mean	7.50	8.52	6.86
SD	7.33	9.26	4.20
Max	31.13	31.13	12.73
Min	0.64	0.64	0.91
N	16	9	7

Seasonal Variations in Mobility

Average monthly distance by all active BBWD individuals is shown in Figure 1. Two well defined peaks appear in September-October (spring) and March-April (autumn). The observed pattern suggests migratory movements to and from breeding areas. An exceptionally high value was recorded in February 2010.

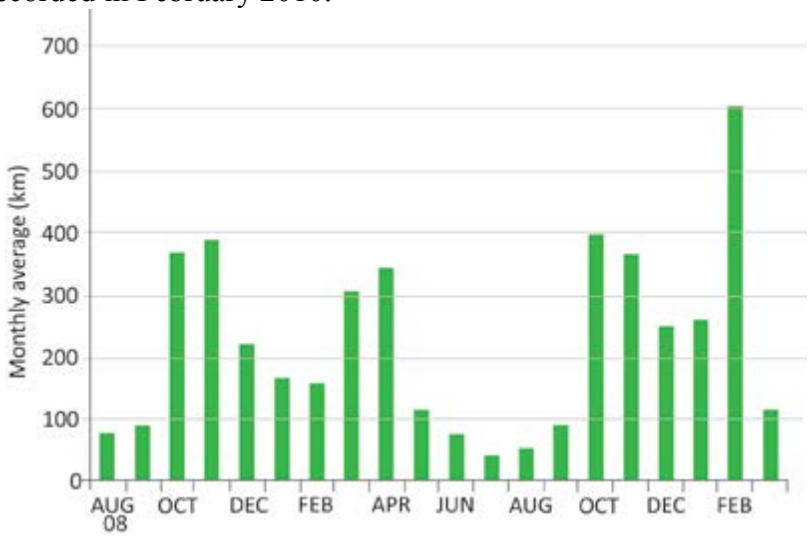


Figure 1. Average monthly distance flown by all transmitting BBWD.

Dispersal Area

Recorded positions included a wide region across Argentina, Brazil, and Paraguay, between 190 -310 S, and 410- 630 W coordinates. However, most of the positions were recorded in a much smaller area located in NE Argentina, particularly associated with the Parana and Paraguay rivers and eastern Chaco wetlands, including the provinces of Chaco, Corrientes, Formosa, and Santa Fe. Only two individuals reached the Paraguayan Chaco. Similarly, only two individuals moved to Brazil. One of them visited the Atlantic coast wetlands in Rio Grande do Sul. The other duck performed a very long flight (2,154 km), reaching the northern state of Espirito Santo Brazil, in a very short time (about two weeks; Figure 2).

Figure 2. Flight track of an exceptional movement of BBWD #00.

Sex-related Differences in Dispersal Range

Our data do not show important differences between the dispersal area of males and females. The two most eastward-reaching flights to Brazil were performed by one male and one female.

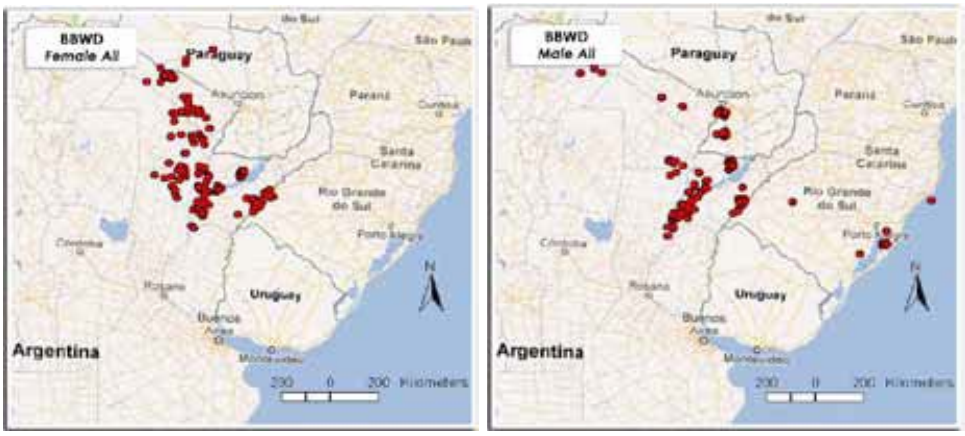


Figure 3. Locations of females (left) and males (right) BBWDs during the study period. Notice that female #00 is not included (see Figure 2).

Interannual Variations

Distribution of location points shows limited variations among years. The 2009-10 period shows a higher concentration in the north-east of Argentina, which may be the consequence of a dry year.

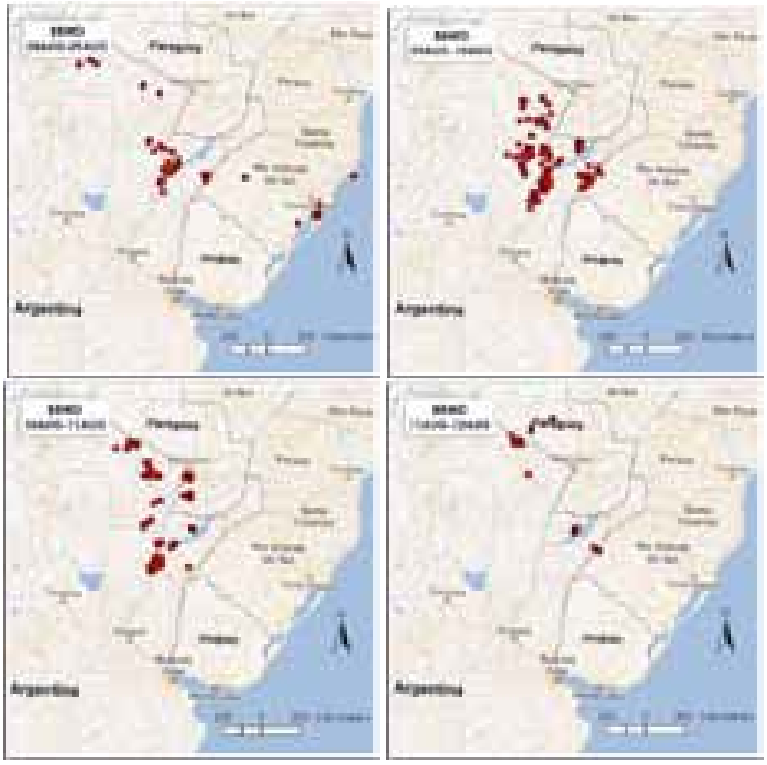


Figure 4. Interannual variations (2008-2012) in BBWD locations.

Seasonal Variations

Seasonal locations are shown in Fig 5. No significant changes are observed between seasons, with the exception of a concentration of points around the release area in Corrientes province, Argentina, together with the presence of a single individual in southern Brazil coastal wetlands in autumn and winter. This information confirms the importance of these wetlands as wintering area for the BBWD, previously noticed by aerial surveys in the region (Menegheti and Dotto 2005).

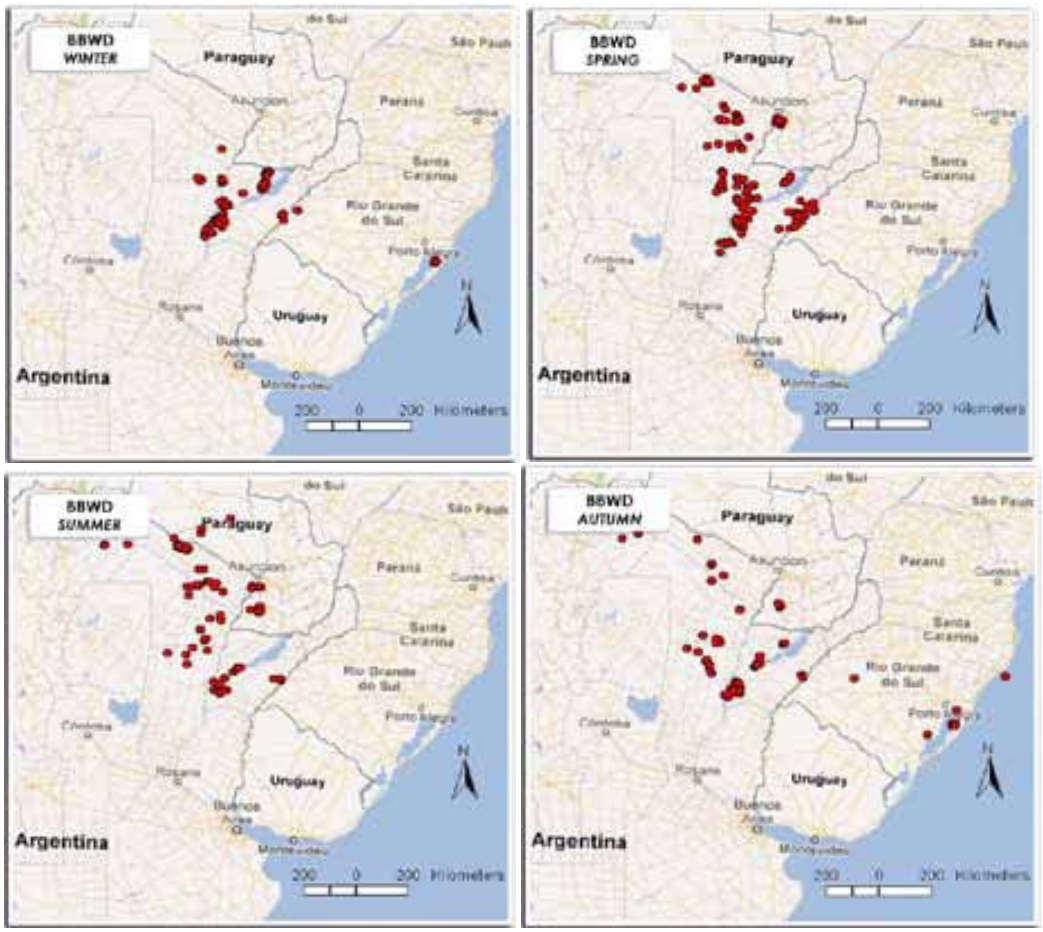


Figure 5. Seasonal variations in BBWD locations (Individual BBWD #00 position in north-eastern Brazil in spring is not shown. See Figure 2 and Appendix 2).

Habitat use

Habitat use by the BBWD is summarized in Table 3. Regarding macroregions, 65% of locations were in the Parana-Uruguay river systems, 33% in the Chaco wetlands (33), and 2% in Brazilian wetlands. With reference to habitat preference, ducks preferred small natural wetlands and riverine wetlands. Dry land cultivated areas were also frequently used, particularly rice fields.

Table 3. Habitat use by the BBWD. Total number and proportion of recorded positions (n=785).

Habitat	Number of records	Proportion of total (%)
Small, natural wetlands	267	37
Riverine areas of rivers and streams	254	35
Dryland cultivated areas	110	15
Pampas ponds and small lakes	35	5
Rice fields	28	4
Extensive wetlands	18	2
Small dams	10	1
Large dams	8	1

Use of rice fields

Rice fields use comprised 6% of recorded positions. BBWD visited rice fields during the entire annual cycle, peaking during the seeding period in spring (September-November), when rice fields are being sown and flooded (Figure 6).

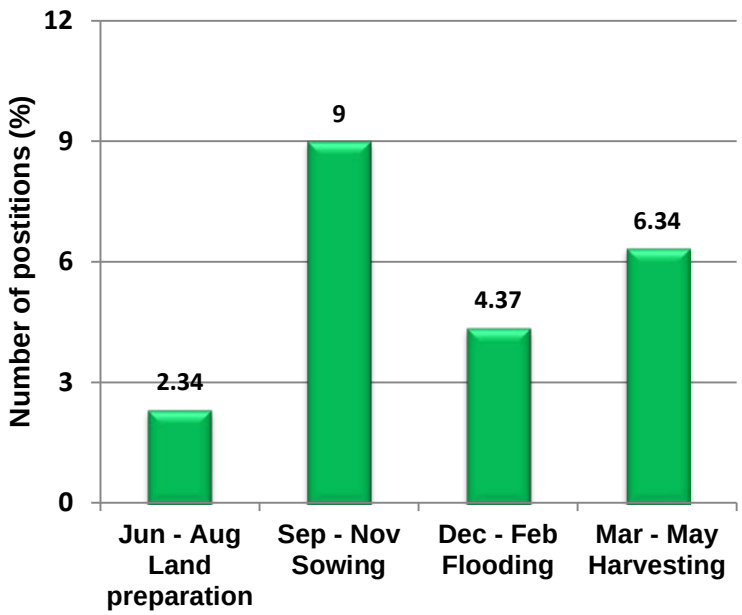


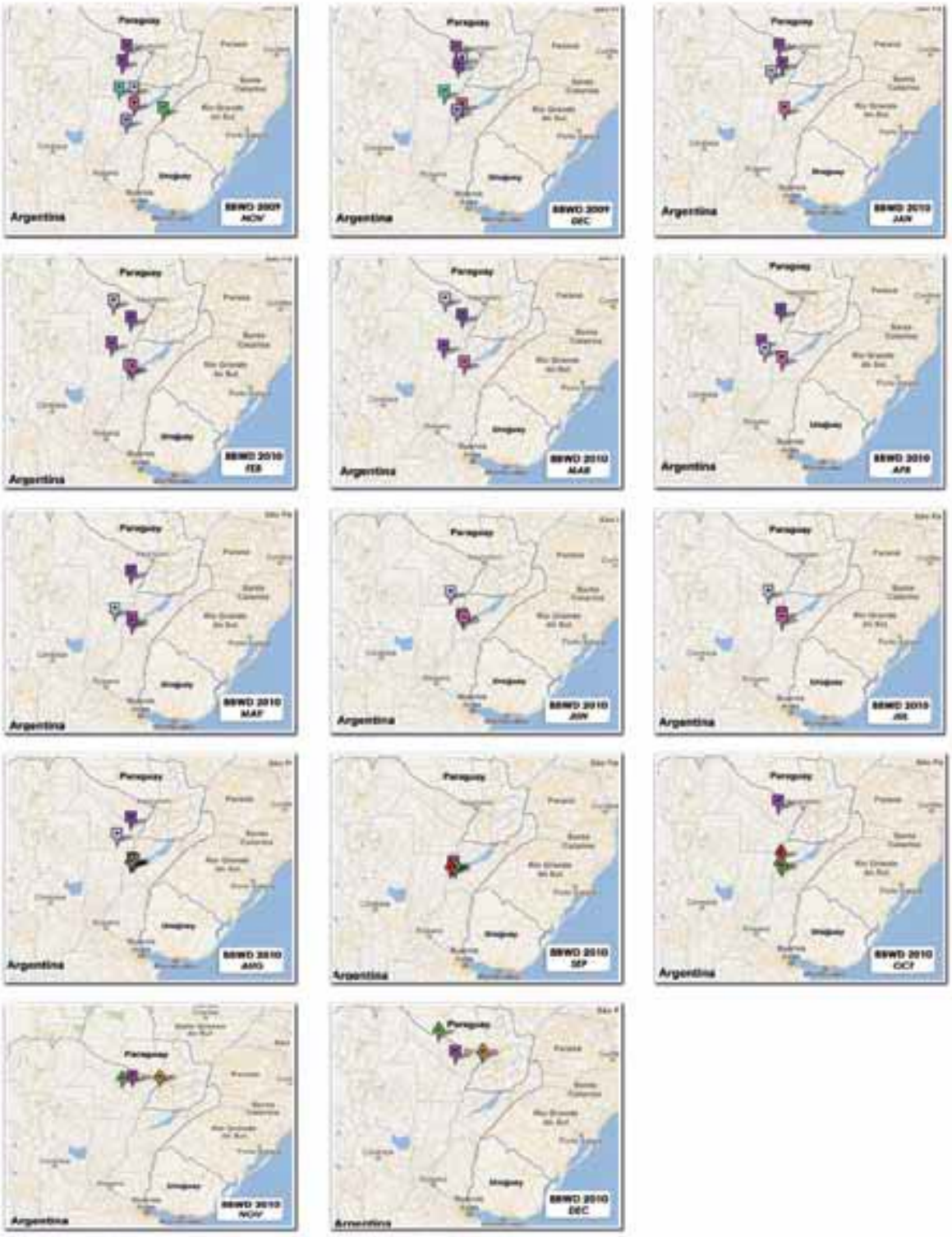
Figure 6. Seasonal frequency of BBWD locations in rice fields throughout the crop cultivation cycle (n=785).

PRELIMINARY CONCLUSIONS

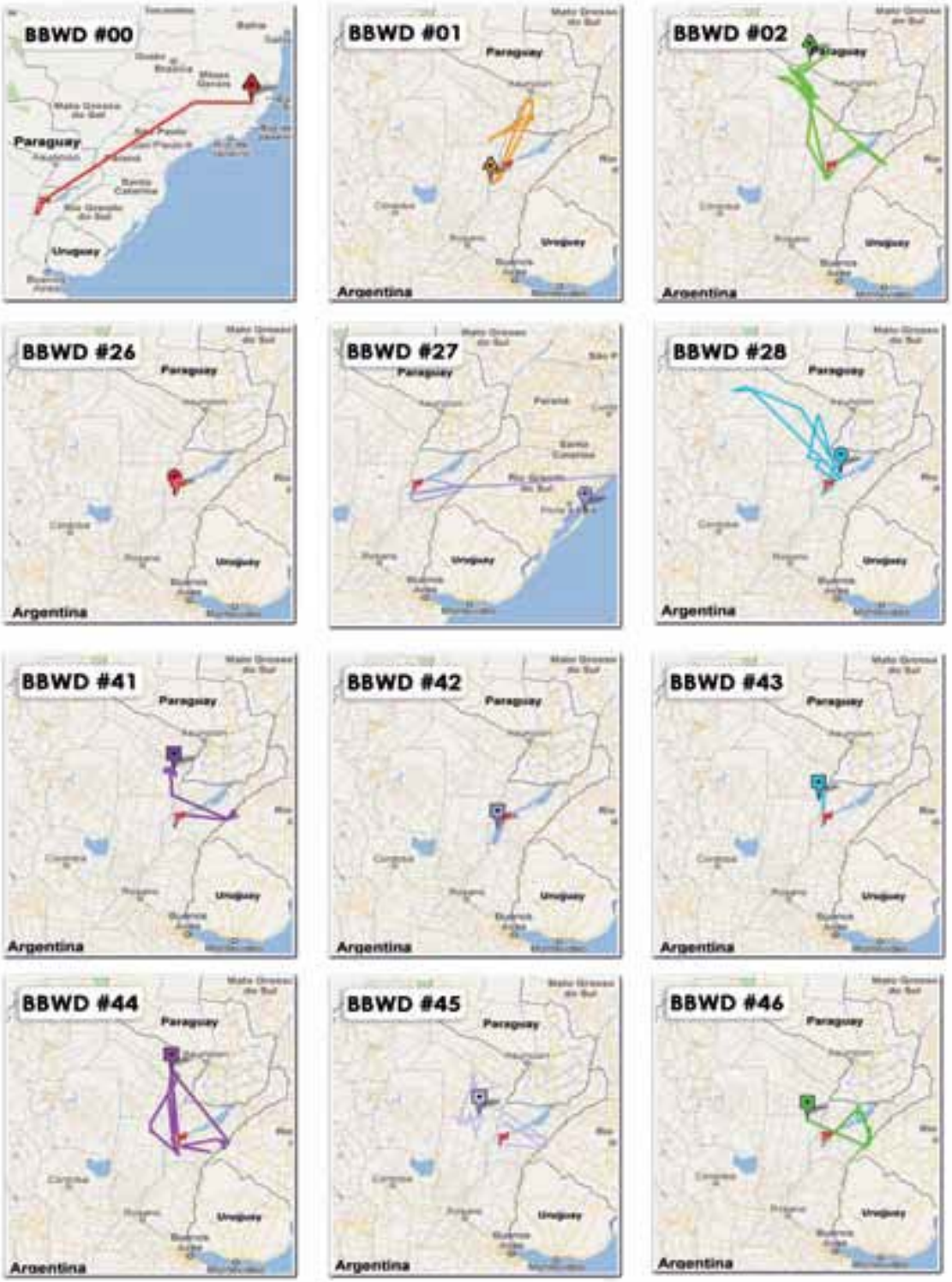
There is a single BBWD population that moves widely in Argentina, Uruguay, Brazil, and Paraguay. Dispersal of implanted individuals was largely restricted to north-east Argentina. The 31^0 S parallel seems to indicate the southern limit of BBWD's range. BBWD individuals are capable of very long-range displacements in short periods (e.g., individual #00, 2153 km). The BBWD shows preference for natural habitats, particularly small wetlands along the Middle and Lower Parana River and the Chaco ecoregion. Its use of rice fields is relatively low compared with other duck species.

Appendix 1.
Monthly maps and individual tracks of BBWD.

Appendix 1 (cont.).



Appendix 2.
Individual tracks of implanted BBWD



Appendix 2 (cont.).

Appendix 16.

Fulvous Whistling Duck (FUWD)

Scientific name: *Dendrocygna bicolor*
Common names: *Siriri colorado (Argentina and Uruguay); Pato silbón, Marreca-caneleira (Brazil)*

BACKGROUND INFORMATION
Distribution: **S**outh of United States to north and east of South America as far south as central Argentina. Also occurs in Africa, Madagascar, and Indian subcontinent (Del Hoyo 1992).

Conservation status: Least concern, lowest risk (IUCN).

Habitat: Wetlands, estuaries, brackish lagoons with aquatic vegetation and along the shores of rivers, being most abundant in flooded savannahs and irrigated rice fields.

Feeding: Almost entirely vegetarian. Feeds on rice. Forages by dabbling, occasionally dives for food; mainly nocturnal. In Argentina, studies based on specimens collected in the Middle Parana River in winter showed a strictly vegetarian diet, based on seeds, particularly *Polygonum* species (Mosso and Beltzer 1991).

Breeding: Nests in loose groups on ground or in tree cavities. Incubation 26-31 days. Fledging 53-63 days. Breeding season largely determined by water availability.

Movements: Considered partially migratory (Del Hoyo 1992).

Movements in South America

Available information indicates important annual displacements in southern South America, including mainly Argentina and Brazil. In the southern border of its range (eastern Buenos Aires province, Argentina), the FUWD is a summer visitor, arriving between September and November and usually leaving by early to mid-February. However, it may be seen as late as June, depending on rains and water availability (Weller 1968).

The autumn migration results in a marked increase in the FUWD population in the Middle Parana River region, particularly in extensive rice-growing areas like San Javier (Weller 1968), (Capllonch et al. 2008). This autumn northward migration has been confirmed by a FUWD specimen banded in November in Buenos Aires province and recovered the following year far north in Corrientes province, NE Argentina (Olrog 1974).

A strong FUWD early spring movement from Rio Grande do Sul (Brazil) into the Middle Parana River wetlands was revealed by banding recoveries (Antas 1994). However, there was no evidence of a reverse movement in autumn, since recoveries indicated that ducks remained in the Middle Parana area, with the exception of some specimens that were in Brazil between two and three years later (Antas 1994).

This suggested that FUWD could move rather nomadically in response to local conditions (especially wetland availability), and without following a regular pattern. Capllonch et al. (2008) confirmed significant spring movements between Brazil and Argentina. Further evidence regarding irruptive movements in southern Brazil was provided by annual aerial surveys. Between 1999 and 2003 the average winter count in southern Brazil was about 14,000 individuals, whereas in 2004 the total count reached 46,000 individuals (Menegheti and Dotto 2005).

RESULTS

Operational Life Span of Transmitters

A total of 26 FUWD were implanted (Appendix 3). Average operational time was 284 days, with a maximum of 617 days (Table 1).

Table 1. Duration of transmitter activity (days) in FUWD, according to sex.

FUWD	All	Females	Males
Mean	284	293	273
SD	192	204	185
Max	617	617	547
Min	7	7	55
N	26	14	12

Seasonal Variations in Mobility

Monthly average distance of implanted FUWD individuals is shown in Figure 1. Considerable differences between months and seasons are observed. Peak values correspond to spring months (October- December), high values extend throughout summer and autumn (January-April), and minimal values were recorded in winter (May to August). The observed pattern clearly suggests migratory or nomadic movements associated with the breeding season.

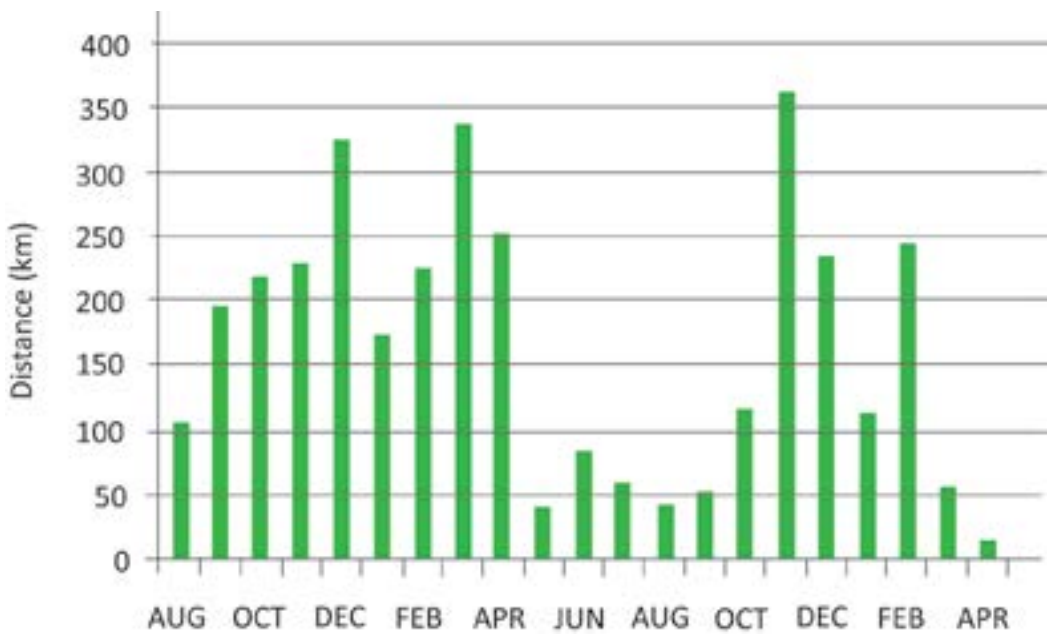


Figure 1. Monthly average distance flown by each transmitting FUWD individual along the study period.

Dispersal Area

Recorded positions included a wide region covering Argentina, Brazil, and Paraguay, between S 210^0-370^0, and W 500^0-630^0 coordinates. However, most of the positions were recorded in a much smaller area located in NE Argentina, particularly along the Parana River Valley and the eastern Chaco wetlands. The area includes the provinces of Chaco, Corrientes, Formosa, and Santa Fe. Moreover, several locations were in the Pampas region, particularly in

Buenos Aires province. Only two individuals reached the Paraguayan Chaco. Similarly, a few locations corresponded to southern Brazil and northern Uruguay.

Dispersal Distance

Mean total distance flown by each duck during the transmission period was 1922 km, ranging between 4891km and 11 km. Mean daily distance was 6.42 km, ranging between 11.81 km and 0.31 km. There was no significant difference between sexes.

Table 2. Average daily dispersal distance by FUWD according to sex.

FUWD	All	Females	Males
Mean	6.41	6.35	6.47
SD	3.03	3.61	2.33
Max	11.84	11.84	10.02
Min	0.31	0.31	2.38
N	26	14	12

Sex-related Differences in Dispersal Range

About sex-related differences in dispersal, both sexes tend to concentrate along the Parana River valley. Within this general pattern, there is a tendency for males to concentrate in wetlands along the Parana and Uruguay rivers, whereas females show a more dispersed pattern, particularly to the west and east of the core area.

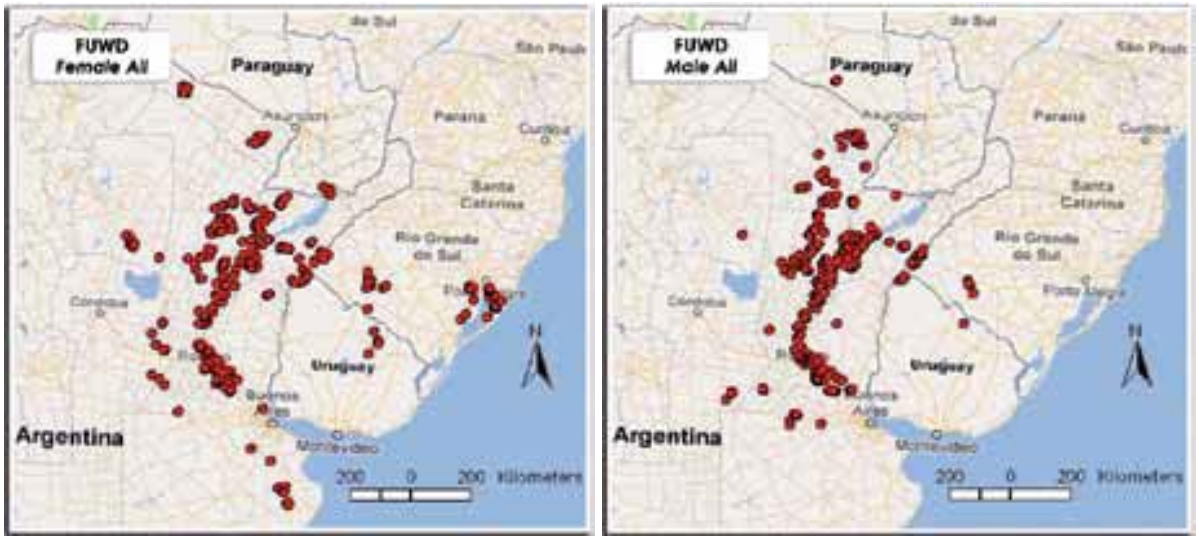


Figure 2. Locations of females (left) and males (right) of FUWD during the study period.

Interannual Variations

Comparison of locations among years (implanted ducks were released in August 2008, 2009, and 2010 shows contrasting variations, both in the location and size of the dispersal area

(Fig 3). During the 2008-2009 period, locations were concentrated in two main areas: one around the release point in Corrientes province, and the other on the coastal wetlands of southern Brazil. The 2009-2010 period, shows a concentration of points along the Parana River Valley, but also important concentrations in the south, in the Pampas ecoregion of Buenos Aires and Santa Fe provinces. More points are also added in the Southern Brazil – Northern Uruguay area. The 2010-2011 period, continued to show a great concentration of points along the Parana River Valley. However, there was a clear decrease in the number of points in the Pampas region, and an increase in northern positions, particularly in the Argentine Formosa province and also a few locations in Paraguay. Although it is clear that variations in the number of implanted FUWD may have influenced point distribution by random factors, it is important to remember that the 2008-2009 year suffered a severe drought in the whole region under study, causing considerable shifts in FUWD displacements.

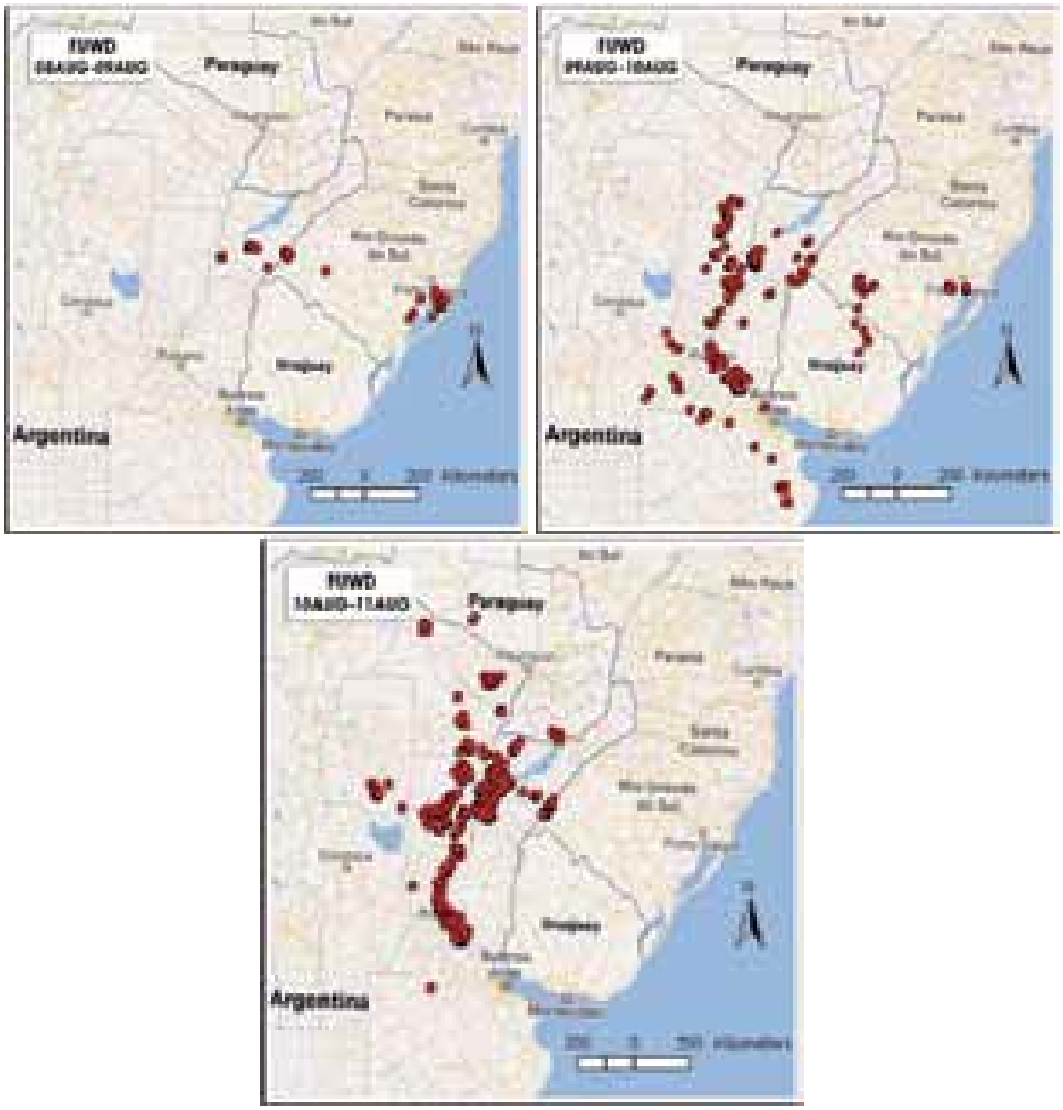


Figure 3. Distribution of FUWD locations in three consecutive annual periods.

Seasonal Movements

In general terms, seasonal variations in the dispersal pattern of the FUWD are limited (Figure 4). However, the main difference consists in an expansion of the wintering areas in spring and summer, particularly to the south (Pampas region) and also to the North along the Parana River axis, reaching northern Corrientes province and even Paraguay. Another interesting feature consists in the presence of FUWDs in the coastal wetlands of southern Brazil throughout the year.

The patterns detected tend to confirm previously observed movements, particularly the winter departure of FUDWs from the southern extreme of its distribution range in winter, as well as a tendency to irregular, nomadic movements.

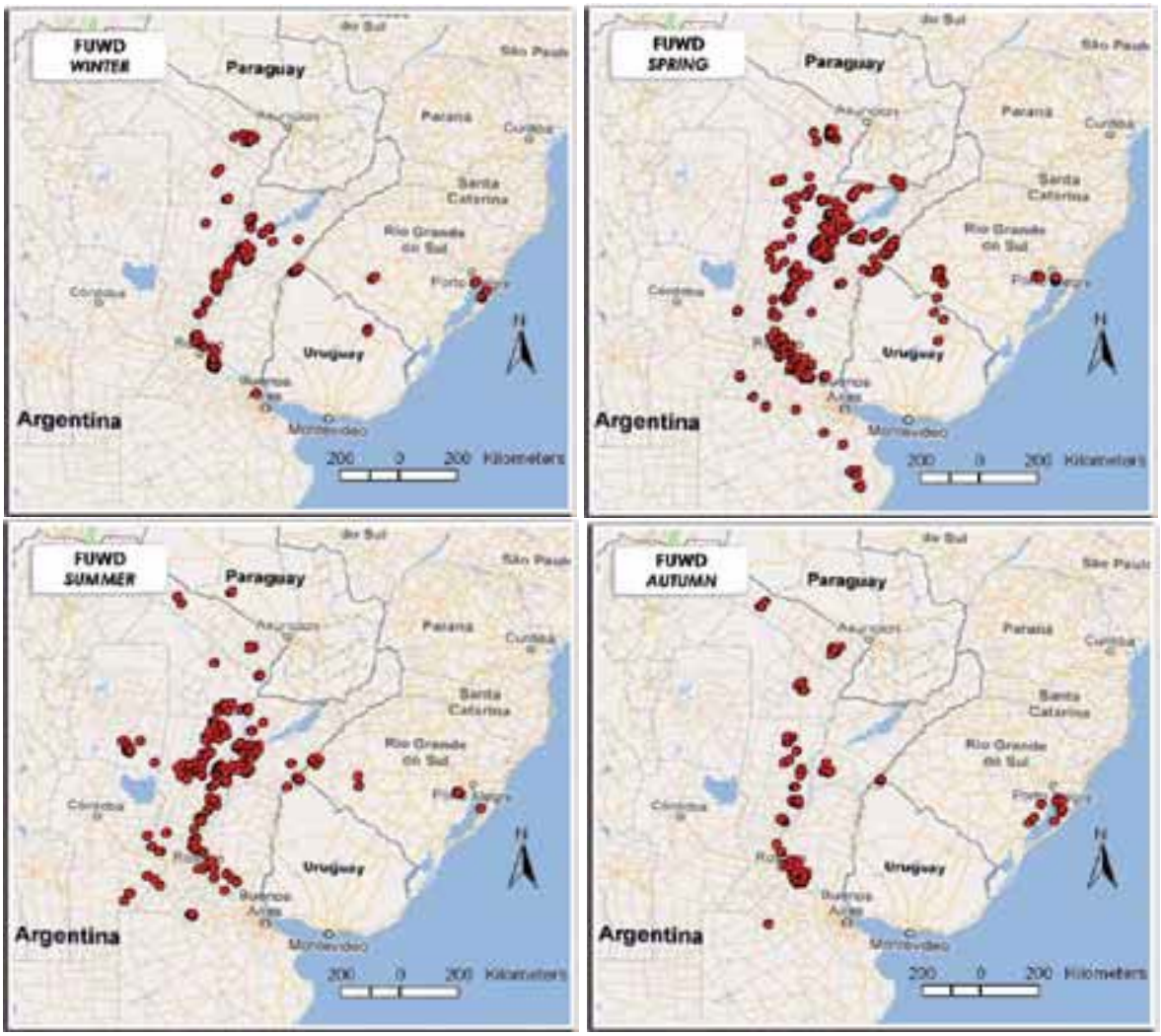


Figure 4. Seasonal variations in FUWD satellite locations.

Habitat Use

Habitat use by the FUWDs summarized in Table 3. Regarding macro regions, 66% of locations were in the Parana-Uruguay river systems, 28% in the Chaco wetlands, 4 % in the Pampas and 2% in Brazilian wetlands. With reference to habitat preference, FUWDs preferred small natural wetlands and riverine wetlands. Rice fields also reached a high proportion of visits.

The least used areas were lagoons in the Pampas region, a marginal area in terms of the FUWD distribution range.

Table 3. Habitat use by the FUWD. Proportion of total number of recorded positions (n=1803).

Habitat	Number of records	Proportion of total (%)
Small, natural wetlands	1037	56
Riverine areas of rivers and streams	375	21
Dryland cultivated areas	81	4
Rice fields	187	10
Small dams	46	3
Pampas Lagoons	12	1

Use of Rice Fields

FUWDs locations indicate that this species makes relatively intensive use of rice fields, as compared with the other studied species, along most of the annual crop cycle.

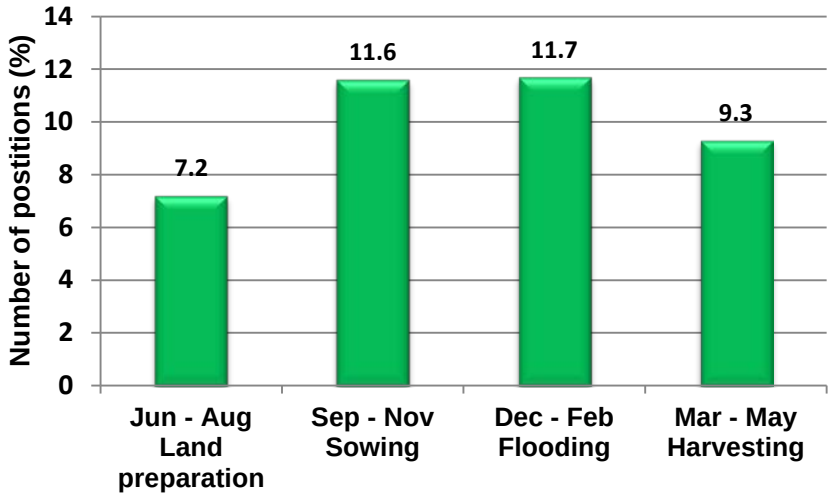
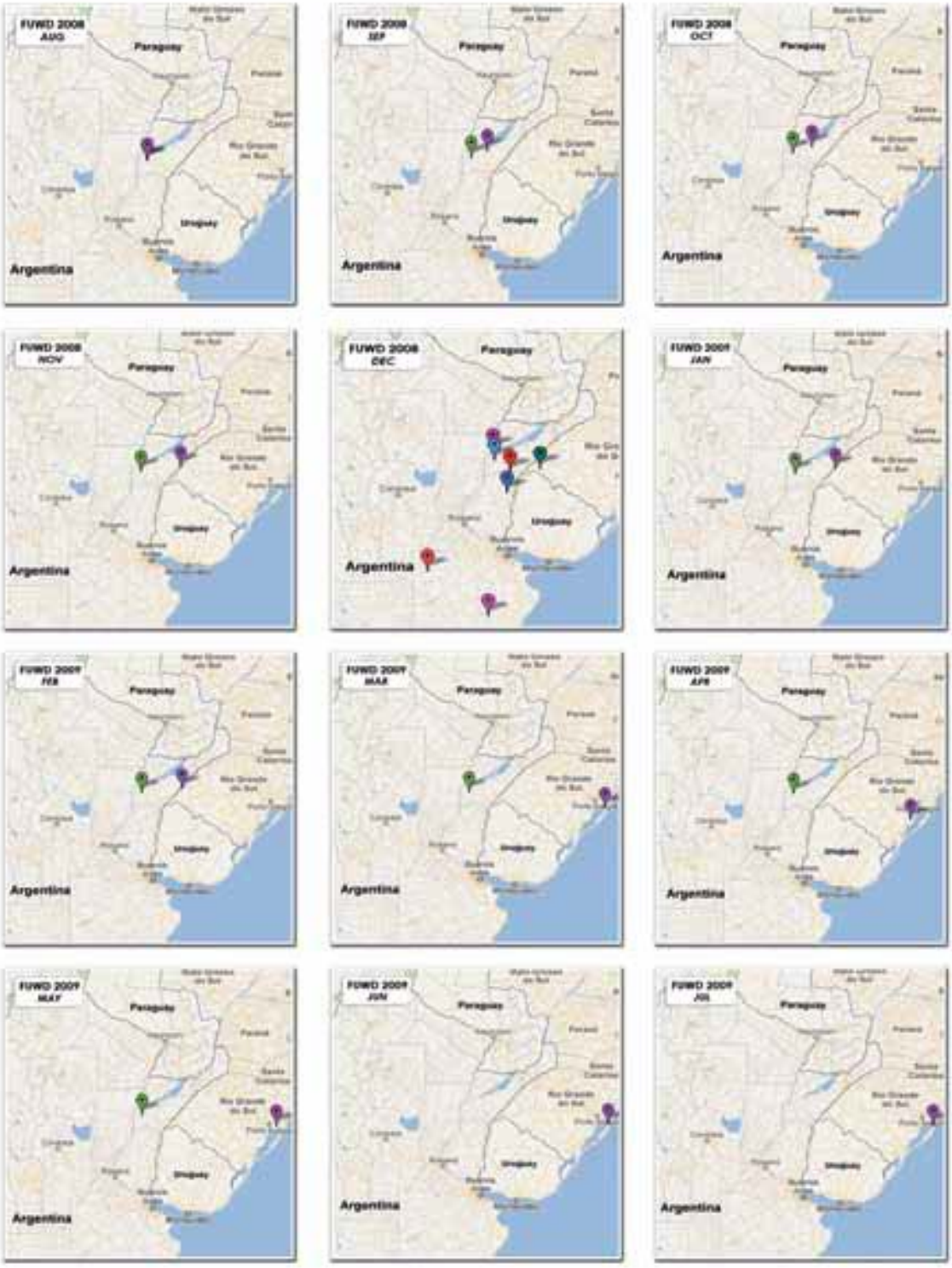


Figure 5. Seasonal frequency of FUWD locations in rice fields throughout the crop cultivation cycle (n = 1803).

PRELIMINARY CONCLUSIONS

There is a single population that moves widely across Argentina, Uruguay, Brazil and Paraguay. The FUWD is a summer visitor in the southern end of its range. Implanted ducks did not go beyond the S 340 latitude. Movements seem restricted in comparison with those of other species. Ducks tend to concentrate in the NE area of Argentina. FUWD shows preference for natural habitats, particularly small wetlands along the Middle and Lower Parana River. However, its use of rice fields is relatively high when compared with the other species studied.

Appendix 1.
Monthly maps and individual tracks of fulvous whistling ducks.



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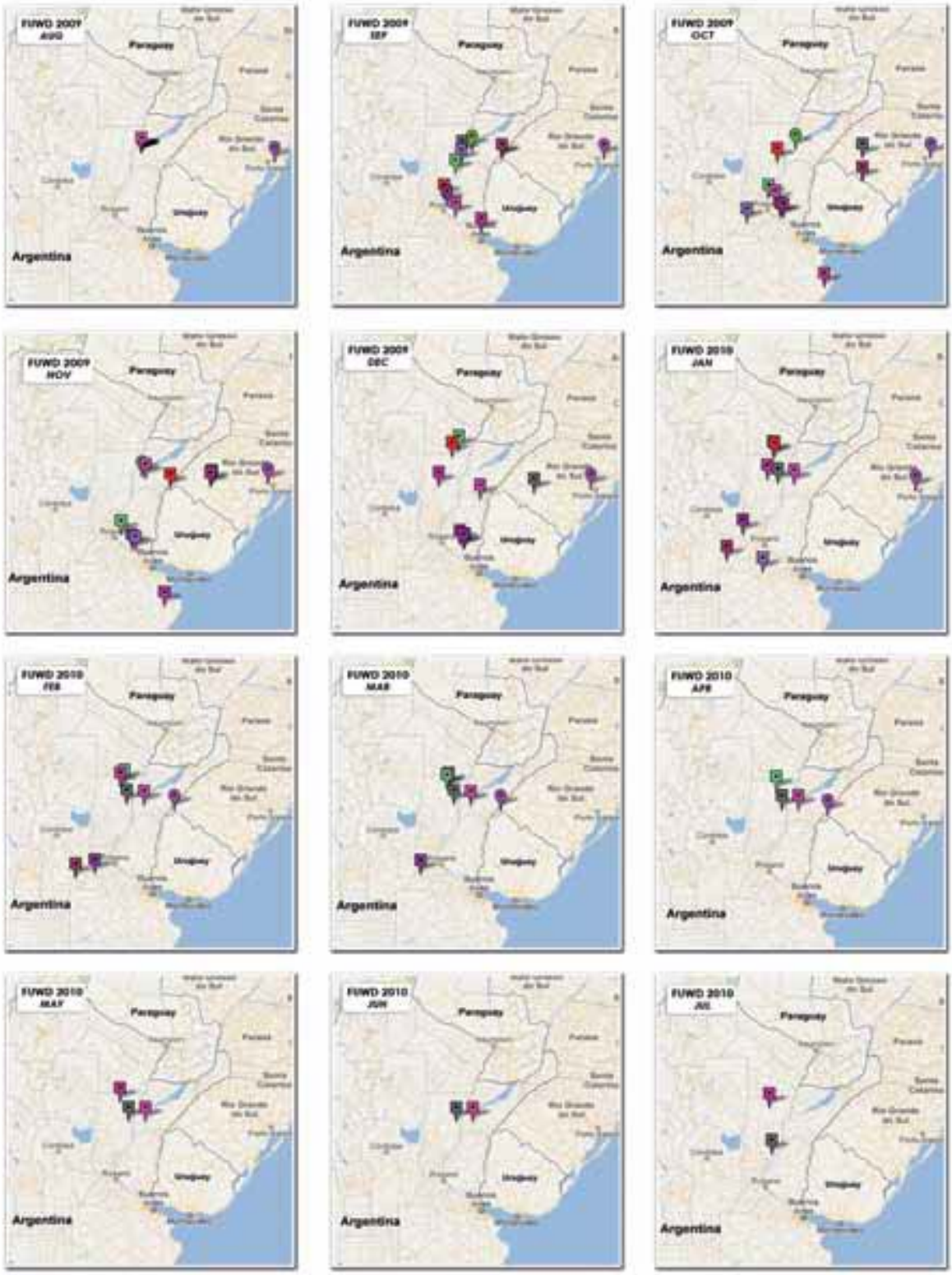

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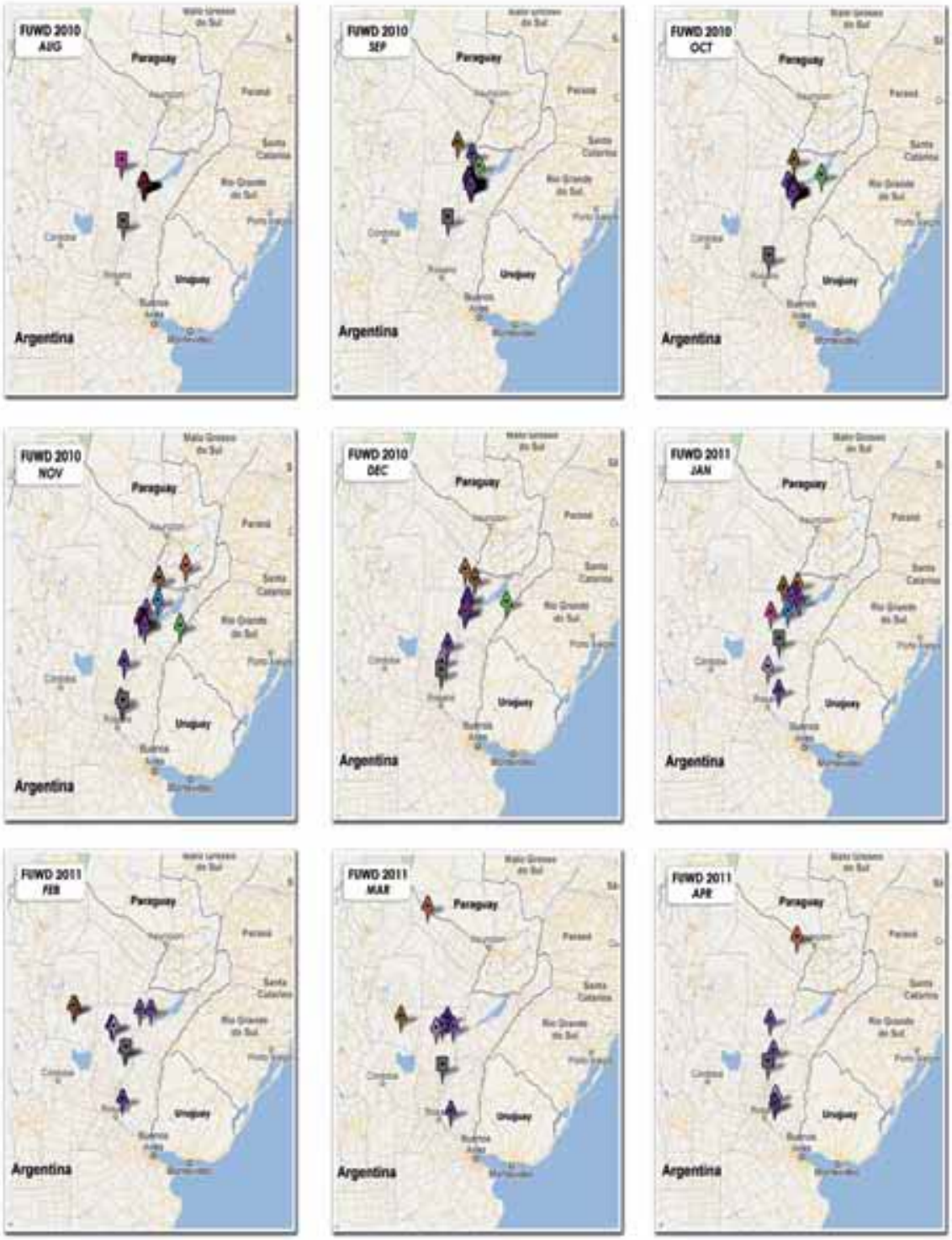
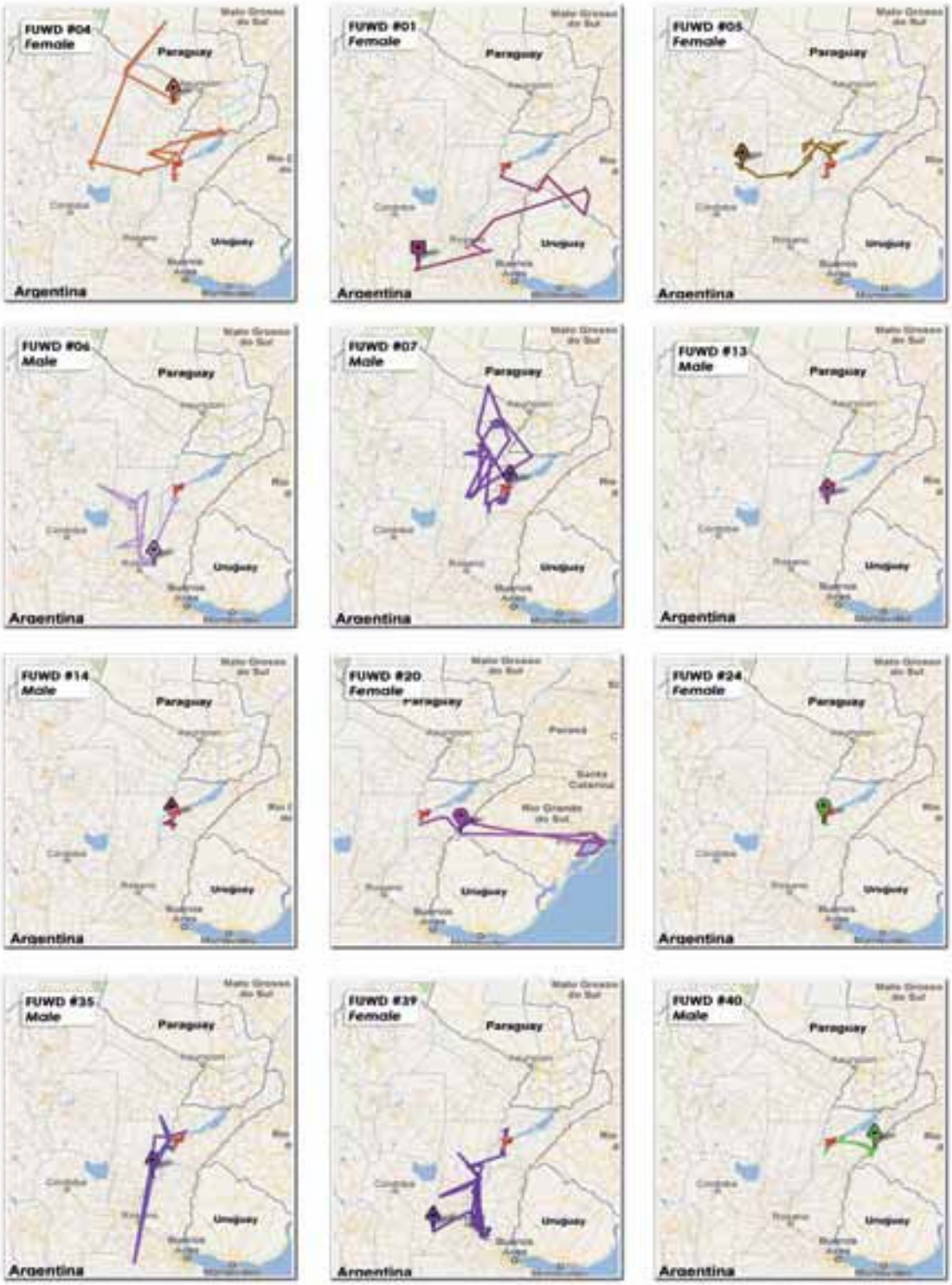


Appendix 2.
Individual tracks of implanted fulvous whistling duck.



Appendix 2 (cont.).

Appendix 3.

FUWD Duration of satellite reception, total distance flown, and daily distance flown

Code	Sex	Release date	Operation time (days)	Total distance (km)	Daily distance (km)
FWDU #04	F	9-Aug-10	357	4023	11.27
FWDU #05	F	9-Aug-10	220	1917	8.71
FWDU #20	F	20-Aug-08	608	2292	3.77
FWDU #24	F	21-Aug-08	439	137	0.31
FWDU #39	F	14-Aug-09	617	3122	5.06
FWDU #39	F	15-Aug-10	554	4434	8.00
FWDU #46	F	16-Aug-10	61	160	2.63
FWDU #47	F	16-Aug-10	7	11	1.52
FWDU #49	F	14-Aug-09	79	567	7.18
FWDU #52-09	F	15-Aug-09	169	1996	11.81
FWDU #88	F	15-Aug-09	217	1330	6.13
FWDU #90	F	15-Aug-09	358	3332	9.31
FWDU #91	F	15-Aug-09	303	2846	9.39
FWDU #99	F	9-Aug-10	117	456	3.90
FWDU #01	M	18-Aug-09	195	1950	10.00
FWDU #06	M	9-Aug-10	446	3404	7.63
FWDU #07	M	9-Aug-10	547	4892	8.94
FWDU #13	M	11-Aug-10	55	131	2.38
FWDU #14	M	11-Aug-10	92	297	3.23
FWDU #3540	M	14-Aug-10	525	2990	5.69
FWDU #40	M	14-Aug-09	242	1569	6.48
FWDU #40	M	15-Aug-10	136	838	6.16
FWDU #50	M	16-Aug-10	141	782	5.54
FWDU #51	M	14-Aug-10	534	4010	7.51
FWDU #52-10	M	14-Aug-10	195	987	5.06
FWDU #89	M	15-Aug-09	164	1505	9.18

Appendix 17.

White-faced Whistling Duck (WFWD)

Scientific name: *Dendrocygna viduata*
Common names: pato siriri (Argentina and Uruguay); marreca-piadeira (Brazil)

BACKGROUND INFORMATION
Distribution: Sub-Saharan Africa and South America. In South America occurs mainly in central and northern South America east of the Cordillera de los Andes, and from central Argentina to north-eastern Brazil, Venezuela, and Colombia. The highest abundances were recorded within the Pampas, in north-east Argentina, Paraguay, Uruguay, southern Brazil, and Venezuela.
Conservation status: Least concern: lowest risk (UICN).
Feeding: The diet is made up of plants, including seeds, complemented with invertebrates. Obtain their food by dabbling and diving.

Figure 1. Distribution range of the White-faced whistling duck

Movements

Known to migrate from central Argentina (Pampas and Chaco) to the wintering areas in Uruguay and southern Brazil, where they arrive in the autumn and leave in southward migration by the spring (Menegheti and Doto 2005).

Field Data

Extensive aerial surveys of wintering white-faced whistling ducks have been carried out in Rio Grande do Sul, Brazil, during the 1990s and 2000s. Highest counts of over 100,000 individuals were recorded, with significant variations among years (Menegheti and Dotto 2005).

RESULTS

Operational Life Span of Transmitters

In total, 34 individuals were implanted in this study. Mean duration of transmitter reception was 351 days, with a maximum of 702 days and a minimum of 11 days (Table 1).

Table 1. Duration of transmitter activity (days) in WFWD, according to sex.

WFWD	All	Females	Males
Mean	351	360	341
SD	215	201	233
Max	702	668	702
Min	11	63	11
N	34	17	17

Distance Flown

Mean daily distance flown is shown in Table 2. There were no significant differences between sexes in both parameters, although female average was considerably higher (probably due to small sample size).

Table 2. Average daily distance flown by WFWD according to sex.

WFWD	All	Females	Males
Mean	4.28	5.18	3.38
SD	3.88	4.94	2.21
Max	22.67	22.67	7.88
Min	0.13	1.69	0.13
N	34	17	17

Seasonal Variations in Mobility

WFWD dispersal showed limited changes between seasons, confirming that the species tends to stay resident performing limited movement. It is noticeable however a higher concentration in spring in Corrientes province, along the Parana and Uruguay rivers. This concentration close to the trapping site may be related with homing movements at the beginning of the breeding season.

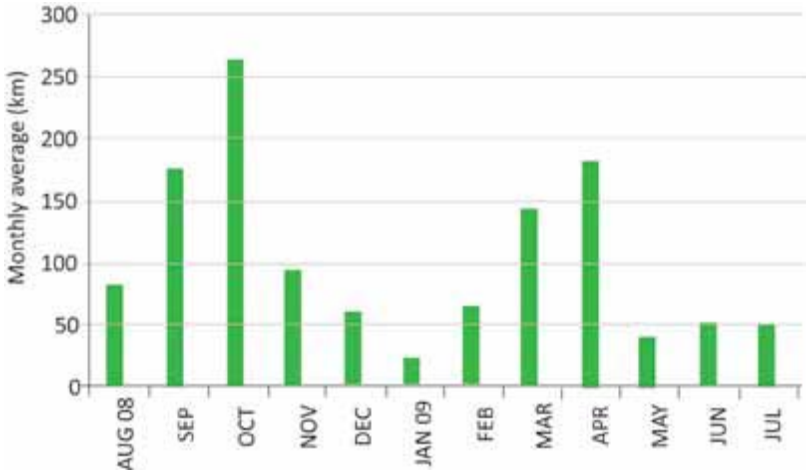


Figure 2. Average monthly distance flown by all transmitting WFWDs.

Dispersal Area

WFWD general distribution (Fig x) was included between latitudes 290^0 40' and 310^0 20' S, and 560 ^{0}20' and 610^0 20' W, being restricted mostly to Argentina, with a few positions in Western Uruguay and Central Paraguay. The greatest concentration is seen around the release point in Corrientes province, particularly along the Parana and Uruguay rivers. Another area of frequent occurrence is the Pampas ecoregion, including Buenos Aires and Santa Fe provinces (Fig 3). An interesting case was an urban location observed in Montevideo city, Uruguay, where one female remained in the area for more than a year.

Sex-related differences in dispersal range

Females showed a wider distribution than males (Figure 3), particularly along the North-South axis, and to a lesser extent- to the west (Figure 3).

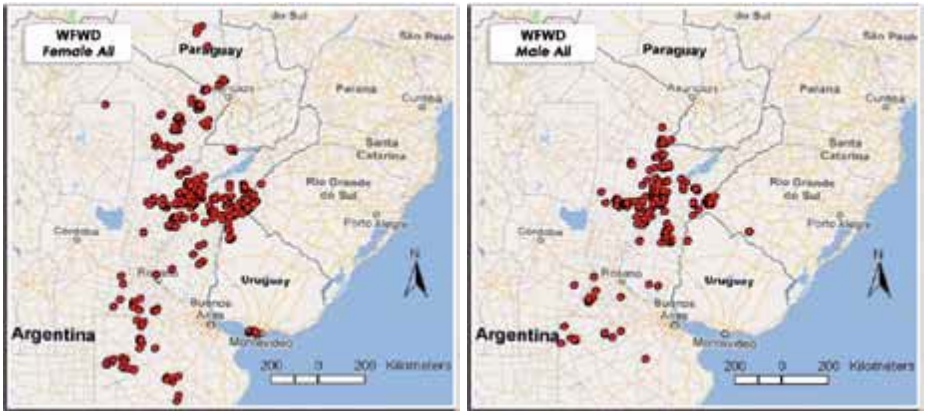


Figure 3. Locations of females and males WFWD (total).

Inter-annual Variations

Our records indicate limited variations in distribution range between years (Figure 4). The 2010-2011 period shows a wider northern dispersion along the Parana River axis, reaching central Paraguay.

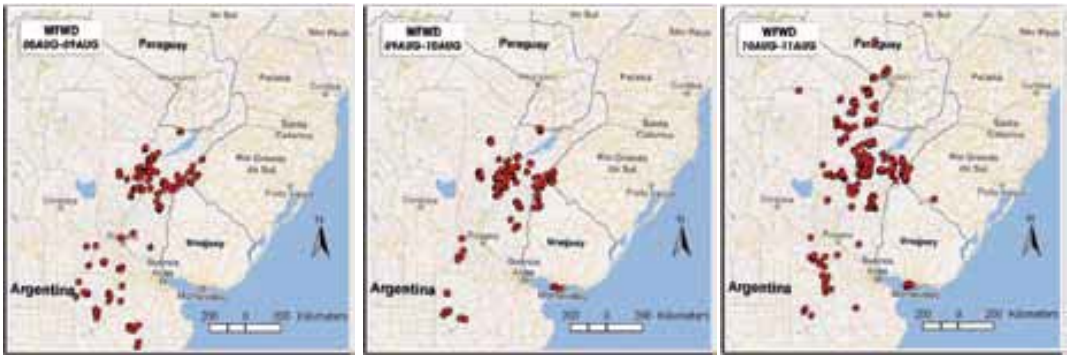


Figure 4. Inter-annual variations (2008-2011) in WFWD locations.

Seasonal Variations

WFWD dispersal showed limited changes between seasons, confirming that the species tends to stay resident performing limited movements. It is noticeable, however, that a higher concentration in spring occurred in Corrientes province, along the Parana and Uruguay rivers. This concentration close to the trapping site may be related with homing movements at the beginning of the breeding season.

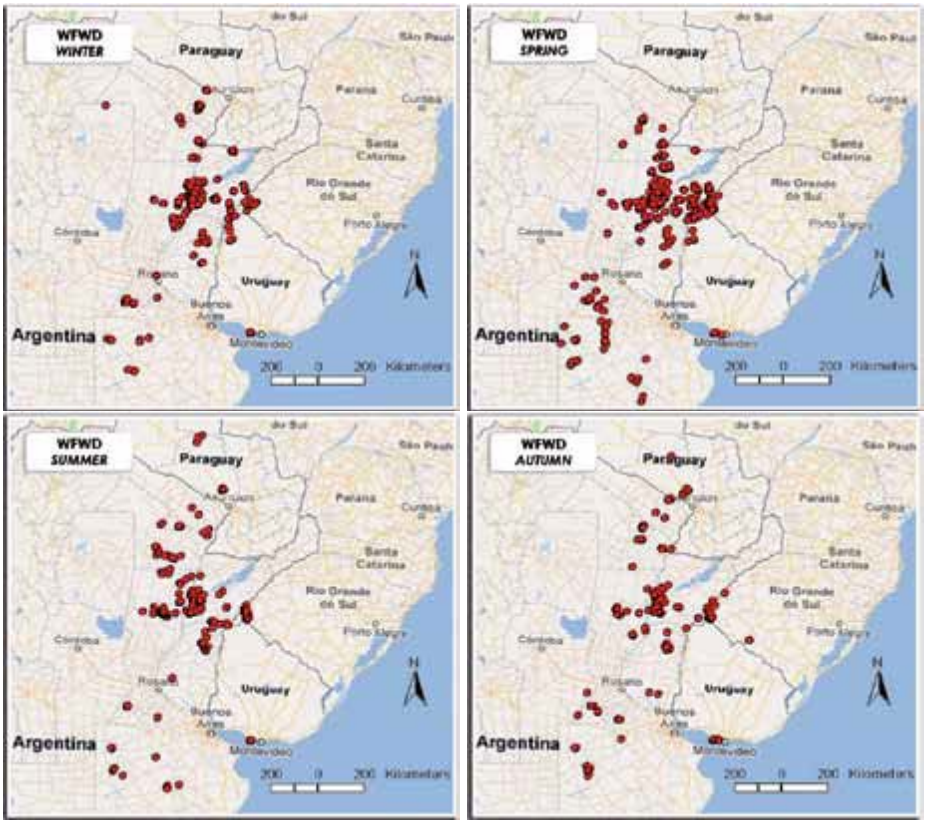


Figure 5. Seasonal variations in WFWD locations.

Habitat Use

At the regional level, most locations were in the Parana and Uruguay rivers area (74%), followed by the Pampas (7 %) and the Chaco wetlands (4%). About habitat selection, the WFWD shows great preference for cultivated areas and rice fields (29% and 13% respectively) (Table 3).

Table 3. Habitat use by the WFWD, showing proportion of total number of recorded positions (n=1285).

Habitat	Number of records	Proportion of total (%)
Small, natural wetlands	469	36
Riverine areas of rivers and streams	141	11
Dryland cultivated areas	375	29
Pampas ponds and small lakes	23	2
Rice fields	164	13
Cities	67	5
Small dams	39	3
Others	7	1

Use of Rice Fields

Given that the WFWDs showed the highest level of rice field locations of the four tracked duck species, a more detailed analysis was conducted with the objective of following the annual sequence of rice fields visits. The proportion of positions in rice fields peaked during summer (1%), when the fields are flooded. Minimum values were observed in winter, at the time when fields are being prepared for sowing (Figure 6).

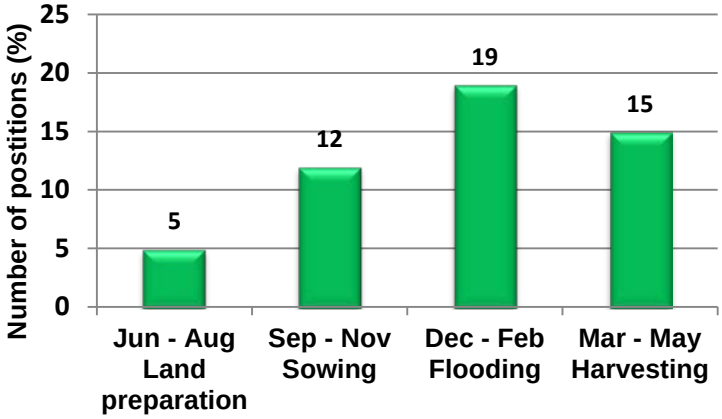


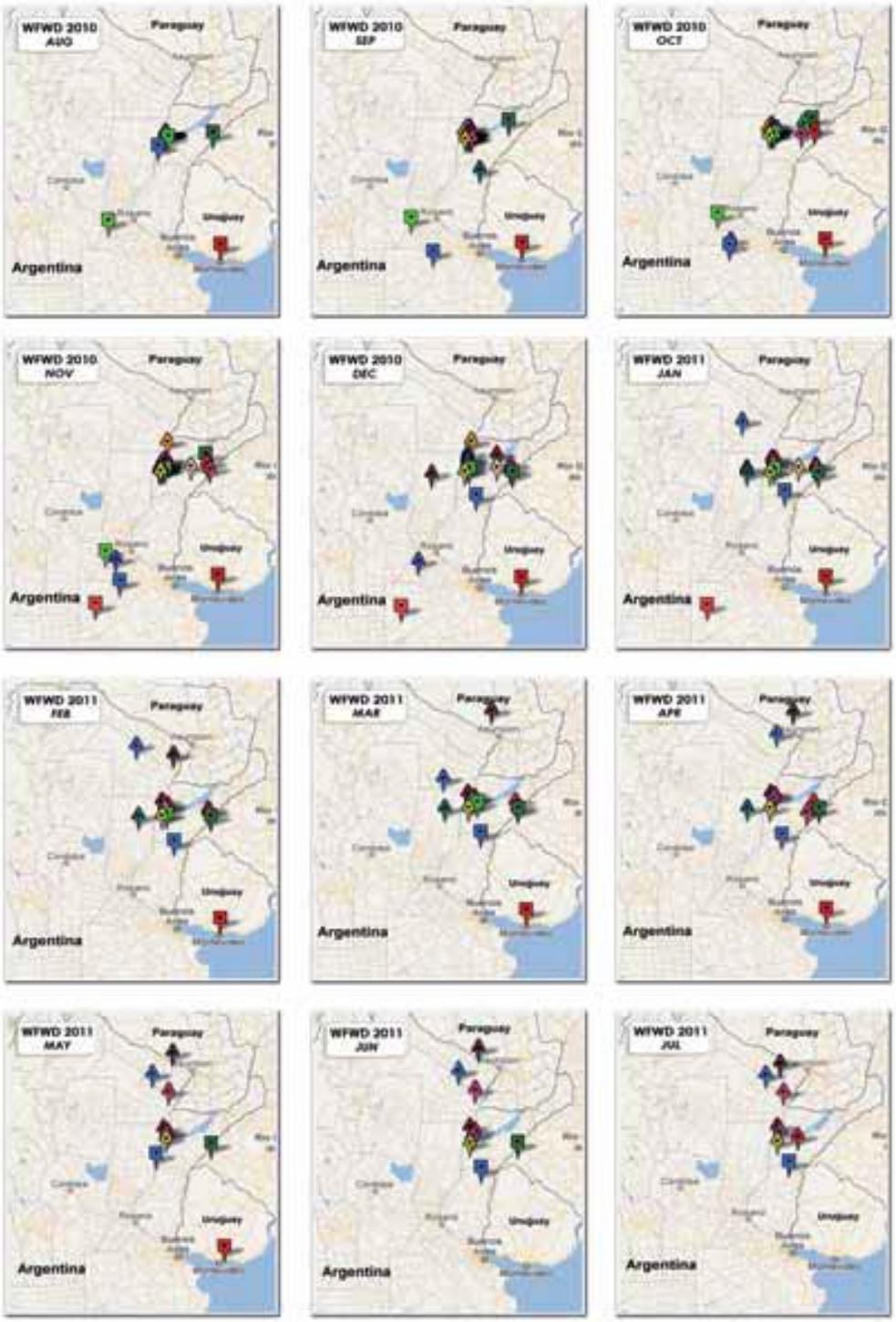
Figure 6. Seasonal frequency of WFWD locations in rice fields throughout the crop cultivation cycle (n=163).

PRELIMINARY CONCLUSIONS

Our results suggest a limited mobility of the WFWD as compared with the other studied species in this study. However, the rate of daily movements of WFWD increases significantly in spring and autumn, suggesting that a possible genetic tendency to seasonal migrations widespread in the population. The WFWD shows a significant preference for cultivated areas and rice fields in particular, well above the remaining studied species.

Appendix 1.

Monthly maps of white-faced whistling-duck



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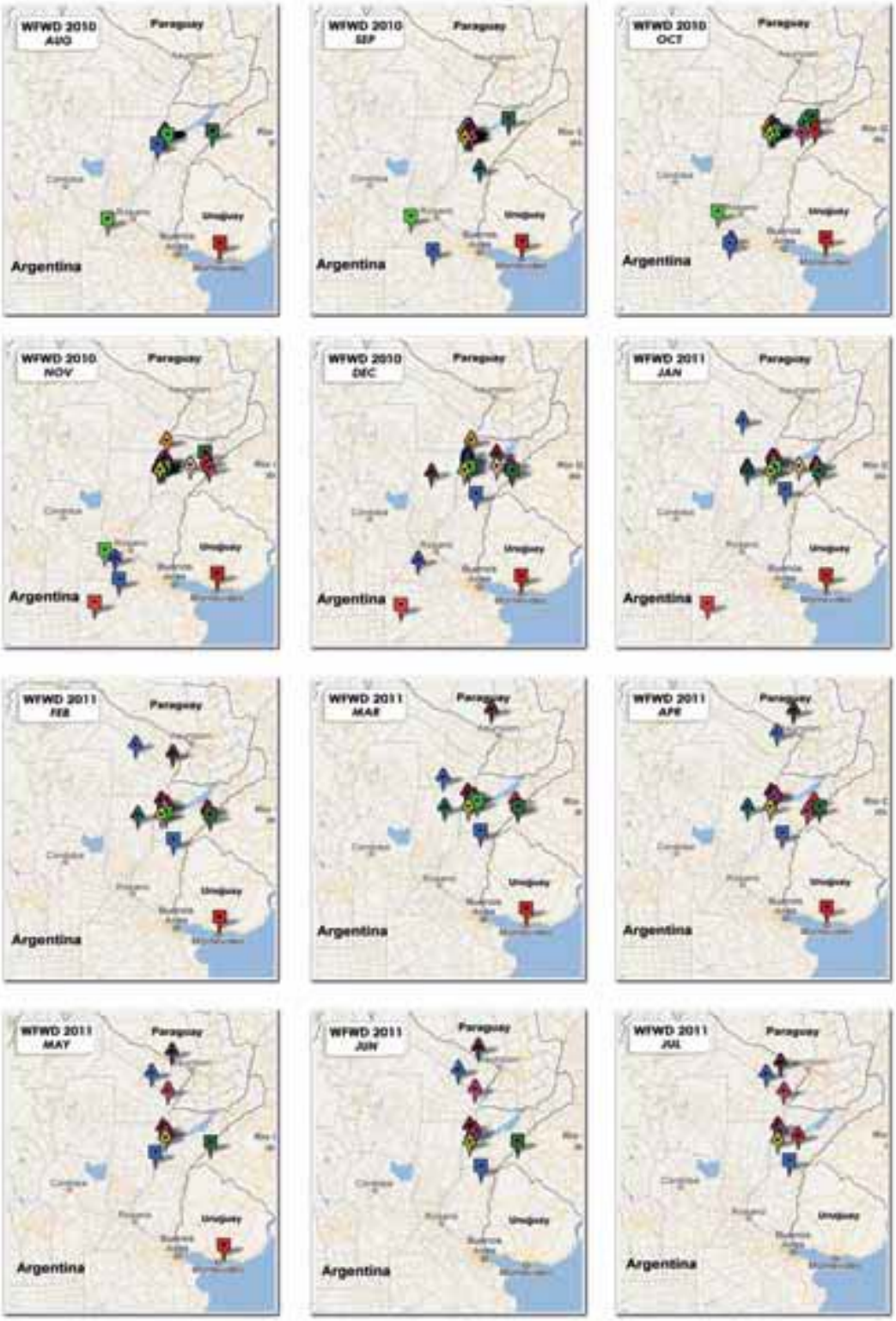

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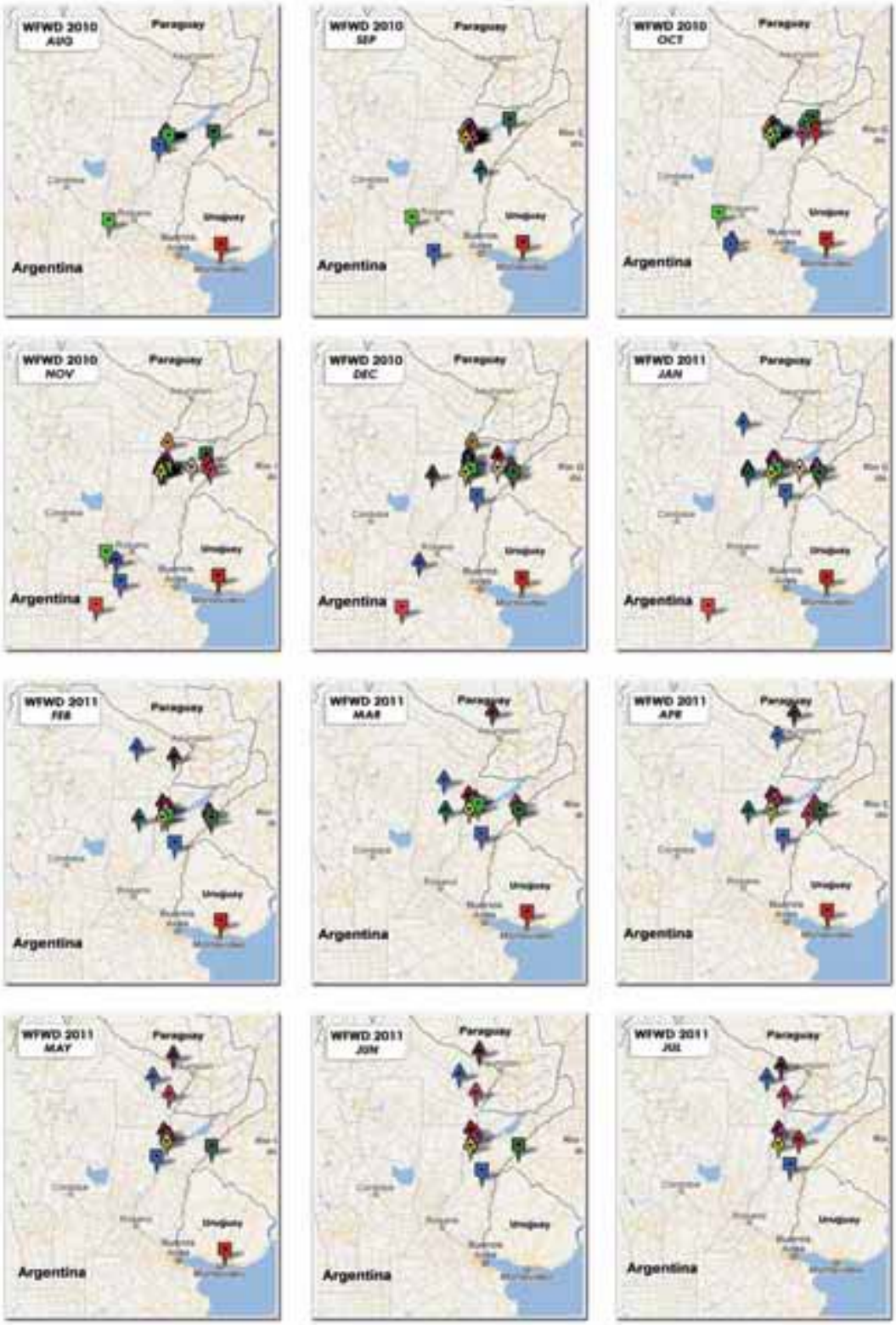
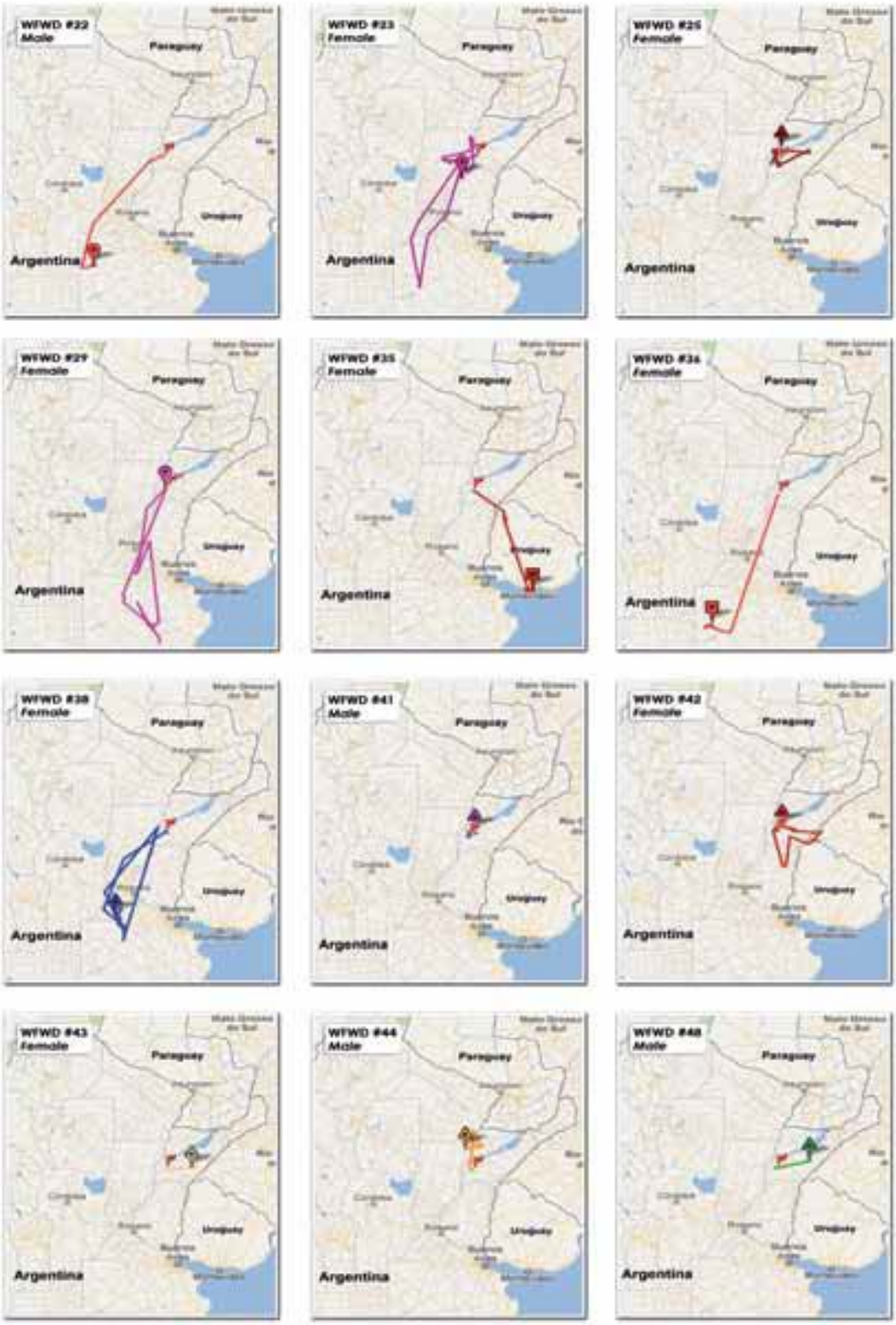


Appendix 2.

Individual tracks of implanted white-faced whistling-duck

Appendix 2 (cont.).



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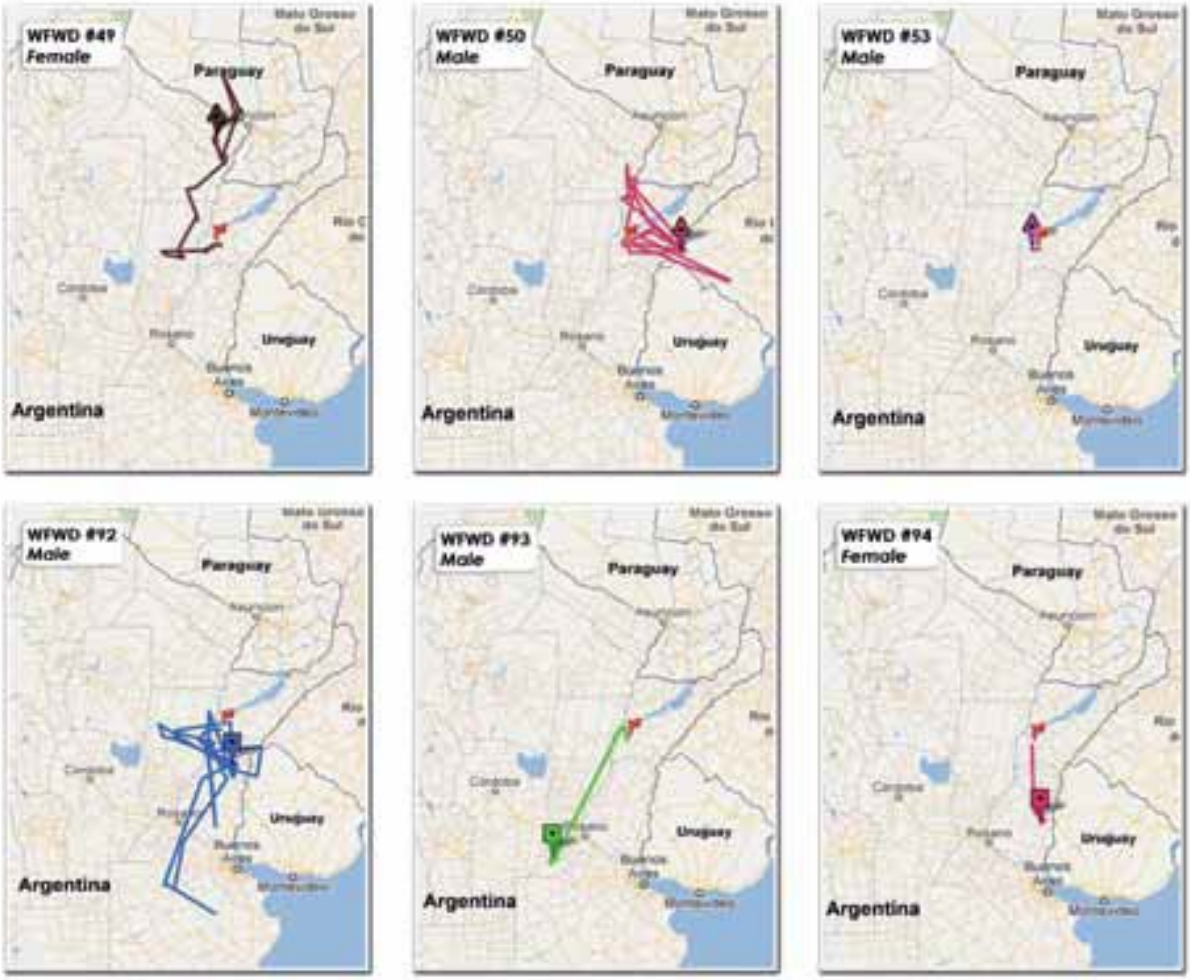


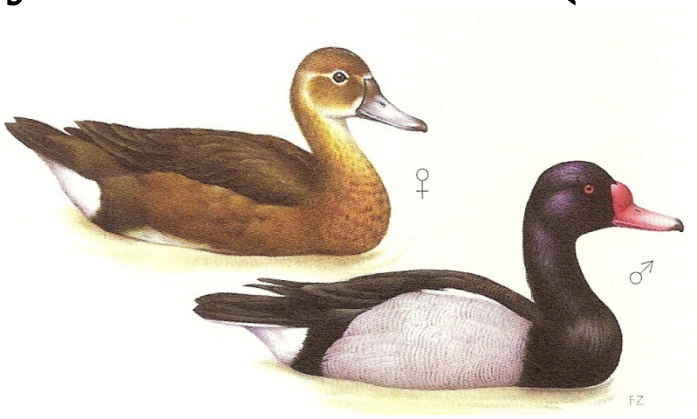
Appendix 3.

WFWD Duration of satellite reception, total distance flown, and daily distance flown

Code	Sex	Release date	Operation time (days)	Total distance (km)	Daily distance (km)
WFWD #02	M	19-Aug-09	12	62.35	5.20
WFWD #03-09	M	20-Aug-09	11	12.2	1.11
WFWD #03-10	M	15-Aug-10	558	2094.31	3.75
WFWD #04	F	20-Aug-09	668	1164.96	1.74
WFWD #05	M	21-Aug-09	569	1718.03	3.02
WFWD #06	F	21-Aug-09	196	975.84	4.98
WFWD #10	F	14-Aug-10	585	3557.71	6.08
WFWD #11	F	15-Aug-10	219	431.56	1.97
WFWD #15-08	M	20-Aug-08	471	1600.52	3.40
WFWD #15-10	M	13-Aug-10	127	53.54	0.42
WFWD #16	F	20-Aug-08	578	1953.13	3.38
WFWD #16	M	13-Aug-10	412	885.42	2.15
WFWD #17	M	20-Aug-08	241	31.44	0.13
WFWD #18	F	20-Aug-08	246	1105.68	4.49
WFWD #21	F	20-Aug-08	63	183.12	2.91
WFWD #22	M	21-Aug-08	588	1033.55	1.76
WFWD #23	F	21-Aug-08	426	2770.04	6.550
WFWD #25	F	13-Aug-10	458	1446.34	3.16
WFWD #29	F	22-Aug-08	321	2927.18	9.12
WFWD #35	F	13-Aug-09	641	1083.75	1.69
WFWD #36-09	F	13-Aug-09	518	1205.35	2.33
WFWD #36-10	M	15-Aug-10	248	1025.54	4.14
WFWD #38	F	15-Aug-10	117	2658.73	22.72
WFWD #41	M	15-Aug-10	501	1004.34	2.00
WFWD #42	F	16-Aug-10	463	2220.74	4.80
WFWD #43	F	15-Aug-10	154	313.07	2.03
WFWD #44	M	16-Aug-10	133	776.72	5.84
WFWD #48	M	16-Aug-10	76	261.15	3.44
WFWD #49	F	16-Aug-10	387	2334.63	6.03
WFWD #50	M	13-Aug-10	586	4045.04	6.90
WFWD #53	M	14-Aug-10	93	152.41	1.64
WFWD #92	M	16-Aug-09	702	5544.9	7.90
WFWD #93	M	17-Aug-09	470	1125.65	2.40
WFWD #94	F	17-Aug-09	85	367.5	4.32

Appendix 18.

Rosy-billed Pochard (RBPO)



Scientific name: *Netta peposaca*
Common names: Pato picazo (Argentina and Uruguay; Marrecao (Brazil)

BACKGROUND INFORMATION
Distribution: Endemic to South America. Argentina, central Chile, Paraguay, Uruguay, and southern Brazil. Vagrant in the Falkland (Malvinas) islands (Figure 1).

Figure 1. Distribution range of the Rosy-billed Pochard in South America

Conservation status: UICN: Least concern: lowest risk.

Feeding

The rosy-billed pochard is a diving duck that spends most of its time on water. Adults dabble, head-dip and up-end in shallow waters, similar to puddle ducks. It rarely grazes on land in the absence of water and, presumably, moves out during dry periods (Del Hoyo 1992). In Santa Fe, Argentina, its diet is based on plant material, including rice sprouts and seeds (95% and 2.7% dry weight, respectively), mostly *Polygonum* sp. and rice seeds (Rozzatti et al. 1994).

Breeding

The rosy-billed pochard nests solitary or in loose groups. Only the female incubates and attends the ducklings. Juvenile broods sometimes group together. Incubation lasts about one month (Del Hoyo 1992). Only females incubate. As other species of the tribe, it exhibits seasonal monogamy, sexual dimorphism, and molt occurs twice annually. It reaches sexual maturity at one year of age (Baldassarre and Bolen 2006).

The breeding season in South America extends from October to March. Testes condition (volume and presence of free spermatozoids in lumen) increases in October, peaks from November to March, and declines rapidly in April (Marteleur et al. 1995). Nesting in the Cabo San Antonio area (Buenos Aires province) was recorded from September to early December (Weller 1968).

Available evidence indicates that the main rosy-billed pochard breeding area is in Argentina, particularly in north-east Buenos Aires province and wetlands along the Middle and Lower Parana River valley (Capllonch et al. 2008, Nascimento et al. 2000, Weller 1968).

Molt

Spring molt was observed in museum skins. Molting adult males were recorded in September, October, and November. Female individuals appeared in August and October (Weller 1968). Body and tail molt were noted in three adults caught in July in Venado Tuerto, Santa Fe Immature males, as adults, seem to have breast molt in spring, and it is uncertain whether it corresponds to a gradual completion of the molt started in winter or if it involves another generation of feathers (Weller 1968).

Potentially important reproduction and molting areas in Argentina include: the Middle Parana River wetlands, particularly between the cities of San Javier and Santa Fe (Nascimento et al. 2000). In Brazil, there is evidence of molting areas on the coastal wetlands of Rio Grande do Sul, where several flightless molting individuals were seen during the non-breeding season (Nascimento et al. 2000). It should be taken into account, however, that in neo-tropical ducks molting may not be simultaneous and also widely dispersed instead of concentrated in a few sites (Weller 1968).

Movements

Field data

Early workers attributed movements to water conditions (Grant 1911), (Gibson 1879). In the Pampas Region close to the Atlantic Ocean (Cabo San Antonio) (Weller 1968) reported that the rosy-billed pochard left the marshes by early to mid-February, soon after the end of the breeding season. The same early departure was observed inland in the same Pampas ecoregion

near Venado Tuerto, Santa Fe province, although a few specimens remained there during the winter (Weller 1968).

Coincidently, observers in more northern areas of Argentina reported population increases of rosy-billed pochards in late February and early March, just following the period of their departure from eastern Buenos Aires. Durnford (1877) noted increases in rosy-billed pochards in winter in Baradero, approximately 50 miles northeast of the city of Buenos Aires along the Parana River.

Further north along the Parana River, in the San Javier area (Santa Fe province), rosy-billed pochards and fulvous whistling ducks were especially common before fall harvest, and local residents mentioned that some individuals nested in the rice fields. Arrival of the bulk of these species was synchronized with their departure from the deep-fresh marshes of eastern Buenos Aires (Weller 1968).

North of Santa Fe, in Santiago del Estero province, significant increases of rosy-billed pochard populations have been recorded in the seasonally flooded Bañados de Figueroa wetland along the Salado River. Olrog (1962) observed that the significant rosy-billed pochard populations increased in late February and early March, departing again in June and July. The rosy-billed pochard does not breed in this area.

A significant portion of the rosy-billed pochard population that breeds along the Parana River wetlands winters in Uruguay and Southern Brazil. Ducks arrive about April and leave in September-October, although great variations occur between years. Moreover, some individuals stay and even breed in Brazil (Nascimento et al. 2000, Menegheti and Dotto 2005).

Banding data

Two banding projects have provided significant information on the movement patterns of the rosy-billed pochard. The first was based in Argentina (Olrog 1962), and the second in Brazil (Nascimento et al. 2000). In Argentina, 173 specimens were banded in Bañados de Figueroa, Santiago del Estero province, between 1962 and 1968 (Olrog 1962, 1971). A total of 20 bands (12%) were recovered, showing that the released ducks took an east-south-east direction, with one specimen reaching southern Brazil near the Atlantic coast.

The Brazilian project banded 4,394 birds in Brazil (state of Rio Grande do Sul), plus 17 in Argentina (Santa Fe province) and 14 in Uruguay. A total of 353 bands (8%) was retrieved. Dispersal of ducks banded in Brazil was very extensive, including Brazil, Argentina, Uruguay, and Paraguay (Nascimento et al. 2000). Most of the recoveries (76 % of total) were concentrated in the southern state of Rio Grande do Sul. Recoveries in Argentina (20.2 % of total) were distributed in the following provinces: Santa Fe: 13.6 %, Chaco: 2.3%, Entre Rios: 2.3%, Buenos Aires: 0.3%, Córdoba: 0.3%, Corrientes: 0.8%, and Santiago del Estero: 0.3%. In Uruguay recoveries reached 2.83 %, and in Paraguay only one specimen was reported. Most of the recoveries (96%) were reported by hunters (Nascimento et al. 2000).

The Brazilian project showed that two very distinct ecoregions concentrated about 90% of all recoveries: in Argentina, the Middle Parana River valley wetlands, and in Brazil and Uruguay the extensive wetlands along the Atlantic Ocean coast. While recoveries in the Middle Parana area occurred in every month of the year, recoveries from the Atlantic coastal wetlands were concentrated in the April-September period. Southernmost recoveries came from Buenos Aires province in Argentina during spring and summer (November-February). The very few recoveries from west and north of the Parana River wetlands (including Santiago del Estero and Paraguay) do not suggest a clear temporal pattern (Nascimento et al. 2000).

RESULTS

Operational Life Span of Transmitters

In total, 13 individuals were implanted (Table 1). Except one individual (RPBO #19) that transmitted for only five days after release (probably due to transmitter failure), the remainder survived long enough to provide useful information. Mean duration of transmitter reception was 284 days (RPBO #19 not included), with a maximum of 557 days and a minimum of 87 days.

Table 1. Duration of satellite reception for rosy-billed pochards.

Number	Sex	Date of Implant	Date of Last Record	Total Days Transmitting
RBPO #00	F	24-Aug-08	12-Feb-10	537
RBPO #19	F	20-Aug-08	26-Aug-08	6
RBPO #25	M	23-Aug-08	13-Nov-09	447
RBPO #30	F	22-Aug-08	2-Mar-10	557
RBPO #31	M	24-Aug-08	12-May-09	261
RBPO #32	M	26-Aug-08	15-Aug-09	354
RBPO #33	M	26-Aug-08	16-Jul-09	324
RBPO #34	F	26-Aug-08	8-Feb-09	166
RBPO #37	M	13-Aug-09	1-Jan-10	141
RBPO #38	F	14-Aug-09	14-Dec-09	122
RBPO #50	F	14-Aug-09	30-Jan-10	169
RBPO #51	F	15-Aug-09	10-Nov-09	87
RBPO #95	F	17-Aug-09	6-Aug-10	354
RBPO #96	M	17-Aug-09	20-Sep-10	399
RBPO #97	M	17-Aug-09	24-Apr-10	250
RBPO #98	M	18-Aug-09	21-Nov-09	95

Distance Flown

Total and mean daily distance flown by rosy-billed pochards individuals are shown in Table 2. Total distance ranged between a minimum of 26 km and a maximum of 6347 km. Corrected by period length, the daily rate of movement ranged between 0.27 km/day and 11.39 km/day. Females tended to fly longer distances than males. Females averaged 8.57 km/day, whereas males averaged 3.65 km/day (difference is significant at $p<0.05$ level).

Table 2. Total and daily distance flown by each rosy-billed pochard during the transmission period[1].

Code	Sex	Release date	Transmission Time (days)	Total Flown (km)	Daily average (km)
25	M	23-Aug-08	447	527	1.18
30	F	24-Aug-08	557	6347	11.39
31	M	24-Aug-08	261	95	0.36
32	M	26-Aug-08	354	674	1.90
33	M	26-Aug-08	324	2565	7.92
34	F	26-Aug-08	166	1957	11.79
37	M	13-Aug-09	141	1050	7.45
38	F	14-Aug-09	122	713	5.84
50	F	14-Aug-09	169	1727	10.22
51	F	15-Aug-09	87	775	8.91
95	F	17-Aug-09	354	2756	7.79
96	M	17-Aug-09	399	2184	5.47
97	M	17-Aug-09	250	1151	4.60
00	F	18-Aug-09	537	2192	4.08
98	M	18-Aug-09	95	26	0.27

[1]Only individuals with at least 60 days of transmission

Dispersal Area

Localization of the totality of position points is shown in Figure 1. Implanted ducks dispersed throughout Argentina, Uruguay, Paraguay, and Brazil. In Argentina, ducks were recorded in the following provinces: Corrientes (where the release site is located), Chaco, Santiago del Estero, Santa Fe, Entre Rios, and Buenos Aires. In Uruguay, nine locations were recorded, dispersed throughout the country. In Brazil, seven records were obtained in the southern state of Rio Grande do Sul, concentrated along the Atlantic Ocean coastal wetlands.

Only four positions were recorded in Paraguay, located in the central Chaco dry woodland close to the border with Argentina. The total area covered by the rosy-billed pochard movements was 1,100,000 square kilometers. Within the dispersal range, Fig 1 clearly shows that the rosy-billed pochard records are concentrated mostly along the Parana River Valley, confirming previous reports in the literature (see background section).

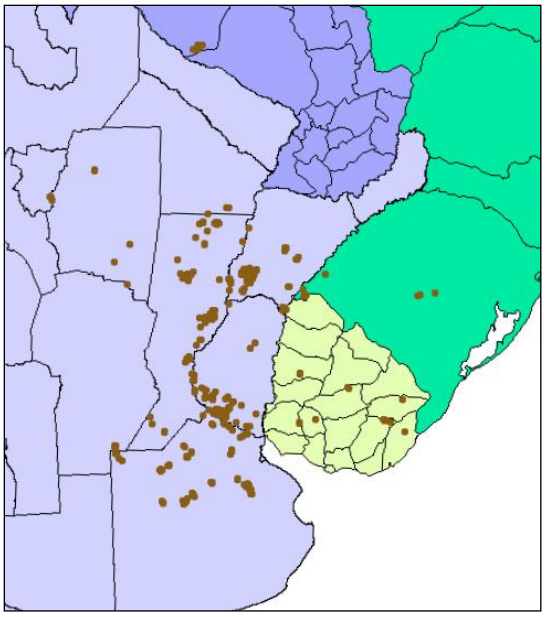
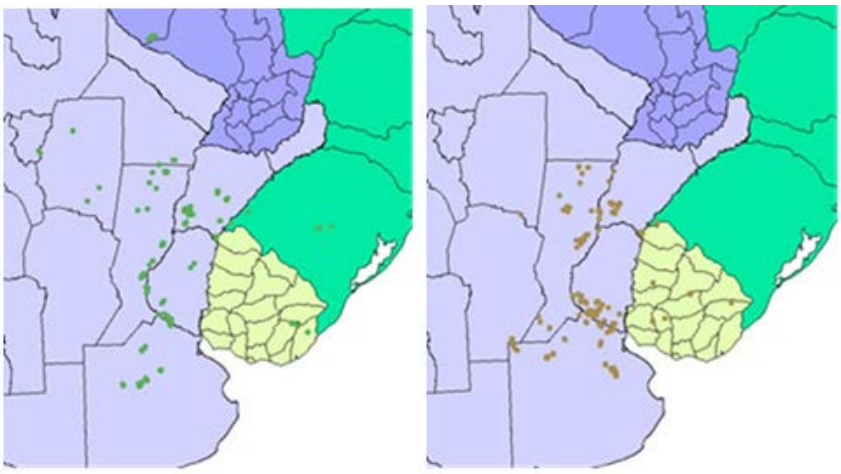


Figure 2. Distribution of all recorded RBPO locations in the study area.

Interannual Variations

Comparison of locations between years (implanted ducks were released in August 2008 and August 2009) shows interesting variations (Fig 3). During the 2008-09 period ducks dispersed in a wide area (1,050,000 km2), expanding to the west and north of the core area in Argentina and as far as Paraguay (Figure 3). This wide expansion may be related to the exceptional dryness of this period that forced ducks to disperse in search of new water bodies. Contrarily, in the wetter 2009-10 period dispersal was more restricted (501,000 km2), with more points along the core area in eastern Argentina and Uruguay. Again, this greater concentration of locations probably relates to the recovery of wetlands of the core area.



2008-2009 **2009-2010**

Figure 3. Distribution of rosy-billed pochard locations in two consecutive annual periods.

Our results indicate that rosy-billed pochard females tend to disperse in a wider area than males. This difference was particularly strong in the dry 2008-2009 period, when several females were recorded in the periphery of the species distribution area, particularly in the western and southern borders (Fig 4).

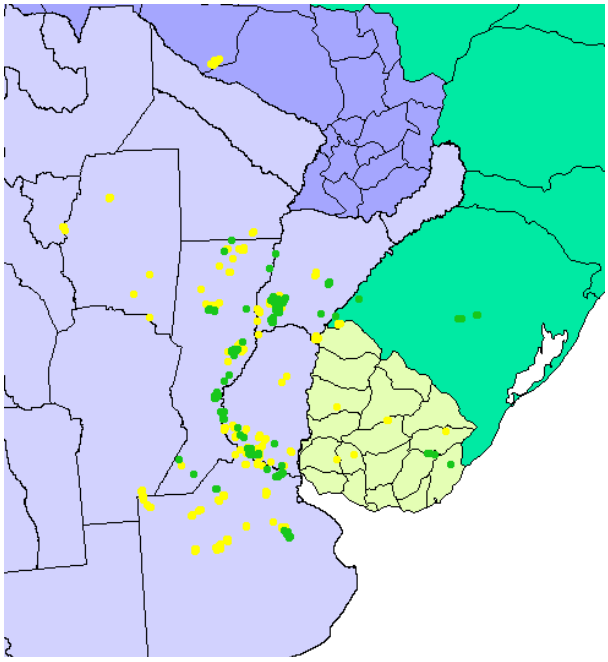


Figure 4. Total locations of females (yellow dots) and males (green dots) RBPOs throughout the study period.

Seasonal Movements

Seasonal location maps (Figure 5), monthly maps (Appendix 1), and sequential individual maps (Appendix 2) show that ducks disperse in a wide area throughout the seasons, without indication of well-defined migrations. However, seasonal differences in locations suggest some weak patterns. In spring and summer (mostly from September to January), there was a general tendency for the implanted RBPOs to move south. A significant part of the tracked ducks concentrated along the Middle and Lower Parana River valley, while others moved further south into northern Buenos Aires province. In late summer and autumn (January-April), these individuals started to fly back north, returning to the Middle Parana area and further north up to northern Argentina (Santiago del Estero, Chaco) and even Paraguay. During winter and early spring, another small group of individuals moved east from the Middle Parana area into Uruguay and southern Brazil. Other individuals, however, remained in the same area throughout the year.

Present evidence suggests that water availability is the main driving force behind the observed movements. According to Weller (REF), who visited Argentina in the 1960s, climate north of the 35 S latitude is less limiting, and therefore waterfowl can breed at most times of year. Then, water availability becomes the limiting factor. The same conclusion was reached the highly erratic movements of Australian ducks (Roshier et al. 2002).

Early workers such (Gibson 1879) and (Grant 1911) noted movements of rosy-billed pochards and fulvous whistling ducks, which they attributed to water conditions. Barrows

(1884) noted increases in rosy-billed pochards with wet periods along the Uruguay River. Frequent and substantial variations in the number of rosy-billed pochards at the wintering grounds in Brazil have also been attributed to water availability in wetlands of either Argentina or Brazil (Weller 1968, Nascimento et al. 2000, Menegheti and Dotto 2005).

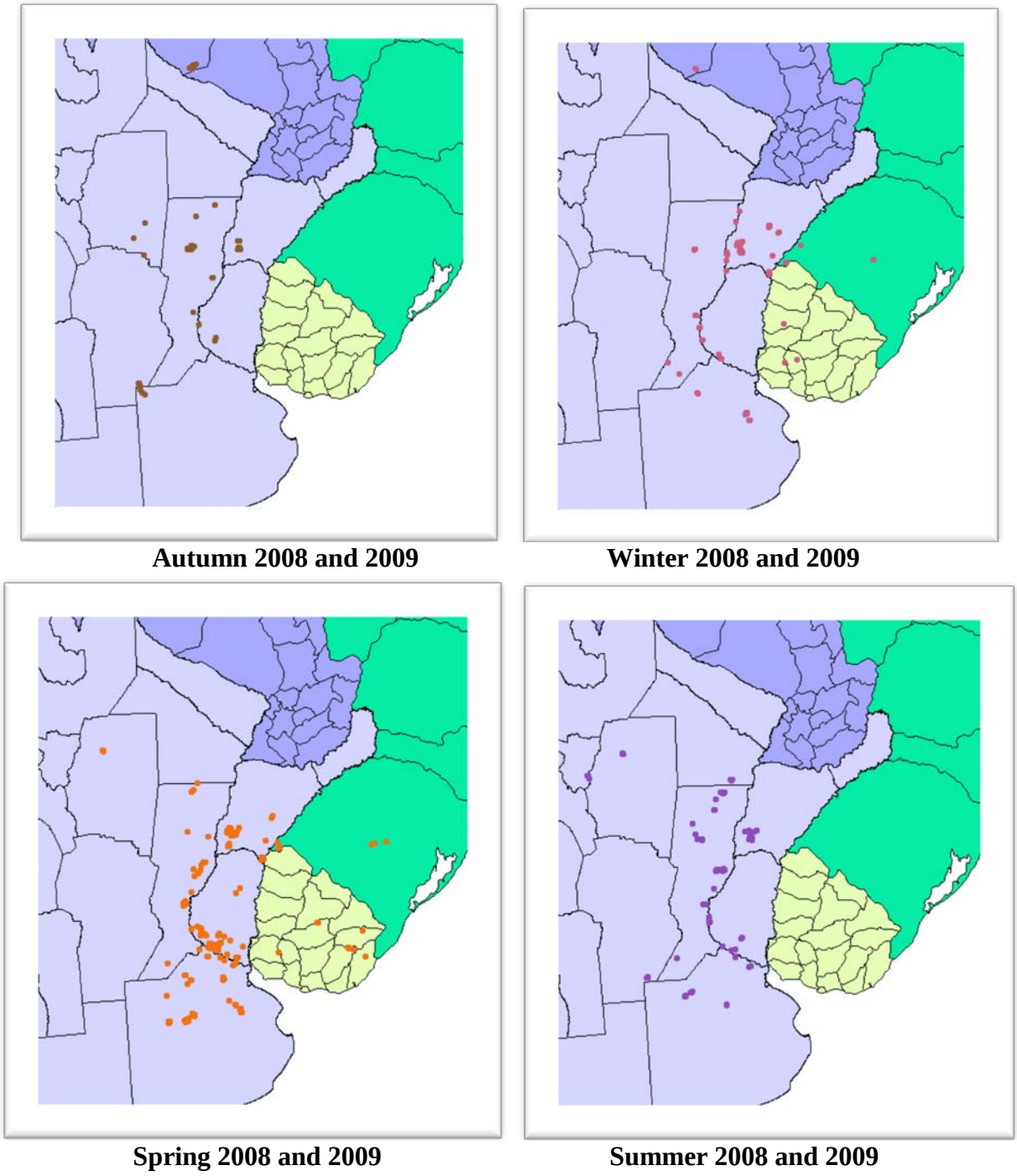


Figure 5. Seasonal variations in distribution of satellite locations of rosy-billed pochards.

Seasonal Variations in Mobility

Initial analysis of the collected tracking information suggests a greater mobility by ducks in spring and summer than in the autumn and winter, although our small sample size (16 ducks) does not allow conclusions. When long flights are considered (over 100 km), the mean monthly total peaks in spring (September- December) and then decreases, reaching a minimum in winter (July – August). Females tend to fly longer distances than males (Figs 6 and 7).

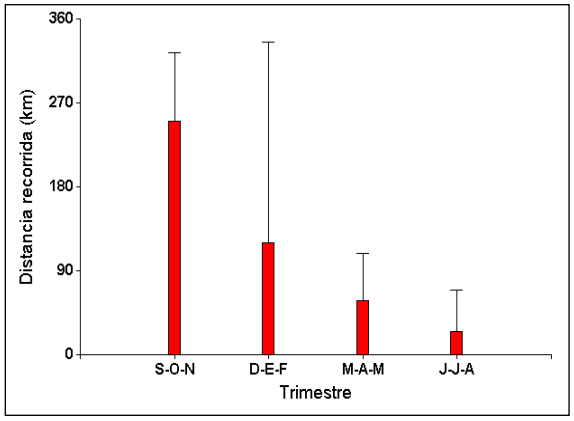


Figure 6. Mean and 95% confidence limits of long distance flights (over 100 km) flown per trimester by RBPO.

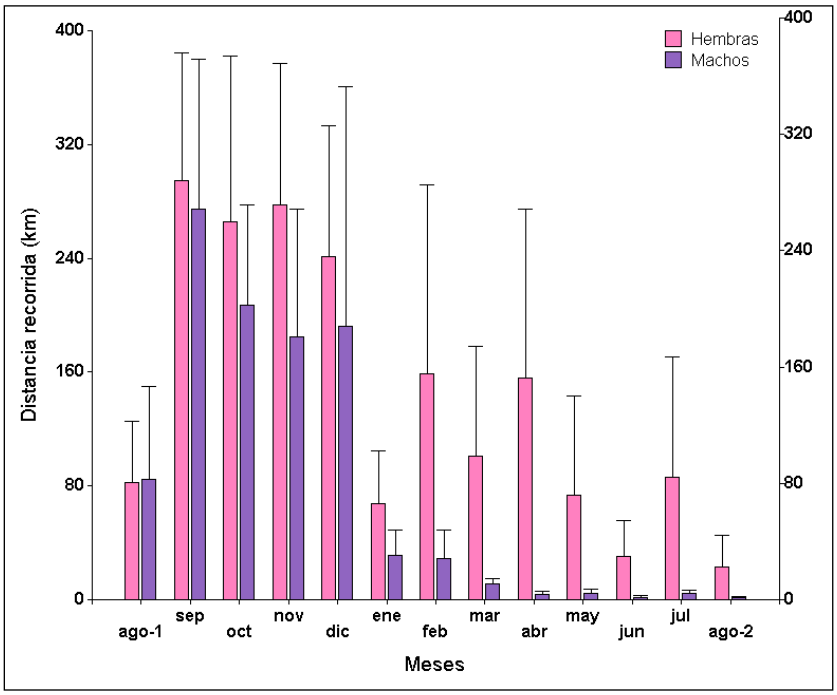


Figure 7. Mean and standard error of monthly flight distance (long flights over 100 km) of RBPO according to sex.

Habitat Use

Rosy-billed pochard habitat use is summarized in Table 3. Most locations (72%) correspond to a) small natural wetlands and b) riverine wetlands. Dry land cultivated areas are also frequently used.

Table 3. Habitat use by the rosy-billed pochard. Proportion of total number of recorded positions (n=730).

Habitat	Number of records	Proportion of total (%)
Small, natural wetlands	267	37
Riverine areas of rivers and streams	254	35
Dryland cultivated areas	110	15
Pampas ponds and small lakes	35	5
Rice fields	28	4
Extensive wetlands	18	2
Small dams	10	1
Large dams	8	1

In rice fields, the number of rosy-billed pochard locations was relatively low compared with the white-faced whistling duck (Figure 8). The peak period was spring (September-November), at the time when the rice fields are sown. There were no records in autumn, when the fields are dry after harvest, which would be expected for a diving duck.

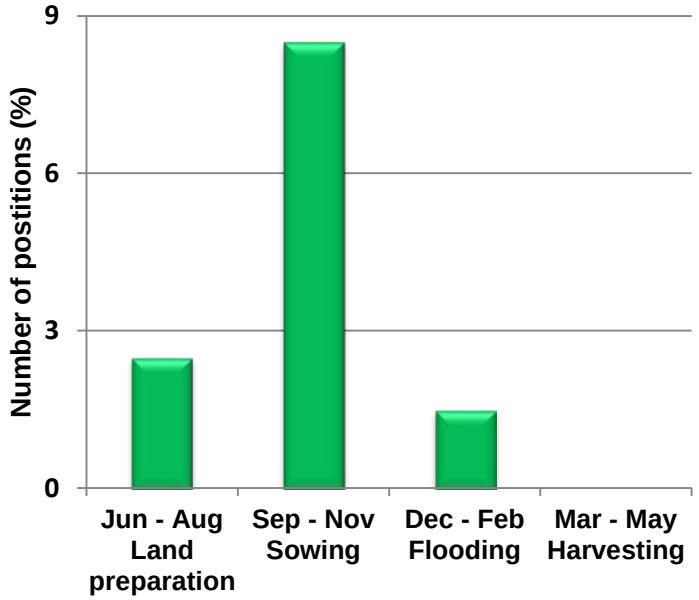


Figure 8. Seasonal frequency of rosy-billed pochard locations in rice fields throughout the crop cultivation cycle (n=730).

PRELIMINARY CONCLUSIONS

An initial analysis of the rosy-billed pochard satellite tracking clearly suggests that the rosy-billed pochard does not follow a unique, regular migratory pathway, as commonly observed in ducks in the northern hemisphere. Instead, there is a general tendency to perform seasonal

movements within a considerable degree of nomadism and independence among individuals. This opportunistic and irregular pattern, also found in Australia, reveals an entirely unknown aspect of duck ecology in the Southern Hemisphere.

Our research also confirms the existence of a single rosy-billed pochard population that moves widely in Argentina, Uruguay, Brazil, and Paraguay, contrary to previous migration models based on banding data that postulated the coexistence of isolated populations moving along different routes (Nascimento et al. 2000, Olrog 1962).

Concerning habitat use, rosy-billed pochards show preference for natural habitats, particularly small wetlands along the Middle and Lower Parana River. Its use of rice fields is relatively low when compared with other duck species. A very interesting behavior of the rosy-billed pochard is the greater mobility of females as compared with males. This is a new discovery, impossible to detect before the satellite telemetry era.

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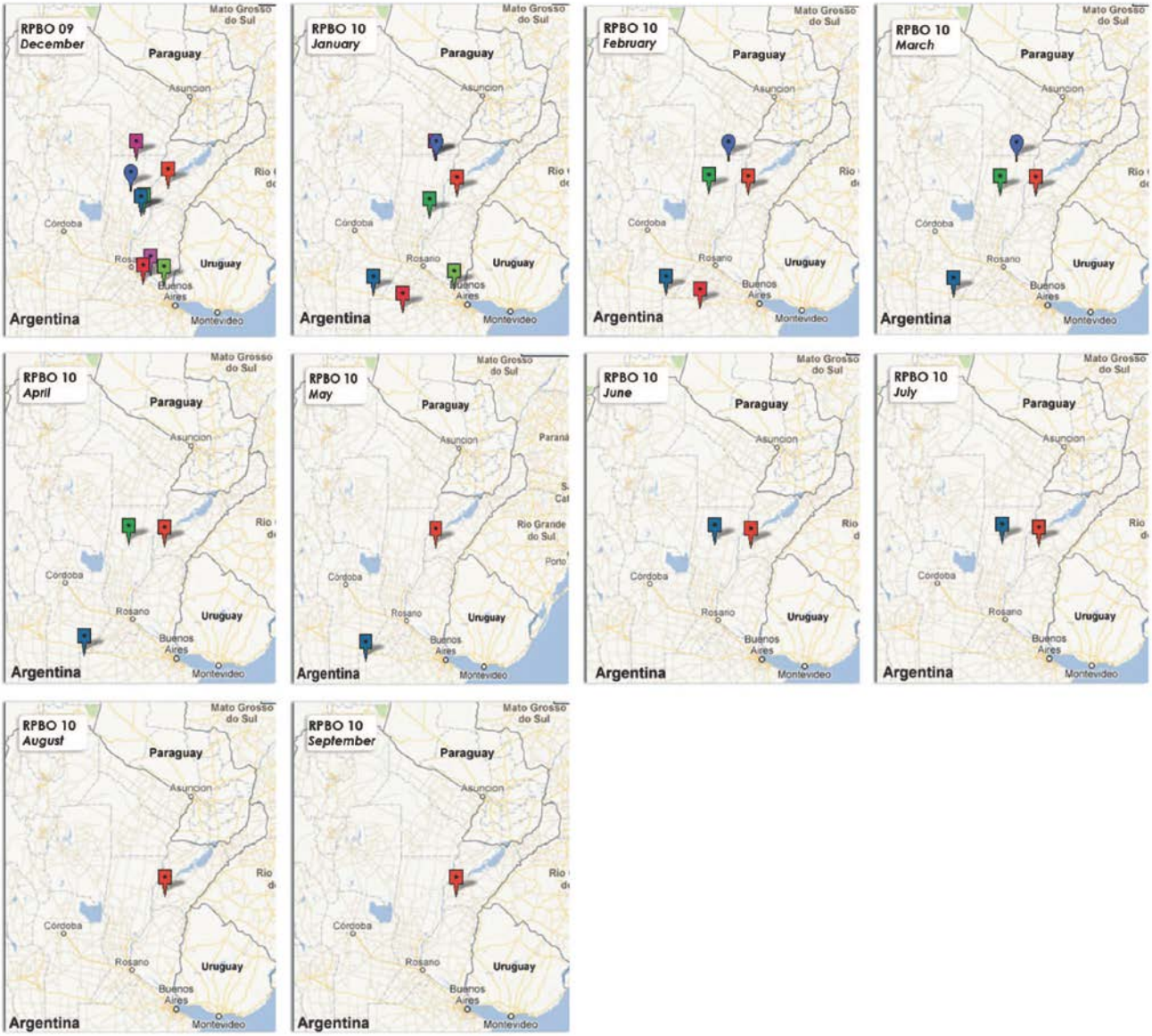
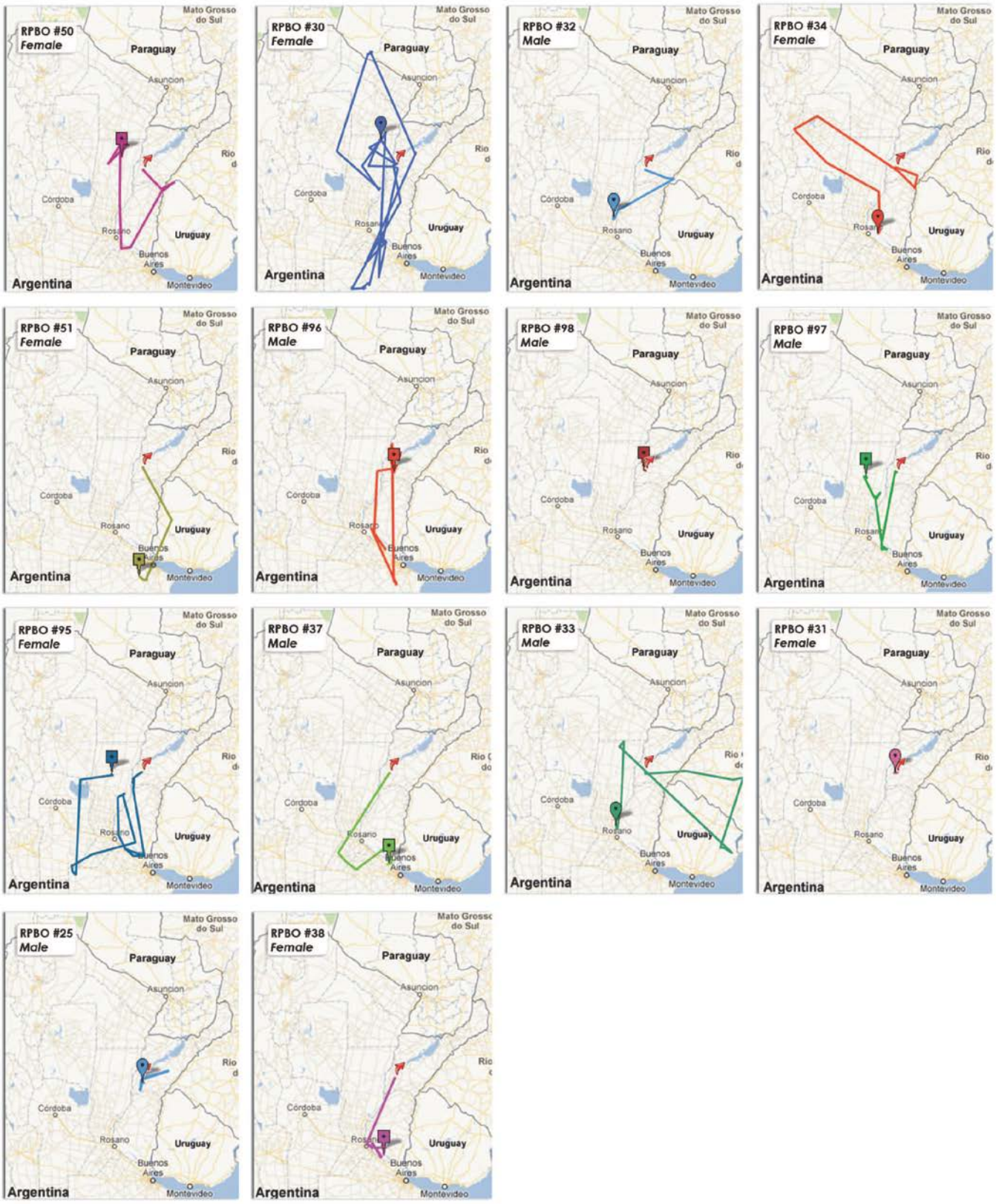
Appendix 1. Monthly maps with the location of transmitting Rosy-billed Whistling ducks

Appendix 1 Monthly Maps (continued).



Appendix 2. Individual tracks of Rosy-billed Pochards along the transmission period.



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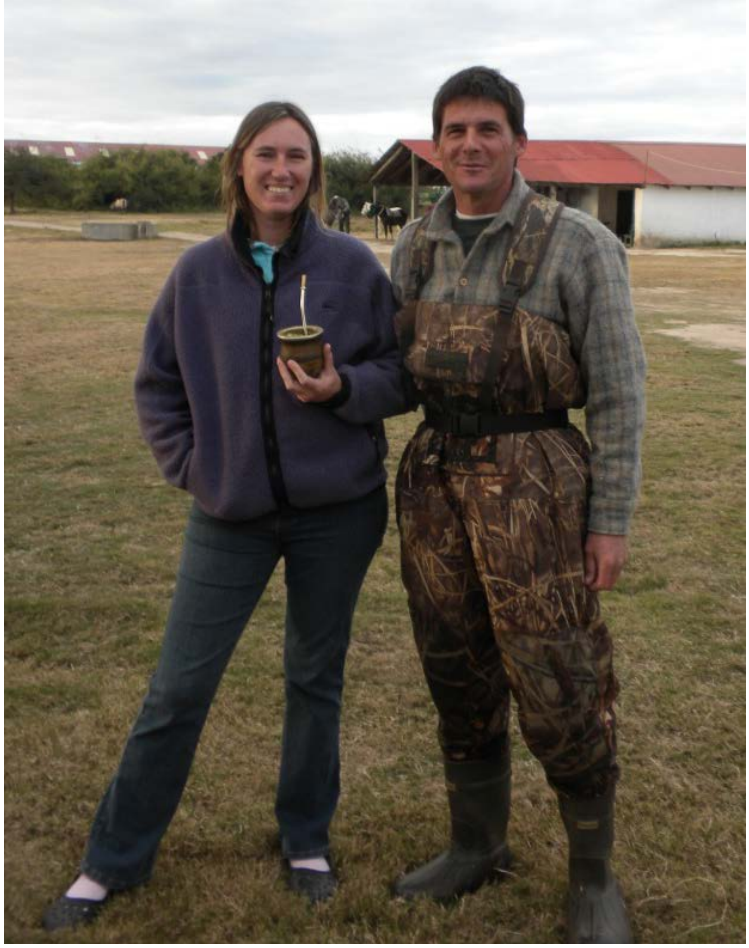

Paula Denies and Marcelo Prodel

Pedro with Ringed Teal Pair