Uso de arroceras por chorlos y playeros migratorios en el sur de América del Sur

Implicancias de conservación y manejo

Use of rice fields by migratory shorebirds in southern South America

Implications for conservation and management

Daniel E. Blanco, Bernabé López-Lanús, Rafael Antunes Dias, Adrián Azpiroz y Francisco Rilla

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Prologue

Wetlands International's technical report on the use of rice fields by shorebirds is an important contribution towards making management plans for rice fields and projects on the conservation and sustainable use of birds in productive wetlands.

Firstly, the report offers a vast revision of previous observations and studies of birds in rice fields in various countries in Latin America. This task has certainly been a great challenge in itself, given that those of us who have previously worked on these issues left a lot of information unpublished or in technical reports that have not been published in the scientific literature. To have compiled this is without doubt a great contribution.

Secondly, surveys of birds in agroecosystems are indispensable tools for the organization of agricultural management and conservation actions for the species. Rice fields are wetlands that are rich in resources that are used by a large number of different resident species and they are obligatory staging areas for migratory species, providing secure feeding grounds even in periods of drought. However, as has been clearly stated in this study, the management of rice pests involves the use of a wide variety of agrochemicals that put the survival of many species at risk. This aspect has not been investigated thoroughly in spite of the evidence. In this respect birds offer an excellent opportunity for carrying out ecotoxicological evaluations since they are particularly sensitive to the various resources that different species use and this characteristic makes them excellent indicators of environmental problems.

The development of an annual plan, systematically monitoring some species, would provide important information for making timely decisions and avoiding population decline that occurs in some species due to causes associated with agricultural management in productive wetlands, as hinted at in this report. This study provides basic information which might serve to refine the methodology for making estimations of abundance / density with known precision which would allow comparison between years so that tendencies could be analyzed. The advantages would be even more valuable for conservation at the continental scale if these efforts could be carried out regularly and on the macroregional scale undertaken in this study.

Finally, it is essential to accept the existence of alternative uses of rice fields, such as hunting or even ecotourism, in the agricultural sector, as long as there is a clear understanding by the producers of the advantages that this would have for the sustainability of their own agricultural enterprises. The next stage of this project noted at the end of the report will inevitably be accomplished, with technical improvements and the efficiency and perseverance of the working group. Viable association with other stakeholders would help to give continuity to this issue and its related activities. This is certainly a great challenge, but I have no doubt that it can be attained.

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Foreword and Acknowledgements

Numerous studies document the role of rice fields as a foraging habitat for waterbirds, and in particular for migratory shorebirds in the Northern Hemisphere. Rice fields function as artificial wetlands, providing feeding habitat for numerous species, at least during part of the lifecycle of the crop, but at the same time they may result as a serious threat due to the use of agrochemicals associated with rice production. The aim of the present project was to assess the use of rice fields by migratory shorebirds in southern South America, contributing valuable unpublished information for their conservation.

This publication is mainly for decision makers and technicians who work in biodiversity conservation in South American agroecosystems. It comprises a revision of current knowledge on the use of rice fields by waterbirds, and also the results of the project, including data on shorebird abundance in rice fields in Argentina, Brazil, and Uruguay, as well as an analysis of use in function of the crop's cycle. Our results are compared with those of other authors and a series of recommendations are presented.

This project and the present publication were made possible thanks to the financial support of the Neotropical Migratory Bird Conservation Act (Division of Bird Habitat Conservation, U.S. Fish & Wildlife Service / USF&WS).

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Daniel Blanco

South American Programme Leader
Wetlands International

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Executive Summary

Many authors have pointed out the importance of rice fields as a waterbird habitat in the Northern Hemisphere, stressing their particular value as concentration areas for migratory shorebirds. At least 116 species of non passerine waterbirds with Neotropical distribution and belonging to 19 families have been recorded in rice fields, including more than 30 Nearctic and Neotropical shorebirds.

Rice fields provide feeding habitats during the breeding and non breeding seasons, as well as refuge areas and, to a lesser degree, breeding sites. The review of Czech & Parsons (2002) emphasizes the scarcity of available information for the Neotropics. The aim of this study was to evaluate the use of these agroecosystems by migratory shorebirds in southern South America, as a first step and a contribution to the conservation of these and other waterbird species.

The study was undertaken in Argentina, Brazil and Uruguay and surveys were mainly carried out in the austral spring and summer 2004-2005. This included a total of 341 point counts in Argentina (166 points), Brazil (77) and Uruguay (98). At each survey point, all shorebirds were counted and information on other bird species and environmental parameters were collected.

Our results confirm the value of rice fields as an alternative feeding habitat for waterbirds, with at least 59 species recorded. Shorebirds (mainly Charadriidae and Scolopacidae) were the dominant group – in species richness as well as in abundance-, representing approximately 29% of all recorded species. A total of 17 shorebirds were recorded in the three countries, including 12 Nearctic migrant and five Neotropical migrant. Most common (greatest incidence in surveys) and most abundant (highest densities) species were the Southern Lapwing (*Vanellus chilensis*), Pectoral Sandpiper (*Calidris melanotos*), Lesser Yellowlegs (*Tringa flavipes*), American Golden Plover (*Pluvialis dominica*), White-backed Stilt (*Himantopus melanurus*) and White-rumped Sandpiper (*Calidris fuscicollis*).

Shorebird species richness, as well as their total and specific abundance, varied in function of the rice crop cycle. The fields were most used by birds during the earlier stages of the crop, with a remarkable decrease in the abundance of all the species as the crop developed and the associated increase in plant height and biomass.

Although it was not possible to estimate shorebird populations feeding in rice fields of southern South America, we know that they reach hundreds of thousands birds. At the same time, agrochemicals are used in the management of rice fields and although shorebirds are not considered harmful to the rice crop, they are exposed to lethal and sub-lethal doses of toxic products, especially species that are abundant when herbicides and insecticides are applied.

It can be seen that, on one hand, rice fields act as important feeding areas for migratory shorebirds, but on the other hand, they may become toxic traps. Therefore it is important to develop a conservation strategy involving all interested actors, with the main objective of reducing the use of agrochemicals, together with effective elimination of the prohibited products and of those that are highly toxic to wildlife from the market.

CHAPTER 1

Introduction

Rice fields as a habitat for waterbirds

Rice (*Oryza* spp.) is a major crop in the world today, covering around 11% of arable lands on the planet. In 2004 (IRRI 2005), it covered a surface area of more than 1.5 million km^2.

The rice field agroecosystem acts as a temporary artificial wetland, alternating between periods of flooding in the summer and dry periods in the winter (Fasola & Ruiz 1966). It displays spatial and temporal heterogeneity which results in the establishment of large populations of birds with different trophic and structural requirements (Acosta 1998). Numerous authors have reported on the importance of these agroecosystems as habitats for waterbirds in the Northern Hemisphere, emphasizing their value as areas of concentration of migratory shorebirds (Martínez-Vilalta 1985, Fasola & Ruiz 1996, Shuford *et al.* 1998, Elphick & Oring 1998, 2003; Manley 1999, Elphick 2000, USGS 2000, Tourenq *et al.* 2003; see review in Czech & Parsons 2003).

At least 116 species of waterbirds with Neotropical distribution and belonging to 19 families have been recorded in rice fields (Appendix 1). Charadriiformes was the best represented order, with seven families and 47 species, followed by Ciconiiformes with three families and 23 species. The best represented families were Anatidae (25 species), Scolopacidae (22), Ardeidae (15), Rallidae (13), Charadriidae (8), Sternidae (7) and Threskiornithidae (6) (Appendix 1). The most numerous genera were *Anas* (12 species), *Calidris* (7), *Charadrius* (5), *Sterna* (5) and *Ardea*, *Dendrocygna*, *Tringa* and *Larus* with four species each (Appendix 1). The species most frequently referred to in the literature were Great Egret (*Ardea alba*), Cattle Egret (*A. ibis*) and Greater Yellowlegs (*Tringa melanoleuca*) with 12 references each, followed by Lesser Yellowlegs (*Tringa flavipes;* 11 references), Snowy Egret (*Egretta thula;* 10), Black-crowned Night-Heron (*Nycticorax nycticorax;* 10), Common Gallinule (*Gallinula chloropus;* 9) and Limpkin (*Aramus guarauna*), Black-necked Stilt (*Himantopus mexicanus*), Grey Plover (*Pluvialis squatarola*), Killdeer (*Charadrius vociferus*), Common Snipe (*Gallinago gallinago*) and Least Sandpiper (*Calidris minutilla*), with eight citations each (Appendix 1).

For some waterbird species, rice fields provide feeding habitat in both the breeding and the non-breeding seasons, and also refuge areas and, to a lesser degree, nesting sites (Causey & Graves 1969, Treca 1975, Acosta *et al.* 1996, Fasola & Ruiz 1996, Fasola *et al.* 1996, Gonzalez-Solis *et al.* 1996, USGS 2000, Tourenq *et al.* 2003; see review in Czech & Parsons 2002). They provide the main foraging areas for herons during the

Rice harvest in March in San Javier, Santa Fe province, Argentina.

D.E. Blanco

reproductive season in the Mediterranean region (Fasola *et al.* 1996) and also host small breeding colonies of Black-tailed Godwit (*Limosa limosa*), Common Black-headed Gull (*Larus ridibundus*) and Black Tern (*Chlidonias niger*) in Italy's Northwest (see review by Fasola & Ruiz 1996). In other regions, such as in the USA, rice fields act as important refuges for waterbirds, mainly in those areas where native wetlands have been reduced and rice-growing areas increased (Czech & Parsons 2002, Elphick & Oring 1998, 2003). However, these agroecosystems do not provide the same habitat conditions as natural wetlands, and are unfavorable to many other species (Azpiroz 1996, Campos & Lekuona 2001, Richardson & Taylor 2003).

Management practices may also increase the value of rice fields as habitat for waterbirds, such as the flooding of fields following harvest, a practice recently adopted in the USA -as a result of new legislation for reducing air pollution- and also known for centuries in Japan and on the Mediterranean coast of Spain (Japanese Association for Wild Geese Protection 2005). In California, for example, restrictions to burning rice stubbles have resulted in a search for alternative methods for accelerating their decomposition, including the intentional flooding of rice fields in winter. This practice has proved beneficial for many waterbirds (Elphick & Oring 1998, 2003), providing similar foraging conditions to those of natural wetlands (Elphick 2000). Therefore flooded rice stubble contributes significantly to the conservation of waterbirds (Elphick & Oring 2003), but it may not be advantageous for all species and may have negative effects on some species (Azpiroz 1996, Elphick 2004).

In the USA, the flooding of rice fields is a practice promoted cooperatively by different sectors, e.g. the rice producers' cooperatives, agricultural extension agencies, federal and state wildlife organizations, representatives of the rice industry and NGOs (USGS 2000). According to Manley (1999), this is a very valuable practice which benefits the environment, crop management and waterbirds.

Rice fields and migratory shorebirds

The use of rice fields by shorebirds during migration in North America is well documented. For example, in the Sacramento valley, some 300,000 shorebirds occupy rice fields during migration (Shuford *et al.* 1998) and in southern Texas, thousands of these birds use the rice fields during the spring migration, when the fields are flooded prior to sowing (Farmer & Parent 1997). Rice fields are also used in winter. According to Twedt *et al.* (1998), 13 species of shorebirds use rice fields and other agricultural habitats during winter in the Mississippi valley, with an average density of 58.6 birds/100 ha.

Shorebirds are an essential component of the waterbird community found in rice fields. In the Camargue in France, the dominance of this group is seen clearly when the abundance of waterbirds is analyzed, showing 73% Charadriiformes (17 species), 15.5% Anseriformes, 6.5% Ciconiiformes and 5% other species (Tourenq *et al.* 2003). The main species were the yellowlegs (*Tringa* spp.), primarily the Common Greenshank (*T. nebularia*) and the Wood Sandpiper (*T. glareola*).

Rice field partially flooded in San Javier, Santa Fe province, Argentina.

D.E. Blanco


A. Parera

Burning of rice stubble at the end of the summer.

The use of rice fields by shorebirds is conditioned by the rice cycle (Martínez-Vilalta 1985, Shuford *et al.* 1998), as well as other factors such as the depth of water, the age of the rice fields and the management of stubble prior to flooding (Elphick & Oring 1998, 2003, Tourenq *et al.* 2003). These factors strongly condition the use of rice fields by waterbirds, in many cases restricting it to a few days or weeks per year. In Texas, for example, a rice field provides habitat for shorebirds for a period of one to three weeks, during seeding and flooding (Farmer & Parent 1997). On the other hand, rice fields in the Camargue are used intensively by migratory shorebirds during a very brief period in spring (Tourenq *et al.* 2001).

Environmental changes associated with the crop cycle limit the use of rice fields by birds. In California for example, low numbers of waterbirds were recorded in August because the mature rice crop does not leave much open water surface for the birds (Shuford *et al.* 1998). On the other hand, the depth of water determines the quantity of available habitat (Collazo *et al.* 2002) and seems to be a good indicator of presence/absence of waterbirds (Elphick & Oring 2003)(Figure1). Elphick & Oring (2003) showed that the densities of birds were significantly related to the depth of water and the date, and that the species richness was greatest at depths of 10-15cm. They also observed that the densities of shorebirds decreased with the depth of water until they reached zero at greater depths.

Another factor which affects the use of rice fields by shorebirds, is the age of the field. Older rice fields appear to be less attractive to insectivorous waterbirds, due to lower availability of prey as a result of intensive land management and the repeated use of pesticides over the years (Tourenq *et al.* 2003).

The flooding of rice fields in the winter is often preceded by specific management practices which are intended to accelerate the decomposition of rice stubble. Some studies have shown that shorebirds are more abundant in fields with a high manipulation of stubble and specially in those where the stubble was incorporated into the soil prior to flooding (Elphick & Oring 1998, 2003).

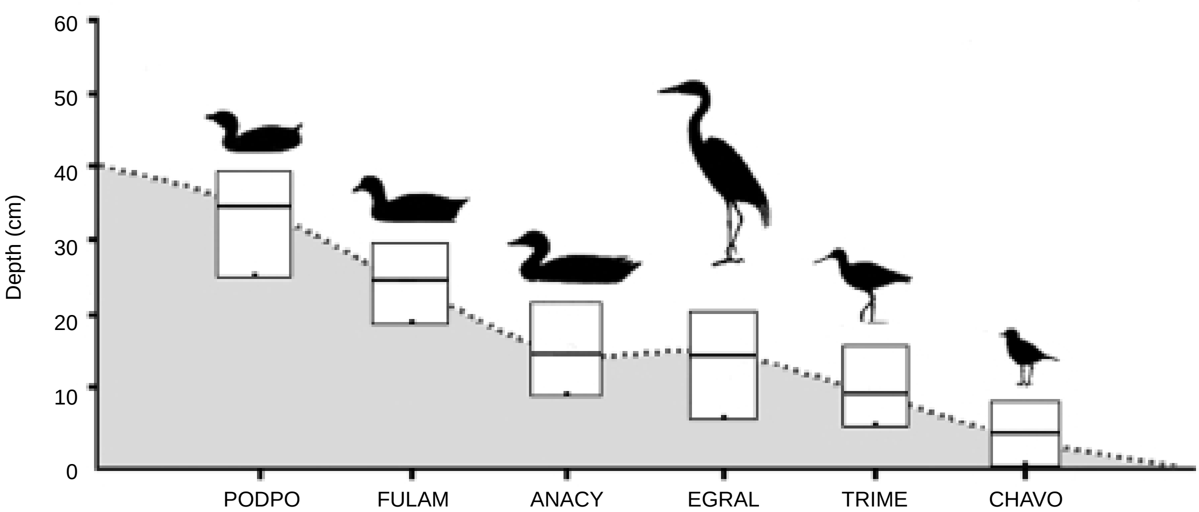


Figure 1.- Range of water depths preferred by each species, based on Elphick & Oring (1998). The box represents the range of depths (interquartile) recorded for each species and median values are represented by the solid line within each box. The species are the Pied-billed Grebe (*Podilymbus podiceps;* PODPO), American Coot (*Fulica americana;* FULAM), Cinnamon Teal (*Anas cyanoptera;* ANACY), Great Egret (*Ardea alba;* EGRAL), Greater Yellowlegs (*Tringa melanoleuca;* TRIME) and Killdeer (*Charadrius vociferus;* CHAVO).

B. López-Lanús

Most available studies focus their attention on the management of rice fields for wintering waterbirds. Additional work is necessary in order to understand the effects of cultivation practices throughout the rice cycle on both breeding and migratory species (Tourenq *et al.* 2003).

Rice fields in the Neotropics

The review by Czech and Parsons (2002) emphasizes the scarcity of available information on the use of rice fields by waterbirds in the Neotropics. Major studies on the subject are those from Suriname (Vermeer *et al.* 1974, Hicklin & Spaans 1992), Cuba (Acosta 1998, Acosta *et al.* 1996, Mugica 2000, Mugica *et al.* 2001, 2003) and southern Brazil (Lanctot *et al.* 2002, Dias & Burger 2005), as well as some observations and general communications for the region (Menegheti *et al.* 1990) and specifically for Colombia (McKay 1981), Guyana (Bourne 1981) and Uruguay (Rodriguez & Arballo 1995, Azpiroz 1996, Lanctot *et al.* 2002). In general these papers highlight the role of rice fields as habitats for foraging and resting waterbirds, and in some cases confirm their function as a breeding habitat for species such as the Fulvous Whistling-Duck (*Dendrocygna bicolor*), White-cheeked Pintail (*Anas bahamensis*) and Black-necked Stilt in Cuba (Mugica 2000, Mugica *et al.* 2003), the Purple Gallinule (*Porphyrio martinicus*) in Colombia (McKay 1981), and the Pied-billed Grebe, Pinnated Bittern (*Botaurus pinnatus*), Fulvous Whistling-Duck, White-faced Whistling-Duck (*Dendrocygna viduata*), Brazilian Teal (*Amazonetta brasiliensis*), Common Gallinule, White-winged Coot (*Fulica leucoptera*) and Southern Lapwing (*Vanellus chilensis*) in Brazil (Dias & Burger 2005). McKay (1981) points out that the Purple Gallinule –an abundant species in a large part of the rice producing area to the east of the northern Andes of South America - uses rice fields as nesting habitat, with greater abundances during May and a minimum density of 21 birds/ha. According to McKay (1981), rice paddies in eastern Colombia provide good nesting habitat for the Purple Gallinule, as well as abundant food and constant water levels.

In Cuba, rice fields are important feeding areas for waterbirds, where species with the highest density were the Cattle Egret, Snowy Egret, Glossy Ibis (*Plegadis falcinellus*), Fulvous Whistling-Duck, White-cheeked Pintail, Blue-winged Teal (*Anas discors*), Black-necked Stilt and Least Sandpiper (Acosta 1998, Mugica 2000, Mugica *et al.* 2001).

The Charadriiformes are important from a taxonomic point of view and in general dominate the composition of the waterbird community of rice fields (see Figure 2). In particular, references to the Neotropics agree on the importance of these habitats for migratory shorebirds during the non-breeding season (Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2001, 2003; Dias & Burger 2005), totaling 33 recorded species (see Table 1).

High numbers of wading birds –mainly Wood Storks– in the dry season.

P. Canevari

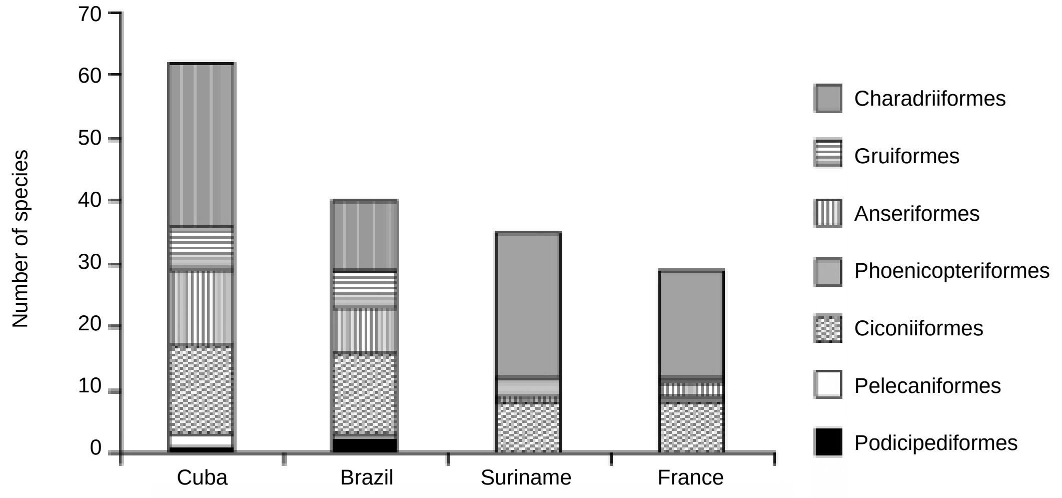


Figure 2.- Taxonomic composition of waterbirds inhabiting the rice fields of Cuba (Mugica *et al.* 2001), Brazil (Dias & Burger 2005), Suriname (Hicklin & Spaans 1992) and the Camargue in France (Tourenq *et al.* 2003).

Table 1.- Shorebird species recorded in Neotropical rice fields.

Vernacular name	Scientific name	Countries	References
Northern Jacana	*Jacana spinosa*	Cuba	Acosta 1998, Mugica 2000
Wattled Jacana	*Jacana jacana*	Argentina, Brazil, Suriname	Hicklin & Spaans 1992, Zaccagnini 2002, Dias & Burger 2005
South American Painted-Snipe	*Rostratula semicollaris*	Uruguay	Azpiroz *in litt*.
Black-necked Stilt	*Himantopus mexicanus**	Cuba	Acosta 1998, Mugica 2000
White-backed Stilt	*Himantopus melanurus*	Argentina, Brazil, Uruguay	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
American Avocet	*Recurvirostra americana*	Cuba	Mugica 2000
Southern Lapwing	*Vanellus chilensis**	Argentina, Brazil, Uruguay	Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
American Golden Plover	*Pluvialis dominica*	Brazil, Suriname, Uruguay	Hicklin & Spaans 1992, Rodríguez & Arballo 1995, Dias & Burger 2005,Azpiroz *in litt.*
Grey Plover	*Pluvialis squatarola*	Cuba, Suriname	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000
Semipalmated Plover	*Charadrius semipalmatus*	Cuba, Suriname	Hicklin & Spaans 1992, Mugica 2000
Wilson's Plover	*Charadrius wilsonia*	Cuba,Suriname	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000
Killdeer	*Charadrius vociferus*	Cuba	Acosta 1998, Mugica 2000
Collared Plover	*Charadrius collaris*	Argentina, Brazil, Suriname	Hicklin & Spaans 1992, Zaccagnini 2002, Dias & Burger 2005
Common Snipe	*Gallinago gallinago*	Cuba, Suriname	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000
South American Snipe	*Gallinago paraguaiae*	Argentina, Brazil, Uruguay	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
Short-billed Dowitcher	*Limnodromus griseus*	Cuba, Ecuador	Acosta 1998, López-Lanús & Gastezzi Arias 2000, Mugica 2000
Long-billed Dowitcher	*Limnodromus scolopaceus*	Cuba	Mugica 2000
Hudsonian Godwit	*Limosa haemastica*	Brazil, Suriname	Hicklin & Spaans 1992, Dias & Burger 2005
Upland Sandpiper	*Bartramia longicauda*	Argentina, Suriname	Hicklin & Spaans 1992, Zaccagnini 2002
Greater Yellowlegs	*Tringa melanoleuca*	Argentina, Brazil, Cuba, Suriname, Uruguay	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
Lesser Yellowlegs	*Tringa flavipes*	Argentina, Brazil, Cuba, Suriname, Uruguay	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
Solitary Sandpiper	*Tringa solitaria*	Argentina, Suriname, Uruguay	Hicklin & Spaans 1992, Rodríguez & Arballo 1995, Zaccagnini 2002
Spotted Sandpiper	*Actitis macularia*	Cuba, Suriname	Hicklin & Spaans 1992, Mugica *et al.* 2001
Willet	*Catoptrophorus semipalmatus*	Cuba	Mugica 2000
Ruddy Turnstone	*Arenaria interpres*	Cuba, Suriname	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000
Sanderling	*Calidris alba*	Suriname	Hicklin & Spaans 1992
Semipalmated Sandpiper	*Calidris pusilla*	Cuba, Suriname	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000
Western Sandpiper	*Calidris mauri*	Cuba	Acosta 1998, Mugica 2000
Least Sandpiper	*Calidris minutilla*	Cuba, Suriname	Hicklin & Spaans 1992, Acosta 1998
White-rumped Sandpiper	*Calidris fuscicollis*	Brazil, Cuba, Suriname	Hicklin & Spaans 1992, Acosta 1998, Dias & Burger 2005
Pectoral Sandpiper	*Calidris melanotos*	Argentina, Brazil, Uruguay	Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
Stilt Sandpiper	*Micropalama himantopus*	Brazil, Cuba, Suriname	Hicklin & Spaans 1992, Mugica 2000, Dias & Burger 2005
Buff-breasted Sandpiper	*Tryngites subruficollis*	Brazil	Lanctot *et al* 2002, Dias & Burger 2005

* Breeding / nesting in rice fields


M. Ruda Vega

Yellowlegs (*Tringa* sp.) are noteworthy due to their abundance in the rice fields of Suriname.

Hicklin & Spaans (1992) stress the importance of rice fields in Suriname as a feeding habitat for Nearctic shorebirds as well as for Neotropical species of herons, rails and the Wattled Jacana (*Jacana jacana*). They recorded 39 species of non passerine birds in the rice fields and irrigation canals, with an average density of 3.1-3.3 birds/ha in cultivated rice fields. Shorebirds were undoubtedly the most numerous group feeding in rice fields with 19 species, amounting to 62.2% of the total birds counted, followed by herons (33%) and terns (4%). Dominant species were the Least Sandpiper (36.6% total shorebirds) and the Lesser Yellowlegs (33.9%).

The studies undertaken in Cuba point to the importance of the first phases of the rice cultivation cycle for shorebirds (Acosta 1998, Mugica 2000, Mugica *et al.* 2003), with decreasing densities once the rice begins to grow. The microhabitat with the highest species richness (46 species) and density over the year was the muddy pre-sowing preparations (Mugica 2000, Mugica *et al.* 2003). Moreover, these authors observed a segregation in the use of different fields by herons and shorebirds, with a strong preference for fields in preparation for sowing, although both groups require slightly different water levels. Shorebirds were found in marginally shallower zones and on mounds of earth that become partially submerged when flooding begins.

In a more recent study, Dias & Burger (2005) recorded 49 species of waterbirds in the rice fields of Rio Grande do Sul (Brazil). Of these, 67.35% were carnivorous species, while 32.65% were species that feed on plants and seeds. The authors stressed the importance of Scolopacidae and Charadriidae during the early stages of the rice cycle (during flooding), because of the abundances of aquatic invertebrates and their larvae. The American Golden Plover (*Pluvialis dominica*) and the Lesser Yellowlegs were among the most abundant species. They found that the presence of certain species was associated with planting method; e.g. Hudsonian Godwit (*Limosa haemastica*), Greater Yellowlegs, White-rumped Sandpiper (*Calidris fuscicollis*), Stilt Sandpiper (*Micropalama himantopus*) and White-backed Stilt (*Himantopus melanurus*) were found exclusively on paddies associated with the “mix” method of sowing, where flooding occurred 20 days earlier than in the “direct drilling” method. Other species, such as the Southern Lapwing used the fields more generally and intensively due to their size and ability to feed in flooded, as well as in dry fields.

All these papers stress the importance of the early stages of rice crops for the feeding of shorebirds (Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2003, Dias & Burger 2005). In Suriname, rice fields were more attractive from three weeks before until two weeks after sowing and especially during and just after flooding of paddies (Hicklin & Spaans 1992). The highest densities of birds were associated with flooded fields which were being plowed and leveled (total birds: 34.3 birds/ha; Lesser Yellowlegs: 7.8 birds/ha and Greater Yellowlegs: 2.1 birds/ha), while densities were lower in other habitats, varying from 0 birds/ha in fields of mature rice to 11.1 birds/ha in recently flooded fields (Lesser Yellowlegs: 4.6 birds/ha and Greater Yellowlegs: 1 bird/ha).

In southern Brazil the flooding of rice fields coincides with the spring/summer season, when the water levels in natural wetlands goes down due to high temperatures, resulting in the availability of food in the rice fields being more favorable to shorebirds (Dias & Burger 2005). Some species, such as the White-backed Stilt were only recorded at the beginning of cultivation at times of low water depths (Dias & Burger 2005). The rise in the water level and the growth of vegetation finally exclude most shorebird species, especially the smaller ones. According to these authors, the height and density of rice, water depth, the availability of food and disturbances due to human activities, were factors limiting the use of rice fields by shorebirds.

Waterbirds and agrochemicals

Rice fields are managed with the use of many herbicides, insecticides and other agrochemicals and the birds found there are exposed to lethal or sub-lethal doses of these products. Furthermore, some passerine and non-passerine birds are considered “pests” of the rice (Elias & Valencia 1983) and are killed using pesticides, either by poisoning the seeds (poisoned baits) or by spraying toxic substances from the air from small planes (Zaccagnini 2002, M. Serra pers. com.).

Reports on waterbird mortality in rice fields resulting from pesticide use are numerous (Vermeer *et al.* 1974, Littrell 1988, Zaccagnini pers. comm.).

Carbofuran and Monocrotophos are among the highly toxic pesticides used in rice fields. Carbofuran is an extremely toxic product to wildlife and is considered as one of the most toxic pesticides to birds (Iolster & Krapovickas 1999). The death of migratory birds in rice crops in the USA has been associated with the use of this pesticide. Birds were probably contaminated while feeding on insects and crustaceans on wet mud, or they may have mistaken grains of Carbofuran for seeds (Eisler 1985; in Iolster & Krapovickas 1999). On the other hand, Littrell (1988) analyzed 22 waterbird and birds of prey mortalities due to intoxication with Carbofuran in rice fields in the Sacramento valley in California, including species such as the Mallard (*Anas platyrhynchos*), American Wigeon (*A. americana*), Northern Shoveler (*A. clypeata*), Gadwall (*A strepera*), Northern Pintail (*A. acuta*), Common Teal (*A. crecca*), Cinnamon Teal, Blue-winged Teal and American Coot.

In the USA, the use of Monocrotophos caused the death of 1,100 birds of 12 different species due to the consumption of rice seeds treated with this product and with Dicrotophos (Smith 1987; in Iolster & Krapovickas 1999).

There is also evidence for the accumulation of chemicals in waterbird eggshells. Causey and Graves (1969) reported finding remains of Dieldrin in species that nest in rice fields in southern Louisiana, with levels of contamination varying between 0.49 and 5.39 ppm for the Least Bittern (*Ixobrychus exilis*) and average levels of 6.51 and 9.37 ppm for the Purple Gallinule and Common Gallinule, respectively.

Based on these reports, we see that the use of agrochemicals in rice fields could have a significant impact on resident waterbird populations. Thus these agroecosystems might result in a serious threat to the avifauna and especially for species that are abundant when herbicides and insecticides are applied, as in the case of the Nearctic shorebirds (Dias & Burger 2005).

Pesticides use in rice fields in Suriname

Pesticides have been commonly used in rice fields in Suriname and some highly dangerous chemicals were found to be the cause of mortality of fish, amphibians, raptors like Snail Kite (*Rosthramus sociabilis*), herons and jacanas in that country (Hicklin & Spaans 1992). These authors have indicated that the application of agrochemicals from one week before sowing until a few days before harvesting was an important threat to shorebirds which feed on recently sprayed fields. The extent of this threat varies with the extent a species use of recently sowed fields, with the most vulnerable shorebirds being the Least Sandpiper, White-rumped Sandpiper and Grey Plover (Figure 3).

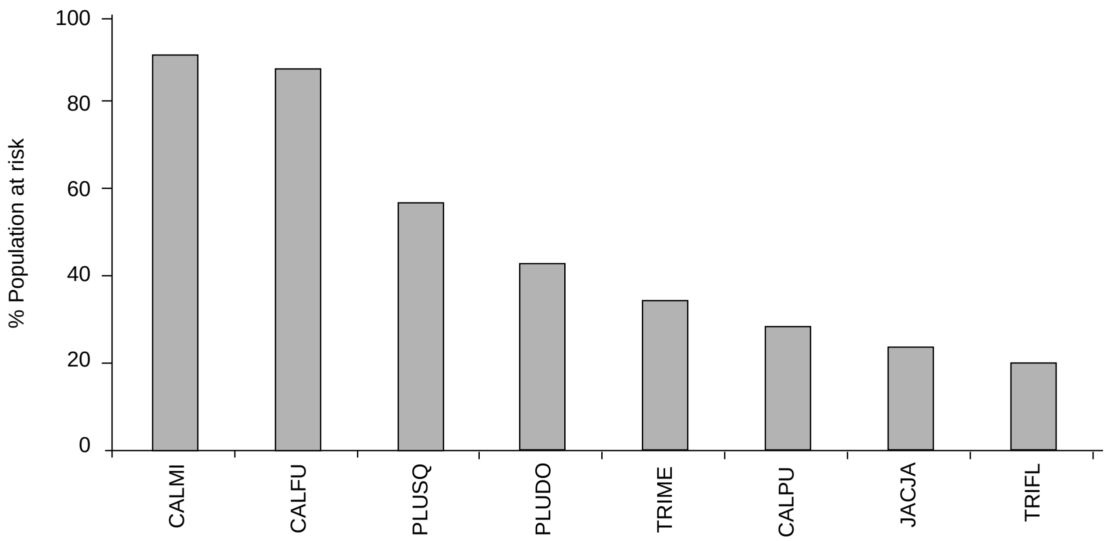


Figure 3.- Percentage of populations of Wattled Jacana (*Jacana jacana*; JACJA), American Golden Plover (*Pluvialis dominica;* PLUDO), Grey Plover (*P. squatarola;* PLUSQ), Greater Yellowlegs (*Tringa melanoleuca;* TRIME), Lesser Yellowlegs (*T. flavipes;* TRIFL), Semipalmated Sandpiper (*Calidris pusilla;* CALPU), Least Sandpiper (*C. minutilla;* CALMI) and White-rumped Sandpiper (*C. fuscicollis;* CALFU), at risk while foraging in fields sprayed with Brestan (molluscicide) and Ambush (insecticide) in Suriname (Hicklin & Spaans 1992).

This project

On the basis of a revision of current knowledge, we see that on one hand rice fields offer feeding habitats to numerous waterbirds, including many migratory species and more than 30 Nearctic and Neotropical shorebirds. However at the same time, the use of agrochemicals associated with this crop constitutes a significant threat to these species.

The aim of the present study was to i) evaluate the use of rice fields in southern South America by migratory shorebirds during the non-breeding season, and ii) contribute to the conservation of these and other waterbird species in the Western Hemisphere.

This project was based on preliminary observations of the numbers of shorebirds using rice fields in eastern Uruguay and southern Brazil in 2001 (Lanctot *et al.* 2002, D.E Blanco unpublished data), but also on the need for assessing the importance of these agroecosystems as feeding and non-breeding concentration areas for migratory shorebirds (Acosta 1998, Czech & Parsons 2002), attempting to answer the following questions:

- *¿Are rice fields in southern South America being used by migratory shorebirds during the non-breeding season?*
- *How intensely are they used?*
- *How does this use vary regionally and in function of the lifecycle of the crop?*
- *What are the threats faced by migratory shorebirds in rice fields?*
- *What should be the next steps to be taken for the conservation of these and other waterbirds and their habitats?*

This paper attempts to answer these questions and provides a basis of knowledge for work on shorebird conservation in rice field ecosystems.

Appendix 1

Waterbird species with Neotropical distribution recorded in rice fields. Taxonomy and classification are according to Wetlands International (2002).

Family	Species	References
Podicipedidae	*Rollandia rolland*	Dias & Burger 2005
	Podilymbus podiceps	Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001, Dias & Burger 2005
Phalacrocoracidae	*Phalacrocorax brasiliensis*	Acosta 1998, Mugica 2000, Mugica *et al.* 2001, Dias & Burger 2005
Anhingidae	*Anhinga anhinga*	Acosta 1998, Mugica *et al.* 2001
Ardeidae	*Ardea herodias*	Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001, 2003
	Ardea cocoi	Hicklin & Spaans 1992, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Ardea alba	Hicklin & Spaans 1992, Acosta 1998, Elphick & Oring 1998, 2003, Elphick 2000, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002, Richardson & Taylor 2003, Tourenq *et al.* 2003, Dias & Burger 2005, Azpiroz *in litt*.
	Ardea ibis	Hicklin & Spaans 1992, Fasola & Ruiz 1996, Fasola *et al.* 1996, Acosta 1998, Mugica 2000, Mugica *et al.* 2001, 2003; Zaccagnini 2002, Tourenq *et al.* 2003, Richardson & Taylor 2003, Dias & Burger 2005, Azpiroz *in litt*.
	Butorides virescens	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Butorides striatus	Hicklin & Spaans 1992, Dias & Burger 2005
	Egretta tricolor	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Egretta caerulea	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Egretta thula	Hicklin & Spaans 1992, Acosta 1998, Elphick & Oring 1998, 2003, Kushlan & Hafner 2000, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Syrigma sibilatrix	Zaccagnini 2002, Dias & Burger 2005
	Nyctanassa violacea	Hicklin & Spaans 1992, Mugica 2000, Mugica *et al.* 2001
	Nycticorax nycticorax	Hicklin & Spaans 1992, Fasola *et al.* 1996, Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001, Tourenq *et al.* 2003, Dias & Burger 2005, Azpiroz *in litt*.
	Botaurus pinnatus	Rodríguez & Arballo 1995, Kushlan & Hafner 2000, Dias & Burger 2005
	Botaurus lentiginosus	Elphick & Oring 1998, 2003
	Ixobrychus exilis	Causey & Graves 1969, Acosta 1998, Mugica 2000, Mugica *et al.* 2001
Ciconiidae	*Mycteria americana*	Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Ciconia maguari	Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
Threskiornithidae	*Theristicus caerulescens*	Azpiroz *in litt*.
	Phimosus infuscatus	Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Eudocimus albus	Acosta *et al.* 1996, Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Plegadis falcinellus	Acosta *et al.* 1996, Acosta 1998, Mugica 2000, Mugica *et al.* 2001, 2003
	Plegadis chihi	Rodríguez & Arballo 1995, Elphick & Oring 1998, 2003, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Ajaia ajaja	Acosta 1998, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002, Dias & Burger 2005
Phoenicopteridae	*Phoenicopterus ruber*	Fasola & Ruiz 1996, Mugica 2000, Mugica *et al.* 2001, Tourenq *et al.* 2003
Anhimidae	*Chauna torquata*	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
Anatidae	*Dendrocygna bicolor*	Acosta 1998, Menegheti *et al.* 1990, Mugica 2000, Mugica *et al.* 2001, 2003; Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Dendrocygna viduata	Menegheti *et al.* 1990, Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Dendrocygna arborea	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Dendrocygna autumnalis	Bourne & Osborne 1978, Bourne 1981, Menegheti *et al.* 1990, Hicklin & Spaans 1992
	Callonetta leucophrys	Zaccagnini 2002, Dias & Burger 2005
	Aix sponsa	Mugica *et al.* 2001

Family	Species	References
Anatidae (cont.)	*Amazonetta brasiliensis*	Dias & Burger 2005
	Anas americana	Littrell 1988, Elphick & Oring 1998, 2003, Mugica *et al.* 2001
	Anas strepera	Littrell 1988, Fasola & Ruiz 1996
	Anas crecca	Littrell 1988, Fasola & Ruiz 1996
	Anas flavirostris	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Anas platyrhynchos	Littrell 1988, Fasola & Ruiz 1996
	Anas acuta	Treca 1975, Littrell 1988, Fasola & Ruiz 1996, Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Anas georgica	Menegheti *et al.* 1990, Dias & Burger 2005, Azpiroz *in litt*.
	Anas bahamensis	Acosta 1998, Mugica 2000, Mugica *et al.* 2001, 2003
	Anas versicolor	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt.*
	Anas cyanoptera	Littrell 1988, Elphick & Oring 1998, 2003
	Anas discors	Littrell 1988, Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Anas clypeata	Littrell 1988, Fasola & Ruiz 1996, Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Netta peposaca	Menegheti *et al.* 1990, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Aythya americana	Mugica *et al.* 2001
	Aythya collaris	Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Bucephala albeola	Elphick & Oring 1998, 2003
	Oxyura dominica	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Oxyura jamaicensis	Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
Gruidae	*Grus canadensis*	Elphick & Oring 1998, 2003
Aramidae	*Aramus guarauna*	Hicklin & Spaans 1992, Rodríguez & Arballo 1995, Acosta 1998, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
Rallidae	*Laterallus jamaicensis*	Mugica 2000, Mugica *et al.* 2001
	Rallus elegans	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Aramides ypecaha	Zaccagnini 2002
	Porzana carolina	Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Porzana flaviventer	Hicklin & Spaans 1992, Acosta 1998
	Pardirallus sanguinolentus	Dias & Burger 2005, Azpiroz *in litt*.
	Porphyrio martinicus	Causey & Graves 1969, McKay 1981, Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002
	Porphyrio flavirostris	Hicklin & Spaans 1992
	Gallinula chloropus	Causey & Graves 1969, Fasola & Ruiz 1996, Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001, Tourenq *et al.* 2003, Dias & Burger 2005
	Gallinula melanops	Dias & Burger 2005
	Fulica americana	Littrell 1988, Acosta 1998, Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Fulica leucoptera	Zaccagnini 2002, Dias & Burger 2005
	Fulica armillata	Dias & Burger 2005
Jacanidae	*Jacana spinosa*	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Jacana jacana	Hicklin & Spaans 1992, Zaccagnini 2002, Dias & Burger 2005
Rostratulidae	*Rostratula semicollaris*	Azpiroz *in litt*.
Recurvirostridae	*Himantopus mexicanus*	Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Elphick 2000, Mugica 2000, Mugica *et al.* 2001, 2003
	Himantopus melanurus	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Recurvirostra americana	Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Mugica 2000, Mugica *et al.* 2001
Charadriidae	*Vanellus chilensis*	Rodríguez & Arballo 1995, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Pluvialis dominica	Hicklin & Spaans 1992, Rodríguez & Arballo 1995, Twedt *et al.* 1998, Dias & Burger 2005, Azpiroz *in litt*.

Family	Species	References
Charadriidae (cont.)	*Pluvialis squatarola*	Hicklin & Spaans 1992, Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Mugica 2000, Mugica *et al.* 2001
	Charadrius semipalmatus	Hicklin & Spaans 1992, Mugica 2000, Mugica *et al.* 2001
	Charadrius wilsonia	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Charadrius vociferus	Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Elphick 2000, Mugica 2000, Mugica *et al.* 2001
	Charadrius alexandrinus	Tourenq *et al.* 2003
	Charadrius collaris	Hicklin & Spaans 1992, Zaccagnini 2002, Dias & Burger 2005
Scolopacidae	*Gallinago gallinago*	Hicklin & Spaans 1992, Fasola & Ruiz 1996, Acosta 1998, Elphick & Oring 1998, Twedt *et al.* 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Gallinago paraguaiae	Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Limnodromus griseus	Acosta 1998, Shuford *et al.* 1998, Twedt *et al.* 1998, López-Lanús & Gastezzi Arias 2000, Mugica 2000, Mugica *et al.* 2001
	Limnodromus scolopaceus	Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Elphick 2000, Mugica 2000, Mugica *et al.* 2001
	Limosa haemastica	Hicklin & Spaans 1992, Dias & Burger 2005
	Numenius phaeopus	Shuford *et al.* 1998, Tourenq *et al.* 2003
	Bartramia longicauda	Hicklin & Spaans 1992, Zaccagnini 2002
	Tringa melanoleuca	Hicklin & Spaans 1992, Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Elphick 2000, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Tringa flavipes	Hicklin & Spaans 1992, Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Mugica 2000, Mugica *et al.* 2001, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.
	Tringa solitaria	Hicklin & Spaans 1992, Rodríguez & Arballo 1995, Mugica *et al.* 2001, Zaccagnini 2002
	Tringa macularia	Hicklin & Spaans 1992, Mugica *et al.* 2001
	Catoptrophorus semipalmatus	Mugica 2000, Mugica *et al.* 2001
	Arenaria interpres	Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Calidris alba	Hicklin & Spaans 1992
	Calidris pusilla	Hicklin & Spaans 1992, Acosta 1998, Twedt *et al.* 1998, Mugica 2000, Mugica *et al.* 2001
	Calidris mauri	Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Mugica 2000, Mugica *et al.* 2001
	Calidris minutilla	Hicklin & Spaans 1992, Acosta 1998, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Twedt *et al.* 1998, Elphick 2000, Mugica *et al.* 2001
	Calidris fuscicollis	Hicklin & Spaans 1992, Acosta 1998, Twedt *et al.* 1998, Dias & Burger 2005
	Calidris melanotos	Rodríguez & Arballo 1995, Farmer & Parent 1997, Twedt *et al.* 1998, Zaccagnini 2002, Dias & Burger 2005, Azpiroz *in litt*.,
	Calidris alpina	Fasola & Ruiz 1996, Elphick & Oring 1998, 2003, Shuford *et al.* 1998, Elphick 2000
	Micropalama himantopus	Hicklin & Spaans 1992, Mugica 2000, Mugica *et al.* 2001, Dias & Burger 2005
	Tryngites subruficollis	Lanctot *et al.* 2002, Dias & Burger 2005
Laridae	*Larus delawarensis*	Elphick & Oring 1998, 2003
	Larus argentatus	Elphick & Oring 1998, 2003, Mugica 2000, Mugica *et al.* 2001
	Larus maculipennis	Dias & Burger 2005
	Larus atricilla	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
Sternidae	*Sterna nilotica*	Hicklin & Spaans 1992, Fasola & Ruiz 1996, Acosta 1998, Mugica 2000, Mugica *et al.* 2001, Tourenq *et al.* 2003
	Sterna caspia	Acosta 1998
	Sterna maxima	Acosta 1998, Mugica 2000, Mugica *et al.* 2001
	Sterna antillarum	Mugica 2000, Mugica *et al.* 2001
	Sterna superciliaris	Hicklin & Spaans 1992
	Phaetusa simplex	Hicklin & Spaans 1992
	Chlidonias niger	Fasola & Ruiz 1996, Mugica 2000, Mugica *et al.* 2001, Tourenq *et al.* 2003

CHAPTER 2

Study area

The present study was carried out in the southern portion of South America, in Argentina, Brazil and Uruguay. The main rice areas were identified and the study areas were selected in each country on the basis on this information, taking into account the necessary logistics for the field work for this project (Figure 1).

Argentina

The study area (30°50'S, 60°00'W) comprises the rice belt in the province of Santa Fe and sectors of the departments of San Javier and Garay (Figure 1), in the surroundings of San Javier (30°35'S, 59°57'W; Paynter 1995). It is found in the “Espinal” ecoregion on the boundary with the Delta and Islands of the Paraná (Cabrera & Willink 1980, Administration of National Parks 1999) and contains relicts of Espinal habitat mainly in a good state of conservation, native grasslands and numerous freshwater wetlands. The climate is warm and humid (Cabrera & Willink 1980), with more than 1,000 mm precipitation per annum, but at low levels during the winter months (Figure 2). The locality of Sauce Viejo (Santa Fe; south of our study area), is characterized by variable rains which reach 1,011 mm per annum and an average annual temperature of 18.7°C (for 1991-2000; Figure 2).
The study area is located on the final stretch of the Brazilian central migratory flyway (Antas 1983) and has recently been declared as an “Important Bird Area”, IBA SF07 “San Javier” (López-Lanús & Blanco 2005).

Rice crop production

The provinces of Entre Ríos, Corrientes and Santa Fe produce more than 90% of the rice of Argentina, while the rest is produced in the provinces of Chaco, Formosa and Misiones (Aranguren 1998, Begenisic 1998, Ruiz 1998).

In Santa Fe, rice production is located mainly in the central and eastern parts of the province, on the flood-plains of the Paraná River (Alvisio 1998), and occupying a north-south band of approximately 15-20 km wide and 100 km long (Alvisio 1998, Ruiz 1998). The rice cultivation area reached 14,850 ha in 2000 (Agricultural Estimates / SAGPyA, C. Fonda in litt.), with an estimated 17,000 ha sown in the 2004/05 season (Serra pers. comm.). As a result of the expansion of this crop and the need to maintain the rotations, cultivation has been carried out on wetland areas where problems of drainage are more severe (Ruiz 1998). The expansion of the rice crop also involves deforestation and destruction of the Espinal.

Rice cultivation in Santa Fe alternates with extensive cattle raising and the most frequent size of farms is between 150 and 500 ha (Begenisic 1998). Two varieties of rice are sown in this area: long fine and long wide or “Doble Carolina” (Alvisio 1998, Begenisic 1998). The San Javier river (a tributary of the Paraná river), is the main source of water for irrigation and extraction is undertaken with pumps of different sizes according to the height of the river (Ruiz 1998). The irrigation system is made up of canals, ditches, defenses and pumping stations, which vary in size according to the extension of the rice fields and the characteristics of the terrain. Surplus water drains into the natural watercourses in the area (Alvisio 1998).

The optimal time for sowing is during October, but in most cases it starts in mid-September and sometimes extends until the end of November (Ruiz 1998; Table 1). Before sowing the fields are sprayed with glyphosphate

Rice crop

Rice (*Oryza sativa*) was originated in Asia, where it has been cultivated for several thousand years. The main characteristic of this crop, which has a lifecycle that lasts for approximately four months, is its great spatial and temporal instability, with marked peaks in the production of resources, partly resembling some native wetlands that are subject to periods of floods and droughts (Acosta 1998).

The cultivation of rice depends on key factors such as the topography and the availability of water, and it needs flat ground, as the fields must remain flooded during most of the crop's development.

D.E. Blanco

Rice plant of the "Fortuna" variety by mid March.

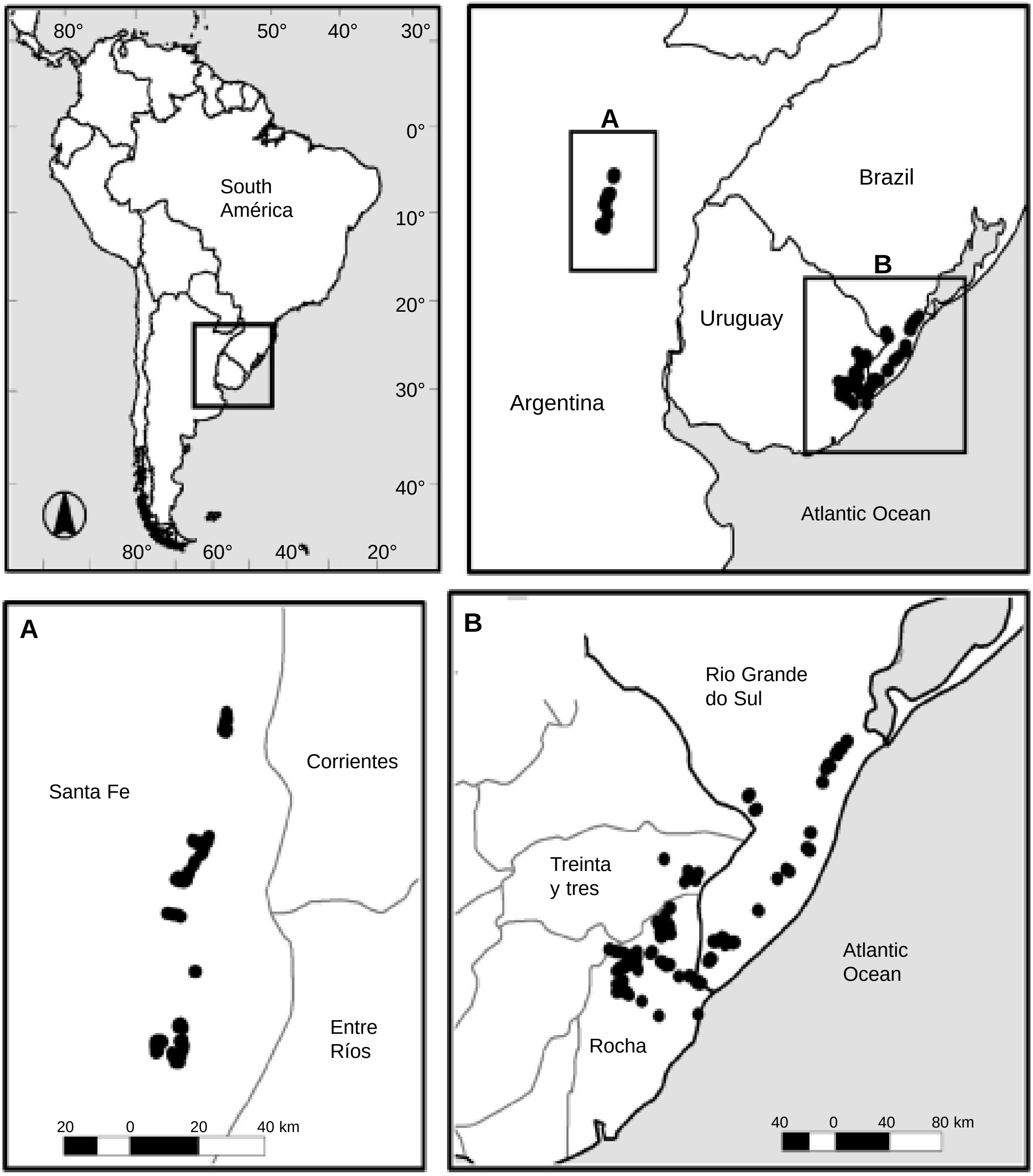


Figure 1.- Map of the study area showing the surveyed areas and the point counts made in the province of Santa Fe, Argentina (A), the state of Rio Grande do Sul, in Brazil (B) and the departments of Rocha and Treinta y Tres, in Uruguay (B).

herbicide (Ruiz 1998). Application of pesticides is carried out in two stages: a) by treatment of the rice seeds before cultivation to combat consumption by ducks and other birds, and b) by spraying the rice crop when the grain is green (M. Serra pers. comm.). The harvest is carried out in March (Table 1).

Studies on waterbirds in rice fields

Studies of birds in rice fields are scarce and generally restricted to the pest species. Zapata (1962) evaluated the economic potential of birds inhabiting rice fields in Gualeguaychú, Entre Ríos. Furthermore the INTA Paraná undertook some work on sport duck-hunting in

Rice field with a broad open water surface in San Javier, Santa Fe province, Argentina.

Table 1.- Specifications about the rice production cycle in the study areas of Argentina, Brazil and Uruguay.

Stages of cultivation	**Santa Fe, Argentina** (Alvisio 1998, Ruiz 1998, Serra pers. comm.)	**Rio Grande do Sul, Brazil** (Pedroso 1985, IRGA 2001, Dias & Burger 2005)	**Rocha and Treinta y Tres, Uruguay** (Evia 1996, Gamarra 1996)
Soil Preparation. Soils should be prepared for efficient use in terms of irrigation water and nutrient consumption, including leveling, formation of field borders and the construction of canals and ditches for optimal irrigation.	In general tillage is done in advance. Around three months before sowing, fields are prepared and borders are constructed.	Variable. Between three months to several weeks before sowing, fields are prepared and borders are constructed. In some cases this is done one year earlier.	Variable.
Sowing. Optimal sowing periods vary regionally in function of various factors such as latitude, climatic conditions, logistical issues, etc.	Mid-September to end of October.	End of October to December, with a peak in November.	15th October to 15th November.
Flooding of paddies. Rice plant requires water and therefore irrigation is a key factor for successful crop. Flooding period extends over 90-100 days.	Mid/end of November	From November to March / April.	Starts 30-45 days after the emergence of the plant and extends around 90-100 days.
Drainage of paddies. Fields are drained 10-20 days before the harvest.	Starting at the end of February	End of February to March/April.	Drainage occurs 15-20 days before the harvest.
Harvest. Harvest takes place after drainage of the paddies and the date varies regionally.	March	End of February to May.	Between March and May.


F. Rilla

Rice paddy recently flooded in Rocha, Uruguay.

rice fields (Zaccagnini & Venturino 1991, 1992, 1993), which included some studies in the area of San Javier (Zaccagnini & Venturino 1992, Canavelli 1999, Zaccagnini 2002). Other studies include the evaluation of damage to rice crops by birds (Zaccagnini 1998, Serra 2000).

Brazil

The study area (32°44'S, 52°50'W) comprises the southern portion of the state of Rio Grande do Sul (30°00'S, 54°00'W; Paynter & Traylor 1991) and includes sectors of the municipalities of Jaguarão, Santa Vitoria do Palmar and Rio Grande (Figure 1). The habitat belongs to the Pioneer Formation of the Coastal Plains of Rio Grande do Sul (IBGE 1986), although the original vegetation has been completely modified. Along the access roads to the rice fields and in the field edges the vegetation is dominated by the Poaceae, in particular *Digitaria sanguinalis*, *Eragrostis bahiensis*, *Paspalum dilatatum*, *P. urvillei*, *Setaria parviflora* and *Sporobolus* sp. (Dias & Burger 2005).

The climate of the Municipality of Rio Grande is humid to sub-humid, with an average annual precipitation of 1,161.6 mm and an average annual temperature of 18.1°C (IBGE 1986). The hydrological balance presents a deficit from December to March (Klein 1998), during the period that the rice paddies are flooded. The climatogram of Santa Vitória do Palmar shows similar values (Figure 2), with an average annual precipitation of 1,359 mm, an average annual temperature of 17.0°C and little rain from October to January.

The study area is located at the end of the Atlantic migratory flyway and also receives flocks of waterbirds that migrate along the central Brazilian flyway (Antas 1983).

Rice crop production

The main rice production area in Brazil is located in the state of Rio Grande do Sul, with nearly 900.000 ha cultivated per annum (Azambuja *et al*. 1996), accounting for 47% of the national production (IRGA 2005). By the end of the 20th century rice cultivation in this state had developed significantly (Zaffaroni *et al*. 1998), with this cereal being the main crop (IBGE 1985). Around 22% of all rice fields are located in the southern part of the state as a result of appropriate edafoclimatic conditions (Zaffaroni *et al.* 1998).

There are two main methods of rice cultivation: direct drilling and mixed or pre-germinated sowing (IRGA 2001). Direct drilling consists of burying the seed with a seed drill in the dry ground. Mixed sowing, on the other hand, is carried out in flooded conditions, where seeds are pre-germinated in water tanks and then dispersed by plane (Pedroso 1985, IRGA 2001, Dias & Burger 2005). Due to the lack of soil movements, the ground should be clear of weeds by using herbicides of total action (Pedroso 1985, IRGA 2001). Mixed sowing is only economically viable on very large scale rice farms (Dias & Burger 2005).

Preparation of the ground for sowing consists in leveling the ground and constructing field borders. Sowing takes place between October and December (Pedroso 1985, IRGA 2001) and the rice is harvested between the end of February and May (Dias & Burger 2005) (Table 1). Total action herbicides are used before sowing, as well as post-emergence herbicides, and insecticides are used during the growth of the rice crop (Dias & Burger 2005).

Almost all the rice crop in Rio Grande do Sul is irrigated; water is taken mainly from rivers, dams and lagoons in

43% of properties, while the others use pumps for obtaining underground water (Zaffaroni & Tavares 1999). The predominant irrigation system in the south of Rio Grande do Sul is driven by electricity (Zaffaroni *et al.* 1998). Irrigation in both sowing systems is different (Table 1). In direct drilling the fields are irrigated from 30 to 40 days after the plants emerge. Flooding is carried out gradually during the vegetative stage of the plant up to a depth of 15-25 cm. The water level is then maintained during the reproductive stage until physiological maturity of the grain, when the water is drained and later the rice is harvested (Gomes & Petrini 1996, IRGA 2001, Dias & Burger 2005). In mixed sowing irrigation is undertaken some days before seeding by flooding the paddies (15-20 cm). After dispersal of the seed the water level is lowered abruptly to a few centimeters, in order to encourage rooting of the plantlets; the rest of the process is similar to the system described above (Gomes & Petrini 1996, IRGA 2001, Dias & Burger 2005).

Studies of waterbirds in rice fields

Use of rice fields by waterbirds is only mentioned in very few publications and in general they concentrate on pest species, including the Anatidae (Menegheti *et al.* 1990) and Icteridae such as the Chestnut-capped Blackbird (*Agelaius ruficapillus*) and Shiny Cowbird (*Molothrus bonariensis*) (see review in Dias & Burger 2005). Dias *et al.* (1997) first mentioned the complexity of the relationships between birds and rice fields in southern Brazil. More recently, Dias & Burger (2005) assessed in detail the community of birds found in rice fields in Rio Grande do Sul, thus presenting the first quantitative data on shorebird occurrence and relative abundances.

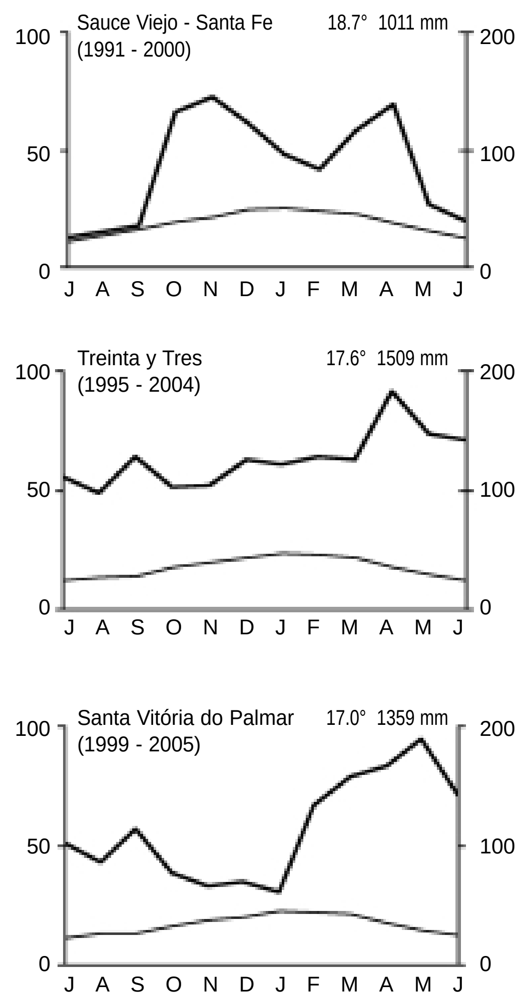


Figure 2.- Climatograms of Sauce Viejo-Santa Fe (31°38'S, Servicio Meteorológico Nacional, Argentina), Treinta y Tres (33°13'S, Dirección Nacional de Meteorología, Uruguay) and Santa Vitória do Palmar (33°31'S, Instituto Nacional de Meteorología, 8th District, Brazil).

Uruguay

The study area (33°25'S, 53°50'W) comprises the central-eastern part of the department of Treinta y Tres and the north of the department of Rocha (Figure 1), including portions of the catchment area of Merín lagoon and the "Bañados del Este"[1] (PROBIDES 1999). It is found in the Pampas biome (Cabrera & Willink 1980), characterized by a wide variety of aquatic habitats and, in this area, by the presence of subtropical flora and fauna which are dispersed from the north.

The ecosystems of this region include high grasslands and hill peaks with associations adapted to xerophytic conditions in the high zones, forests and hill scrubs in the valleys, riparian forests along the flatter valleys and freshwater marshes in the lower zones (PROBIDES 1999).

Native vegetation is represented by palustrine communities, fresh-water marshes and lagoons in the lower areas, riparian forests along the main water courses and palm forests of *Butia capitata* (PROBIDES 1999). The fauna of the region is one of the most diverse in the country (birdlife in particular) and includes an important component of waterbird species (Rilla 1989, 1994; Azpiroz 2001). The study area is located at the end of the Atlantic migratory flyway and also receives migrant shorebirds from the central Brazilian flyway (Antas 1983).

The climate is subtropical humid with warm summers and moderate temperatures due to the closeness to the Atlantic Ocean. Rains are distributed throughout the whole year and there is no dry season, with rainfall values reaching 1,509 mm per annum in the city of Treinta y Tres (for 1995-2004; Figure 2). The average annual temperature for this city over the same period

[1] The "Bañados del Este" have been declared as a Biosphere Reserve and Ramsar Site (PROBIDES 1999).

was 17.6 °C, with an average minimum and maximum of around 11°C and 23°C respectively (PROBIDES 1999; Figure 2).

Rice crop production

Rice production is second in importance after wheat and about 90% of the production is for export (Gamarra 1996). The main rice-growing area in the country is in the Basin of the Merín Lagoon (departments of Cerro Largo, Treinta y Tres and Rocha), encompassing approximately 70% of the total rice growing area (Evia 1996). There is great potential for rice production in the region, which has flat topography and good access to water sources for irrigation, with around 18.8% of catchment area under rice production: 38% of intensive rice, 53% of a mixed cattle-rice system and the rest for rice, palm forests and dams (PROBIDES 1999). The total area cultivated with rice in the last ten years has oscillated between approximately 94,000 and 132,000 ha.[2]

According to Gamarra (1996), the optimal rice sowing period extends from the 15th October to 15th November (Table 1), but due to various factors (climatic conditions, logistic problems, etc) an important part of the area is sown much later at the end of November and beginning of December. After two successive years of rice cultivation it is necessary to alternate with other land uses due to the characteristics of the rice crop. Traditionally, the break extends for 6-7 years (Gamarra 1996).

Rice should be sown on land without weeds, which are controlled with glyphosphate - a total action herbicide that degrades rapidly in the soil (Gamarra 1996). According to Gamarra (1996), the flooding period starts approximately 30-45 days after the emergence of the plant and irrigation is moderate in the first stages of growth (Table 1), with the level of water reaching 5-6 cm. After tilling the rice remains flooded with 5-15 cm of water until maturity. Different pesticides are used to control problems caused by weeds, fungi and insects (Gamarra 1996).

Studies of waterbirds in rice fields

The “Bañados del Este” region contains a very important percentage of the country’s biodiversity, therefore many studies have been undertaken in which waterbirds are well represented (Lagomarsino *et al.* 1988, Rilla 1989, 1994; Vaz-Ferreira & Rilla 1991, Santos *et al.* 1995, Gambarotta *et al.* 1999, PROBIDES 1999). In the particular case of waterbirds associated with rice fields, two research papers are especially noteworthy. Rodríguez & Arballo (1995) identified species that use rice paddies and described spatial and temporal variations. As well Azpiroz (1996) emphasized the role of natural freshwater marshes as a habitat for a rich birdlife, in comparison with rice fields which do not satisfy the ecological requirements of many species.

Use of agrochemicals in rice fields

Agrochemicals are used in the rice fields of Argentina, Brazil and Uruguay, mainly fertilizers and herbicides. Pesticides (insecticides, fungicides) are used to a lesser extent, as pest control today is mainly carried out by flooding and with water management (Evia 1996, Alvisio 1998, Begenisic 1998, Zaffaroni *et al*. 1998, A. Martins de Magalhaes Jr. pers. comm.). In Rio Grande do Sul the use of insecticides is mainly associated with the control of “bicheira-da-raiz” (*Oryzophagus oryzae*) and in 90% of the cases applications of Carbofuran are used (A. Martins de Magalhães Jr. pers. comm.).

M. E. Zaccagnini

The uses of at least 17 herbicides, 10 insecticides and seven fungicides were documented in the three countries (Table 2). Among the herbicides those of total action such as Sulphosate and Glyphosphate (Roundup) and those of selective action, like Clomazone, Quinclorac, Propanil and Molinate are most commonly used (Begenisic 1998, Gamarra 1996, Zaffaroni *et al.* 1998, Zorrilla 1998, A Martins de Magalhães Jr. pers. comm.; see Table 2). Among the insecticides, some products are highly toxic to birds (Iolster & Krapovickas 1999), such as Carbofuran and Endosulfan (Table 2).

[2] Asociación Cultivadores de Arroz://www.aca.com.uy/datos_estadisticos/area_ departamento.htm

Table 2.- Agrochemicals used in rice crops (last 10 years) in Argentina (ARG), Brazil (BRA) and Uruguay (URU): non selective and selective herbicides (NSH and SH respectively), insecticides (IN) and fungicides (FU). For each country, data sources are indicated with numbers (see References at the end of the table). The most commonly used products are marked in gray. Toxicity (a)= Argentina (CASAFE 2005) and (b)= Brazil (http://www4.anvisa.gov.br/AGROSIA/asp/): I= Extremely toxic, II= Highly toxic, III= Moderately toxic and IV= Slightly toxic. N/d= no data.

Type	Active principle	Commercial Name	Chemical Group	Toxicity	ARG	BRA	URU
NSH	Glyphosate	Roundup & others	Substituted glycine	IV(a,b)	2,3,5,10	4,8,9	1
NSH	Sulphosate	Sulfosate	Substituted glycine	III(a,b)		6,9	
SH	Clomazone	Command, Gamit	Isoxazolidinone	II(a) III(b)	2,5	4,7,9	1
SH	Quinclorac	Facet	Quinoline-carboxylic acid	III(a,b)	2,3,5,10	4,7,8	1
SH	Propanil	Stam, Pilon	Anilide	II(a) III(b)	2,3,5,10	4,9	1
SH	Dicamba	Misil I y II	Benzoic acid	III(a)	2,3,5,10		
	Metsulfuron methyl		Sulfonylurea				
SH	Pyrazosulfuron	Sirius	Sulfonylurea	III(b) IV(a)	2	6,8	
SH	Bentazone	Basagran	Benzothiadiazinon	III(a,b)	2,3,5,10		1
SH	MCPA	MCPA	Aryloxy-alcanoic acid	III(a,b)	3		
SH	2,4-D	Various	Aryloxy-alcanoic acid	II(a,b)	5,10		
SH	Picloram	Tordon	Pyridine-carboxylic acid	IV(a,b)	10		
SH	Cyhalofop-butyl	Clincher	Aryloxy-phenoxy-propionic acid	III(a,b)	10	7,8	
SH	Fenoxaprop-P-ethyl	Furore Super	Aryloxy-phenoxy-propionic acid	III(a,b)	3,5		
SH	Molinate	N/d	Thiocarbamate	II(a,b)	3,5	4	1
SH	Pendimethalin	Herbadox	Dinitroaniline	III(a,b)	3,5		
SH	Profoxydim	Aura	Cyclohexene oxime	IV(a,b)		7	
SH	Bispyribac sodium	Nominee	Pyrimidinyloxybenzoic	III(b) IV(a)	10	7	
IN	Mineral oil	Iharol & others	Aliphatic hydrocarbon	IV(a,b)		8	
IN	Fipronil	Klap, Standak	Phenylpyrazol	II(a,b)		7	
IN	Gamma-cyhalothrim	Fighter Plus	Pyrethroid	I(b) III(a)	10		
IN	Lambda-cyhalothrin	Karate	Pyrethroid	I(a) III(b)	10	6	
IN	Cypermethrin	Cipermetrina Dupont, Arrivo	Pyrethroid	II(a,b)	10		1
IN	Permethrin	Pounce	Pyrethroid	II(a) III(b)		8	
IN	Endosulfan	Endosulfan	Organochlorine	I(a,b)	10		1
IN	Carbofuran	Furadan & others	Carbamate	I(a,b)		9	1
IN	Carbaryl	Sevin, Ralex & others	Carbamate	II(a,b)			1
IN	Chlorpyrifos	Magnum, Lorsban	Organophosphate	II(a,b)			1
FU	Edifenphos	N/d	Organophosphate	II(a,b)			1
FU	Trifloxystrobin	Stratego 250 EC	Estrobilurin	II(b)		7	
	Propiconazole		Triazole				
FU	Cyproconazole	Alto	Triazole	III(a,b)			1
FU	Flusilazole	Winner	Triazole	II(a,b)			1
FU	Benomyl	Benlate	Benzimidazole	IV(a,b)			1
FU	Carbendazim	Carbendazim & others	Benzimidazole	III(b) IV(a)			1
FU	Captan	Captan & others	Phthalimide	IV(a,b)			1

References: 1) Gamarra (1996), 2) Alvisio (1998), 3) Begenisic (1998), 4) Zaffaroni (1998), 5) Zorrilla (1998), 6) Dias & Burger (2005), 7) H. Ramírez (*in litt.*; agrochemicals used in rice fields of Jaguarão, RS, Brazil), 8) M. Sanyvan Sigales Gonçalves (*in litt.*; harvest 2004-2005), 9) A. Martins de Magalhães Jr. (com. pers.) and 10) M. Serra (com. pers.).

Birds as rice pests

In our study area ducks, pigeons and blackbirds are considered “pest” species (Bucher 1983, Menegheti *et al.* 1990, Silva *et al.* 1997, Vallacco 1998, Silva 1999, Zaccagnini 2002, Dias & Burger 2005). Other waterbird species like the rails, can also have an impact on the rice crop by trampling, e.g. a study undertaken in Colombia found that the Common Gallinules (*Gallinula chloropus*) caused mechanical damage by crushing rice plants when walking around or building their nests (Sedano Cruz 2003). Other rails considered as rice pests are the White-winged Coot (*Fulica leucoptera*) and the Purple Gallinule (*Porphyrio martinicus*) (Zaccagnini 2002).

Ducks are considered especially harmful for rice as they affect the crop during sowing and emergence, crushing the plants on walking trails, when feeding on sprouts and seeds and using rice plants to build their nests (Vallacco 1998). The main duck species considered as rice pests in our study area are the White-faced Whistling-Duck (*Dendrocygna viduata*), Fulvous Whistling-Duck (*D. bicolor*), Rosy-billed Pochard (*Netta peposaca*),Yellow-billed Pintail (*Anas georgica*) and Brazilian Teal (*Amazonetta brasiliensis*) (Bucher 1983, Menegheti *et al.* 1990, Zaccagnini 2002). Pigeons can also be a problem during sowing, especially when seeds are left on the surface or lie very close to ground level (Vallaco1998). Seed poisoning before sowing is used to avoid their consumption by ducks, pigeons and blackbirds, often causing considerable bird mortality (Evia 1996, M. Serra pers. comm.).

The icterids also feed in great numbers in rice fields. The Chestnut-capped Blackbird is notable due to its great abundance in the rice fields of Argentina, Brazil and Uruguay (Rodriguez & Arballo 1995, Silva *et al*. 1997, Vallacco 1998, Silva 1999, Zaccagnini 2002). The Shiny Cowbird has also been reported as a pest species in rice fields in Brazil, Colombia and Venezuela (Sedano Cruz 2003) and to a lesser extent in Argentina (Bucher 1983), and the Bobolink (*Dolichonyx oryzivorus*) is considered a rice pest in Argentina (Bucher 1983, López-Lanús *et al.* in prep.) and in other countries of the region (Elias & Valencia 1983).

CHAPTER 3

Methods and presentation of results

Shorebird species

The present study is to assess the use of rice fields by Nearctic and Neotropical migratory shorebirds (Jacanidae, Rostratulidae, Haematopodidae, Recurvirostridae, Charadriidae and Scolopacidae), including 30 species that are probably present in our study area (Table 1).

The taxonomy and classification employed in this study for shorebirds and other waterbirds is according to Wetlands International (2002), while for other species (passerines and non- passerines) we followed Mazar-Barnett & Pearman (2001).

Survey design

Surveys were mainly carried out in the austral spring-summer season of 2004-2005, with a last campaign extending into early autumn 2005 (Table 2).

The sampled rice fields were not randomly selected. Our choices were based on accessibility and logistics (previous contact with landowners), trying to distribute the surveys as widely as possible within the study area in each country.

At each rice farm visited, surveys were carried out along the internal and surrounding roads by vehicle. Stops were made every 500 meters, to ensure that survey points would not overlap and thus keep them independent. Distances between points were measured with a GPS (Garmin 12). At each stop we carried out "circular plot sampling" (Reynolds *et al.* 1980), trying as far as possible to complete a minimum of six points per rice farm. The technique of point surveys assumes that 100% birds in the area of the point are observed, while those located outside the survey area are observed with decreasing intensity as the distance increases. However, detection of some species in the point survey area was conditioned by the height and density of the rice crop and by the size and habits of the species, and therefore some abundances may have been underestimated.

In each survey, all shorebirds observed in the point area and its aerial space were counted over a 10 minutes period. The point area was determined by a radius that varied between 150 m (Argentina) and 200 m (Brazil and Uruguay). In three surveys undertaken in Brazil the count lasted for more than 10 minutes (12-13 minutes), due to the great quantity of shorebirds in the survey point area.

Counts were made with 8x40 binoculars and a telescope was used for species identification at long distances. Information on the species, number, perpendicular distance to the observer and behavior was recorded for each bird or group of birds. Distances from the observer were estimated and when necessary corroborated with the aid of a "range-finder". As additional data, shorebirds observed in adjacent habitats outside the survey point area were also recorded.

A. Azpiroz

Survey point in a rice field of Rocha, Uruguay.

In Argentina and Uruguay, after counting the shorebirds, other waterbirds and non waterbird species (birds of prey, pigeons, passerines, etc.) present in the survey point area were also counted. Additionally, after the 10 minutes period other waterbirds observed in the same rice field but outside the survey point area, were also recorded.

At each point, as well as counting all the shorebirds, information was collected on:

1) the name of the rice farm and geographic coordinates of the point count.

2) the date, time of beginning and end of the count

3) type of habitat at the point area, including information about:
   a. stage and height of rice (none, 0-5 cm, 6-10 cm, 11-20 cm, > 20 cm)
   b. flooding / water depth (dry, humid, muddy, < 5 cm of water , 6-20 cm, > 20 cm)
   c. presence of other vegetation
   d. % cover of rice, water, border/ bare ground and other vegetation in the point area

4) climatic conditions (wind, cloudiness and rain).

Table 1.- Shorebird species that distribute in our study area.

Family	Vernacular name	Scientific name	Migratory status
Jacanidae	Wattled Jacana	*Jacana jacana*	Neotropical / Non migratory
Rostratulidae	South American Painted-Snipe	*Nycticryphes semicollaris*	Neotropical / Non migratory
Haematopodidae	American Oystercatcher	*Haematopus palliatus*	Neotropical / Non migratory
Recurvirostridae	White-backed Stilt	*Himantopus melanurus*	Neotropical / Non migratory
Charadriidae	Southern Lapwing	*Vanellus chilensis*	Neotropical / Non migratory
	American Golden Plover	*Pluvialis dominica*	Nearctic migrant
	Grey Plover	*Pluvialis squatarola*	Nearctic migrant
	Semipalmated Plover	*Charadrius semipalmatus*	Nearctic migrant
	Collared Plover	*Charadrius collaris*	Neotropical / Non migratory
	Two-banded Plover	*Charadrius falklandicus*	Neotropical / Patagonian migrant
	Rufous-chested Plover	*Charadrius modestus*	Neotropical / Patagonian migrant
	Tawny-throated Dotterel	*Oreopholus ruficollis*	Neotropical / Patagonian migrant
Scolopacidae	Hudsonian Godwit	*Limosa haemastica*	Nearctic migrant
	Eskimo Curlew	*Numenius borealis*	Nearctic migrant
	Whimbrel	*Numenius phaeopus*	Nearctic migrant
	Upland Sandpiper	*Bartramia longicauda*	Nearctic migrant
	Greater Yellowlegs	*Tringa melanoleuca*	Nearctic migrant
	Lesser Yellowlegs	*Tringa flavipes*	Nearctic migrant
	Solitary Sandpiper	*Tringa solitaria*	Nearctic migrant
	Spotted Sandpiper	*Actitis macularia*	Nearctic migrant
	Ruddy Turnstone	*Arenaria interpres*	Nearctic migrant
	Wilson's Phalarope	*Phalaropus tricolor*	Nearctic migrant
	South American Snipe	*Gallinago paraguaiae*	Neotropical / Non migratory
	Red Knot	*Calidris canutus*	Nearctic migrant
	Sanderling	*Calidris alba*	Nearctic migrant
	White-rumped Sandpiper	*Calidris fuscicollis*	Nearctic migrant
	Baird's Sandpiper	*Calidris bairdii*	Nearctic migrant
	Pectoral Sandpiper	*Calidris melanotos*	Nearctic migrant
	Stilt Sandpiper	*Micropalama himantopus*	Nearctic migrant
	Buff-breasted Sandpiper	*Tryngites subruficollis*	Nearctic migrant

Information on the type of habitat was later used to assign each point count to one of the stages in the rice cycle. In cases where the habitat types on either side of the road were different, two half-point counts were considered separately, assigning each of them to the corresponding stage in the rice cycle (see below).

Rice cycle categories

The following rice cycle categories were defined for data analysis, based on habitat variables such as the crop stage / height and flooding conditions (Figure 1):

1) plowed / sown field, not flooded.
2) germinated rice and field not flooded.
3) immature rice <20 cm high and flooded field.
4) green rice >20 cm high and flooded field where the crop had developed vegetatively with ample coverage.
5) milky stage / mature rice and flooded field where the crop has reached maximum height (around 1 m) and coverage. Flooding is maintained until 15 days before harvest, when fields are drained.
6) flooded or dry rice stubble.

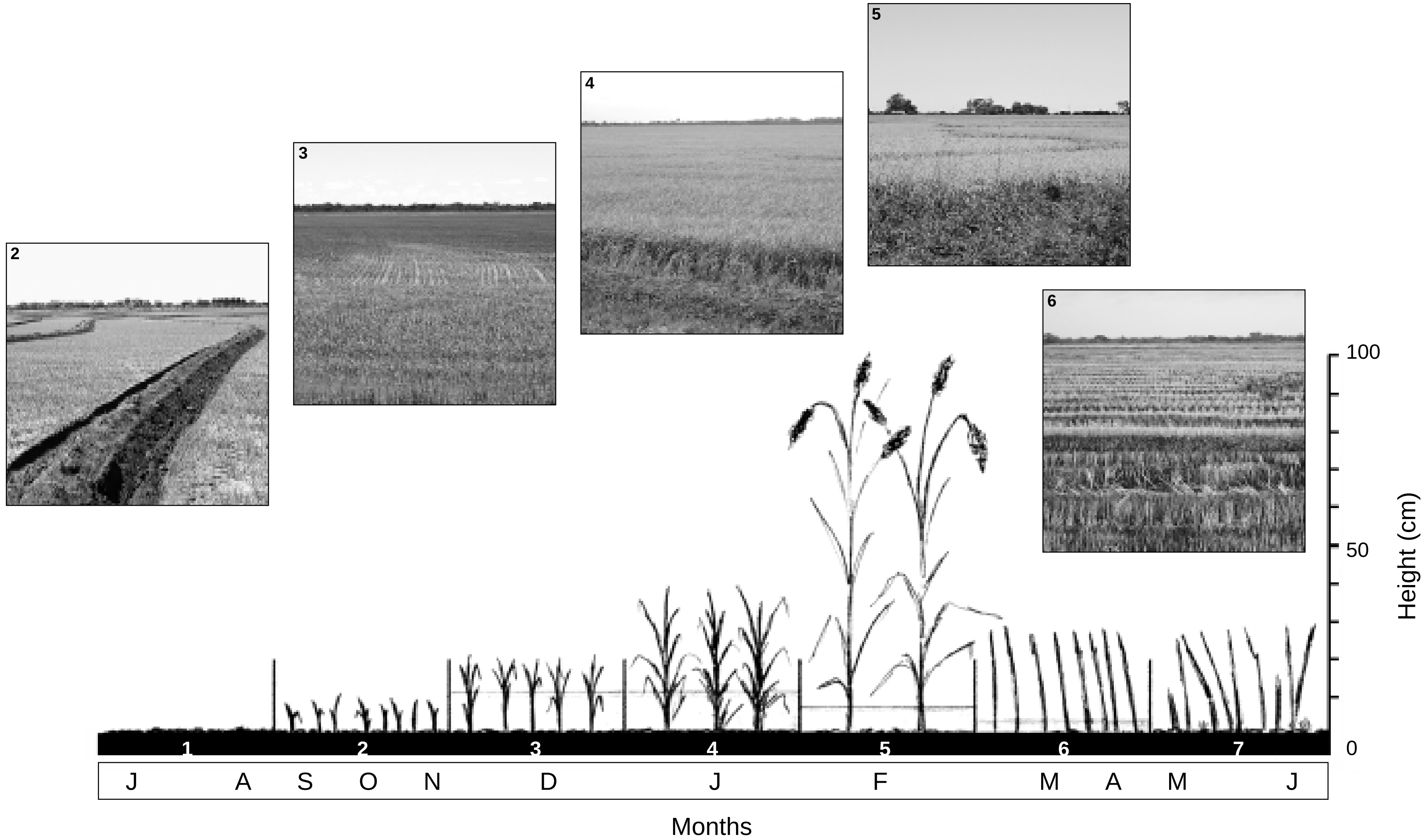


Figure 1.- General scheme of the rice crop cycle in the study area in San Javier (from July to June): 1) field plowed not flooded, 2) germinated rice not flooded, 3) rice <20 cm high and flooded field, 4) green rice >20 cm high and flooded field, 5) milky stage / mature rice and flooded field, 6) flooded rice stubble and 7) dry rice stubble. Photos: D. E. Blanco.

Table 2.- Dates of surveys undertaken in Argentina, Brazil and Uruguay.

Country	2004	2005
Argentina	23-30 November	8-12 March
Brazil	4-6 and 10 December	-
Uruguay	18-24 November 3-5 and 12 December	31 March -3 April

All the stages of the rice crop cycle were sampled, with the exception of "category 1" (plowed / sown field, not flooded). However, since the best habitat conditions for shorebirds are to be expected when fields are flooded and before the rice crop develops vegetatively (Hicklin & Spaans 1992, Acosta 1998, Mugica 2000, Dias & Burger 2005), surveys were concentrated in the Austral spring months and in categories 2 to 4 of the rice crop cycle.

Analysis and presentation of results

For the analysis and presentation of results, the data were grouped according to the survey dates, in two categories:

1) **Austral Spring:** surveys undertaken in November and December 2004, coinciding with the early stages of the rice cycle.
2) **Austral Summer:** surveys undertaken in March and during the first days of April 2005, coinciding with the latter stages of the rice cycle.

Incidence was defined as the frequency of occurrence of a species in the surveys or as the percentage of point counts in which a species was recorded. The incidence of each species was calculated separately for the austral spring and summer. In order to classify the species according to their relative abundances, the following categories were defined based on the average % incidence in the three countries:

1) **Very common**: average incidence > 75%
2) **Common:** 25 < average incidence ≤ 75%
3) **Uncommon**: 3 < average incidence ≤ 25%
4) **Occasional**: average incidence ≤ 3%

In order to analyze the survey effort, the incidences and abundances of the different species, data were considered separately for each country, while in order to analyze changes in species richness and relative abundances as a function of the rice cycle, data from the three countries were analyzed jointly. Species abundance in function of the rice crop cycle was studied using data from the province of Santa Fe (Argentina) and only species with an incidence > 25% in the spring surveys -such as the Southern Lapwing (*Vanellus chilensis*), Pectoral Sandpiper (*Calidris melanotos*) and Lesser Yellowlegs (*Tringa flavipes*)-, were analyzed. In this last analysis, two categories of stubble were differentiated: flooded and dry.

As indicators of abundance, the average densities per species were calculated for the three countries, using the austral spring data. The density at each survey point was calculated as the number of birds counted in function of the point area (or half point area).

In order to analyze for significant differences in shorebird species richness and abundance between countries or stages of the rice cycle the Kruskal-Wallis test and multiple comparisons were used. Point counts without information about the rice crop stage (N=1) and those corresponding to unused rice fields (N=2), were excluded from the analysis.

In order to represent shorebird richness and abundances in function of the rice crop cycle, we utilized graphics to show mean number of birds per category and their associated standard error and standard deviation.

CHAPTER 4

Results

Sampling effort

Surveys undertaken for this study included a total of 341 point counts, 166 in Argentina, 77 in Brazil and 98 in Uruguay; 72% of which were carried out in the austral spring season of 2004 (Table 1).

When we analyzed the distribution of the sampling in relation to the rice cycle, we see that in the spring the counts were undertaken during the stages of *germinated rice not flooded* (N=35), immature *rice and flooded field* (N=142) and *green rice* (N=67). During the summer months, the sampled stages were *milky / mature rice* (N=45) and *rice stubble* (N=49)(Figure 1). For the three countries, the stage best represented in the course of these surveys (largest number of survey points) was the *immature rice and flooded field*.

Species incidence in the surveys

Shorebirds (mainly Charadriidae and Scolopacidae) made up the dominant group among waterbirds observed in rice fields (Figure 2), representing approximately 29% of all recorded species (59 species[1]). Other families that were notable for their species richness were the Rallidae (11 species), Ardeidae (10) and Anatidae (10) (Figure 2; see Chapter 5).

A total of 17 species of shorebirds were recorded in the three countries, including 12 Nearctic migrants and five Neotropical non migratory species [2] (Tables 2 and 3). Patagonian migrant species, such as the Two-banded Plover (*Charadrius falklandicus*), Rufous-chested Plover (*Ch. Modestus*) and Tawny-throated Dotterel (*Oreopholus ruficollis*), were not recorded in the surveys,

D.E. Blanco

Rice field with green rice, where the "taipas" still could be distinguished.

[1] Some waterbirds were only registered outside the survey area as additional species, e.g. *Egretta caerulea, Ixobrychus involucris, Botaurus pinnatus, Dendrocygna autumnalis, Anas georgica, Laterallus melanophaius, Aramides ypecaha, Porzana albicollis, Pardirallus maculatus, Gallinula chloropus, Fulica armillata* and *Fulica rufifrons* (see Chapter 5).

[2] On March 13th, 2006, two *Nycticryphes semicollaris* were recorded outside the survey area on the rice farm Pájaro Blanco (province of Santa Fe, Argentina) in a field of mature rice. This record makes a total of18 species of shorebirds, including six Neotropical ones.

Table 1.- Point counts undertaken by season in each country.

Country	Spring 2004	Summer 2005	Total
Argentina	106	60	**166**
Brazil	77	-	**77**
Uruguay	64	34	**98**
Total	**247**	**94**	**341**

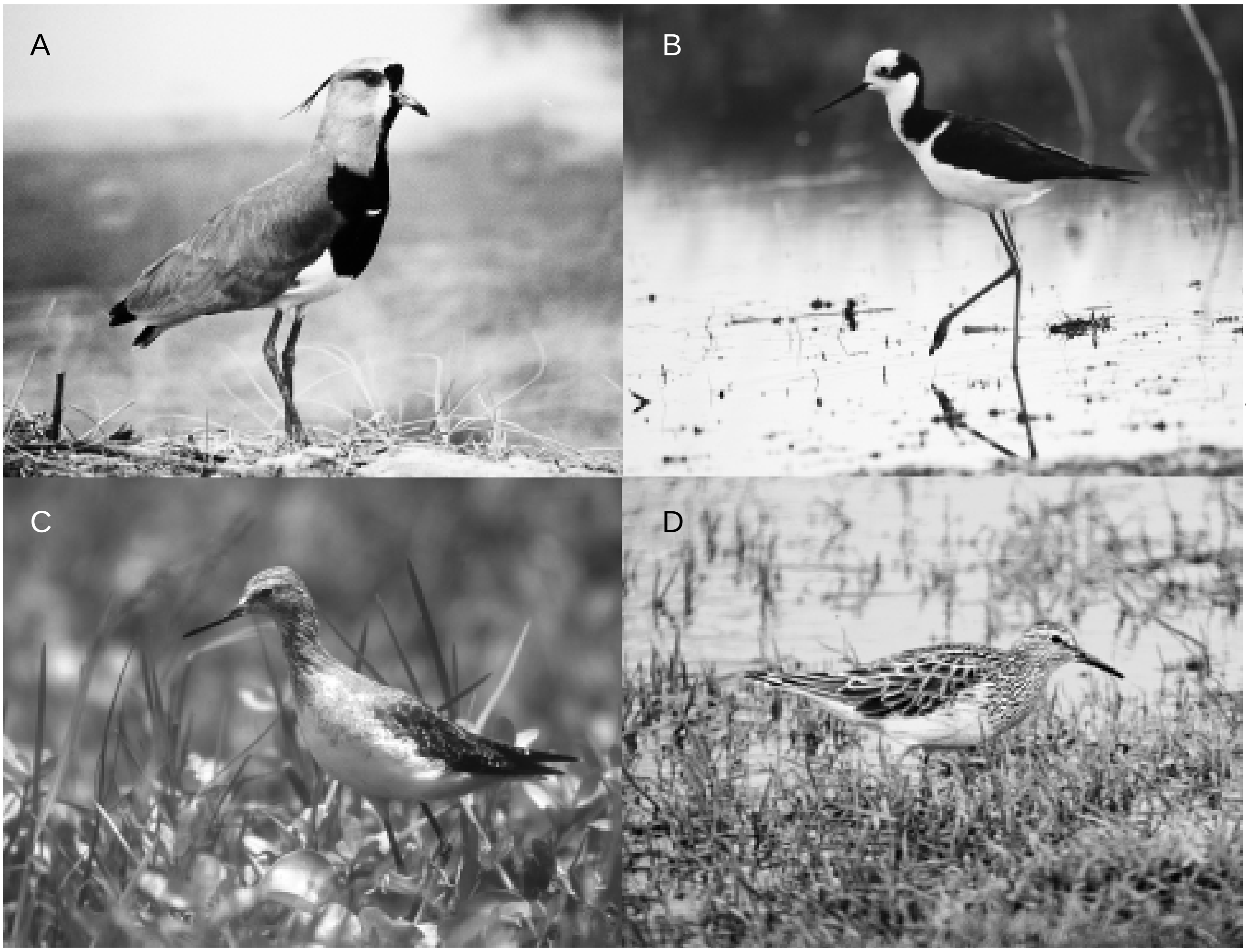
since they had already moved to reproductive areas located further south. Several coastal species were not recorded either, such as the American Oystercatcher (*Haematopus palliatus*), Grey Plover (*Pluvialis squatarola*), Sanderling (*Calidris alba*) and Ruddy Turnstone (*Arenaria interpres*).

The total count and incidence of species varied between countries in the spring as well as in the summer (Tables 2 and 3). In both seasons, the most important shorebirds were the Southern Lapwing (*Vanellus chilensis*) among the Neotropical species (average incidence between 37% and 82.3%) and the Pectoral Sandpiper (*Calidris melanotos*) and Lesser Yellowlegs (*Tringa flavipes*) among the Nearctic migrants.

The most frequent species in the spring, in decreasing order, were the Southern Lapwing, Pectoral Sandpiper, Lesser Yellowlegs, American Golden Plover (*Pluvialis Dominica*), White-backed Stilt (*Himantopus melanurus*) and White-rumped Sandpiper (*Calidris fuscicollis*) (Table 2). The species recorded in ≤3% of the point counts were considered as *occasional species*, as in the case of the Hudsonian Godwit (*Limosa haemastica*),Wilson's Phalarope (*Phalaropus tricolor*), Solitary Sandpiper (*Tringa solitaria*), Upland Sandpiper (*Bartramia longicauda*) and Red Knot (*Calidris canutus*) (Table 2).

Some species showed important differences in their incidence between countries; for example the Pectoral Sandpiper (minimum 22% in Brazil and maximum 71%

Some of the commonest shorebirds in the studied rice fields: Southern Lapwing (A), White-backed Stilt (B), Lesser Yellowlegs (C) and Pectoral Sandpiper (D).



L. Benz
C. del Águila
M. Ruda Vega
R. Güller

Table 2.- Shorebirds recorded in the rice fields of Argentina, Brazil and Uruguay in the austral spring, indicating the total count per country for each species (all surveyed points) and the % incidence in brackets. References: (nr)= not recorded, (ad)= additional species, recorded in rice fields but outside the survey area and (gr)= species observed in grassland adjacent to surveyed rice fields.

Species	Argentina (N=106)	Brazil (N=77)	Uruguay (N=64)	Average Incidence
Very common (average incidence > 75%)				
Southern Lapwing	406 (78%)	1,049 (99%)	810 (70%)	82.3%
Common: (25 < average incidence ≤ 75%)				
Pectoral Sandpiper	1,133 (71%)	77 (22%)	207 (41%)	44.7%
Lesser Yellowlegs	308 (40%)	442 (32%)	278 (58%)	43.3%
American Golden Plover	55 (13%)	1,914 (32%)	2,062 (63%)	36.0%
White-backed Stilt	143 (13%)	161 (19%)	232 (56%)	29.3%
White-rumped Sandpiper	9 (16%)	1,181 (23%)	842 (42%)	27.0%
Uncommon: (3 < average incidence ≤ 25%)				
Greater Yellowlegs	10 (4%)	23 (16%)	48 (27%)	15.7%
Wattled Jacana	6 (1%)	(nr)	84 (48%)	16.3%
South American Snipe	45 (17%)	1 (1%)	25 (14%)	10.7%
Buff-breasted Sandpiper	(gr)	107 (12%)	60 (16%)	9.3%
Collared Plover	26 (9%)	(nr)	1 (2%)	3.7%
Stilt Sandpiper	(nr)	19 (5%)	16 (6%)	3.7%
Occasional (average incidence ≤ 3%)				
Hudsonian Godwit	1 (1%)	4 (1%)	4 (5%)	2.3%
Wilson's Phalarope	(ad)	9 (5%)	(nr)	1.7%
Solitary Sandpiper	4 (4%)	(nr)	(nr)	1.3%
Upland Sandpiper	12 (3%)	(nr)	(nr)	1.0%
Red Knot	(nr)	(nr)	3 (2%)	0.7%

in Argentina) and the American Golden Plover (minimum 13% in Argentina and maximum 63% in Uruguay) (Table 2). Other species showed similar values in all three countries, e.g. Southern Lapwing and Lesser Yellowlegs (Table 2).

In the summer surveys an important decrease was observed in the species richness as well as in the incidence per species (Table 3). The most important species were the Southern Lapwing (decrease in average incidence from 82.3% to 37%), Lesser Yellowlegs (decrease in average incidence from 43.3% to 13%) and Pectoral Sandpiper (decrease in average incidence from 44.7% to 11.5%) (Table 3).

The differences were very striking in the case of Argentina, with an important decrease in the incidence values in the summer and the disappearance of some species observed in the spring, e.g. American Golden Plover, White-rumped Sandpiper, Hudsonian Godwit, Solitary Sandpiper and Upland Sandpiper (Figure 3).

Abundance

When analyzing the abundance by species, significant differences were observed between countries (Table 4), where species with the highest average densities also had the highest average incidences in the surveys (see Table 2). Species with the highest densities, in order of importance, were the American Golden Plover, Southern Lapwing, Pectoral Sandpiper, White-rumped Sandpiper, Lesser Yellowlegs and White-backed Stilt (Table 4).

Table 3.- Shorebirds recorded in rice fields in Argentina and Uruguay in the austral summer, indicating the total count per country for each species (at all surveyed points) and the % incidence in brackets. Note that (nr) refers to "not recorded".

Species	Argentina (N= 60)	Uruguay (N= 34)	Average Incidence
Common (average incidence > 25%)			
Southern Lapwing	42 (27%)	82 (47%)	37,0%
Uncommon (3 < average incidence ≤ 25%)			
Lesser Yellowlegs	75 (20%)	15 (6%)	13,0%
Pectoral Sandpiper	220 (23%)	(nr)	11,5%
White-backed Stilt	8 (7%)	2 (3%)	5,0%
White-rumped Sandpiper	(nr)	5 (9%)	4,5%
Buff-breasted Sandpiper	(nr)	4 (6%)	3,0%
Occasional (average incidence ≤ 3%)			
South American Snipe	1 (2%)	1 (3%)	2,5%
Greater Yellowlegs	7 (3%)	(nr)	1,5%
Wattled Jacana	1 (2%)	(nr)	1,0%
Collared Plover	1 (2%)	(nr)	1,0%

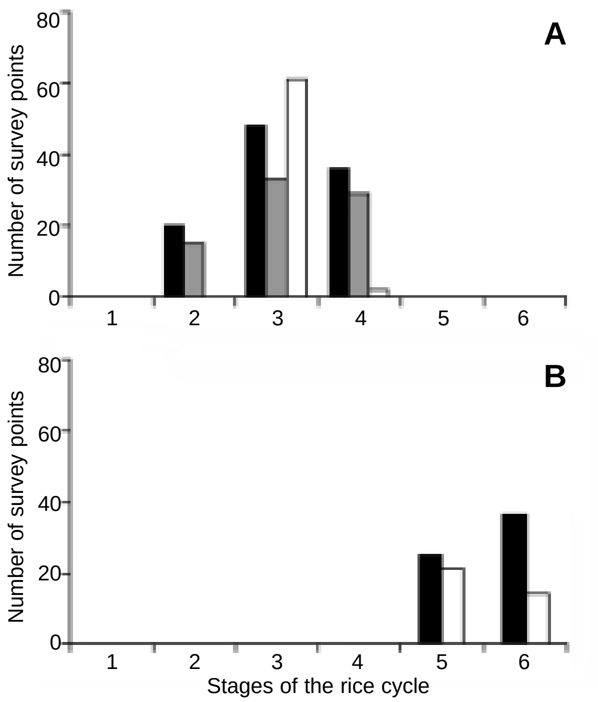


Figure 1.- Sampling in relation to the rice cycle for austral spring (A) and summer (B), in Argentina (black), Brazil (grey) and Uruguay (white). Categories of the rice cycle are: 1) plowed / sown field, 2) unflooded germinated rice, 3) immature rice, 4) green rice, 5) milky / mature rice and 6) rice stubble.

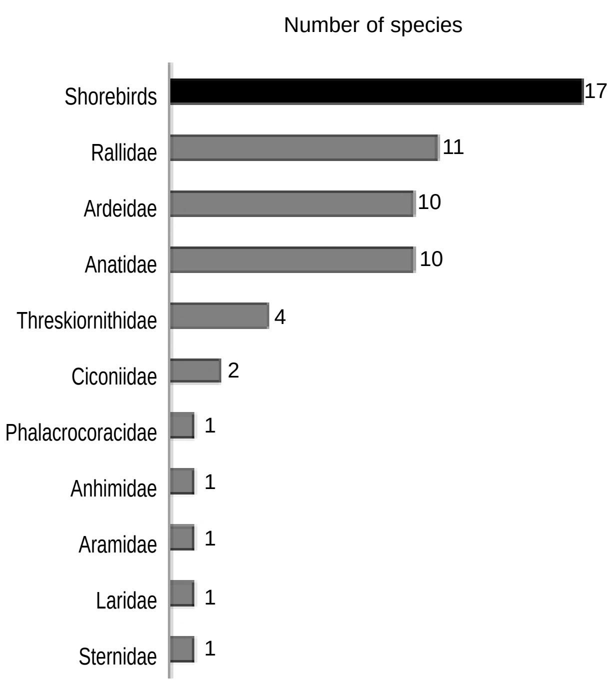


Figure 2.- Taxonomic composition of waterbirds recorded in rice fields of Argentina and Uruguay. The numbers of species are shown at the end of each bar.

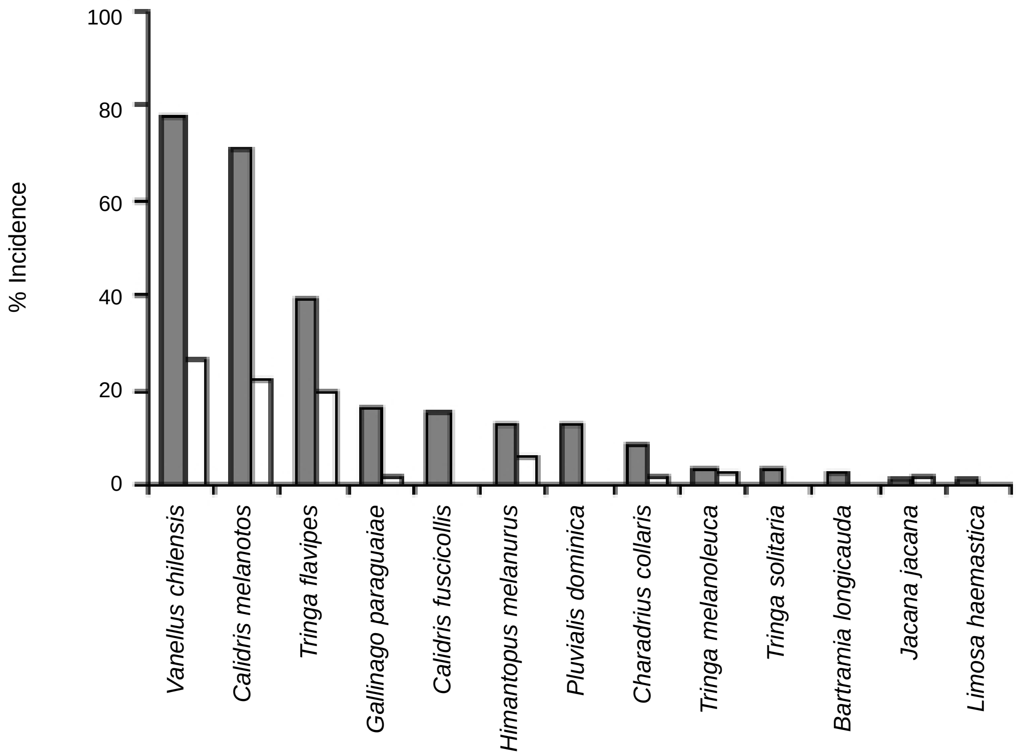


Figure 3.- Percentage of incidence by species in Argentina in austral spring (grey) and summer (white). Occasional species were not included in this graph.

When comparing densities between countries, we see that species such as the American Golden Plover and White-rumped Sandpiper were notably more abundant in Uruguay and Brazil (Table 4, Figure 4), however, when multiple comparisons were applied, no significant differences were encountered. Other species such as the Pectoral Sandpiper presented significantly higher densities in Argentina ($p < 0.0001$) (Table 4, Figure 4).

Very common species

Southern Lapwing (*Vanellus chilensis*) – Very common in spring with 82.3% average incidence in the surveys (Table 2) and densities varying between 0.94 birds/ha in Argentina and 2.02 birds/ha in Uruguay (average density=1.26 birds/ha)(Table 4). The highest counts were in Brazil (1.049 birds) and Uruguay (810 birds) (Table 2). In the summer of 2005, the average incidence went down to 37% (Table 3). Pairs or family groups were observed feeding in rice fields, at both the germinated rice, unflooded, stage as well as later stages of the crop characterized by flooding. Also resting on the field borders.

Common species

Pectoral Sandpiper (*Calidris melanotos*) – Common in spring, with an average incidence of 44.7% in the surveys (Table 2) and densities that varied between 0.08 birds/ha in Brazil and 2.46 birds/ha in Argentina (average density= 1.21 birds/ha)(Table 4). The highest counts corresponded to Argentina with a total of 1,133 birds (71% incidence in surveys; Table 2). They were seen in small groups or flying in large flocks, with a maximum count of 126 birds in a rice field on San Roque farm (Santa Fe, Argentina; November 23, 2004). In the summer of 2005, the species was only recorded in Argentina with 23% incidence in the surveys (Table 3). It frequents flooded rice fields together with the Lesser Yellowlegs, White-rumped Sandpiper and American Golden Plover, feeding in shallow waters and muddy areas and walking along the field borders near to the edge of the water. It was seen resting on the borders and in the middle of the dense rice of low height, where only the birds' heads were visible; in contrast to other species which generally prefer more open areas in the rice fields.

Lesser Yellowlegs (*Tringa flavipes*) – Common in spring with 43.3% average incidence in the surveys (Table 2) and densities that varied between 0.46 birds/ha in Brazil and 0.71 birds/ha in Argentina (average density= 0.63 birds/ha)(Table 4). The highest counts were recorded in Brazil, with a total of 442 birds counted (Table 2). In summer, the average incidence decreased to 13% (Table 3). This species was observed in small groups and mixed flocks together with the Pectoral Sandpiper and the Greater Yellowlegs, feeding in flooded rice fields. They were also seen resting on field borders.

Table 4.- Shorebird densities by country (birds/ha ± standard deviation), general average for the austral spring season (birds/ha) and Kruskal-Wallis test for analyzing differences between countries (* =0.05 > p > 0.01; ** =0.01 > p > 0.001; *** = p < 0.001). Most common species are indicated in bold type. Occasional species are excluded from this table. Note that (nr) refers to "not recorded".

Species	**Argentina** (N= 104)	**Brazil** (N= 77)	**Uruguay** (N= 63)	**General Average** (N= 244)	**Kruskal-Wallis test H** (2, N=244)
American Golden Plover	**0.13 (±0.55)**	**1.98 (±5.34)**	**5.21 (±6.90)**	**2.03**	57.3692 ***
Southern Lapwing	**0.94 (±1.81)**	**1.08 (±0.93)**	**2.02 (±2.39)**	**1.26**	14.1952 ***
Pectoral Sandpiper	**2.46 (±4.35)**	**0.08 (±0.21)**	**0.52 (±1.17)**	**1.21**	64.7848 ***
White-rumped Sandpiper	**0.01 (±0.08)**	**1.22 (±4.91)**	**2.13 (±4.14)**	**0.94**	38.5860 ***
Lesser Yellowlegs	**0.71 (±1.81)**	**0.46 (±1.50)**	**0.70 (±1.07)**	**0.63**	12.1622 **
White-backed Stilt	**0.37 (±2.43)**	**0.17 (±0.53)**	**0.58 (±1.01)**	**0.36**	39.0768 ***
Buff-breasted Sandpiper	(nr)	0.11 (±0.47)	0.15 (±0.46)	0.07	16.1081 ***
Wattled Jacana	0.02 (±0.17)	(nr)	0.21 (±0.27)	0.06	91.4350 ***
South American Snipe	0.10 (±0.40)	< 0.01 (±0.01)	0.06 (±0.23)	0.06	11.3198 **
Greater Yellowlegs	0.03 (±0.20)	0.02 (±0.07)	0.12 (±0.30)	0.05	17.0134 ***
Collared Plover	0.07 (±0.34)	(nr)	< 0.01 (±0.02)	0.03	11.2549 **
Stilt Sandpiper	(nr)	0.02 (±0.14)	0.04 (±0.20)	0.02	6.2867 *

American Golden Plover (*Pluvialis dominica*) – Common in spring with 36% average incidence in the course of these surveys (Table 2) and densities that varied between 0.13 birds/ha in Argentina and 5.21 birds/ha in Uruguay (average density= 2.03 birds/ha) (Table 4).The highest counts were in Uruguay (2,062 birds) and Brazil (1,914 birds) (Table 2). They were observed in small groups, in some cases up to 100-200 birds per survey point, with a maximum count of 442 birds in the rice field of Sobrado (Jaguarão, Brazil; 10 Dec. 2004). It was not recorded in the summer months. It feeds in rice fields with little water or in the unflooded sectors. It was also observed resting on field borders.

White-backed Stilt (*Himantopus melanurus*) – This species was common in spring with 29.3% average incidence in the surveys (Table 2) and densities that varied between 0.17 birds/ha in Brazil and 0.58 birds/ha in Uruguay (average density= 0.36 birds/ha)(Table 4). The highest counts were made in Uruguay, with 232 total birds (Table 2). In the summer of 2005 the average incidence decreased to 5% (Table 3). They were observed in small groups feeding on flooded rice fields with the yellowlegs (*Tringa* spp.).

White-rumped Sandpiper (*Calidris fuscicollis*) – Common in spring with a 27% average incidence in the surveys (Table 2) and densities that varied between 0.01 birds/ha in Argentina and 2.13 birds/ha in Uruguay (average density= 0.94 birds/ha)(Table 4). The highest counts were in Brazil (1,181 birds) and Uruguay (842 birds) (Table 2). This sandpiper was seen in small and medium sized groups in the company of the Pectoral Sandpiper and American Golden Plover, with a maximum count of 475 birds recorded in a rice field in Sobrado (Jaguarão, Brazil; Dec. 10, 2004). Scarce in the summer of 2005 and recorded only in Uruguay (Table 3). They preferred to feed in flooded rice fields in sectors with shallow waters.

Uncommon species

Greater Yellowlegs (*Tringa melanoleuca*) – Not very common in spring with 15.7% of average incidence in surveys (Table 2) and densities that varied between 0.02 birds/ha in Brazil and 0.12 birds/ha in Uruguay (average density= 0.05 birds/ha)(Table 4). The highest counts occurred in Uruguay with a total of 48 birds recorded (Table 2). They were seen alone or in small groups with the Lesser Yellowlegs, feeding in flooded rice fields. In the summer of 2005 the species was only recorded in Argentina with an incidence of 3% (Table 3).

Wattled Jacana (*Jacana jacana*) – Not a very common species in spring with a 16.3% average incidence in the surveys (Table 2) and densities that varied between 0.02 birds/ha in Argentina and 0.21 birds/ha in Uruguay (Table 4). In Uruguay, it reached an incidence of 48% in the austral spring surveys (Table 2). In Brazil the species was not recorded in surveys, but was observed in irrigation canals with abundant floating vegetation and occasionally on the borders of the rice fields.

South American Snipe (*Gallinago paraguaiae*) – Not very common in spring with 10.7% average incidence in the surveys (Table 2) and densities that varied between <0.01 birds/ha in Brazil and 0.10 birds/ha in Argentina (average density= 0.06 birds/ha)(Table 4). In the summer of 2005, its incidence in the surveys decreased considerably (Table 3), although it is difficult to make comparisons with this species due to its cryptic and mimetic habits. They were seen as solitary birds, in pairs or small groups were seen in flooded rice fields and resting on field borders. A rare species in the rice fields of southern Rio Grande do Sul, Brazil.

Buff-breasted Sandpiper (*Tryngites subruficollis*) – Not very common in spring, with 9.3% average incidence in the surveys (Table 2), and densities that varied between 0.11 birds/ha in Brazil and 0.15 birds/ha in Uruguay (Table 4), resulting in total counts of 107 and 60 birds, respectively (Table 2). It was seen in small groups with a maximum count of 45 birds in the rice field of São Lourenço (Santa Vitoria do Palmar, Brazil; Dec. 6th, 2004). In Argentina, the species was twice recorded outside the surveys, with a maximum count of eight birds along with 210 American Golden plovers in a heavily grazed grassland next to a rice field.

Collared Plover (*Charadrius collaris*) – Not very common and seen in spring in Argentina (incidence= 9%) and Uruguay (incidence= 2%) (Table 2). The density for this species in Argentina was 0.07 birds/ha (Table 4). It was seen in small groups on unflooded rice fields with germinated rice and resting on field borders and embankments.

Stilt Sandpiper (*Micropalama himantopus*) – Not very common in spring with 3.7% average incidence in the surveys (Table 2) and densities that varied between 0.02 birds/ha in Brazil and 0.04 birds/ha in Uruguay (Table 4). It was not recorded in Argentina.

Occasional species

Hudsonian Godwit (*Limosa haemastica*) – Occasional in spring with 2.3% average incidence in the surveys (Table 2). It was observed in flooded rice fields.

Wilson's Phalarope (*Phalaropus tricolor*) – Occasional in spring and only recorded in the Brazilian surveys with 5% incidence (Table 2). In Argentina, it was recorded as an additional species. It was seen alone or in small groups with the Lesser Yellowlegs, in flooded rice fields and on open water.

Solitary Sandpiper (*Tringa solitaria*) – Occasional and recorded in spring exclusively in Argentina (incidence= 4%)(Table 2). It was seen alone or with the Lesser Yellowlegs, feeding on flooded rice fields and along irrigation canals and ditches. It was also observed resting on field borders.

Upland Sandpiper (*Bartramia longicauda*) – Occasional and only recorded in spring in Argentina, with 3% incidence in the surveys (Table 2). In pairs or dispersed groups, feeding in unflooded rice fields with germinated rice. It was also observed resting on field borders.

Red Knot (*Calidris canutus*) – Occasional in spring. Only three birds were recorded in a rice field in the department of Treinta y Tres, Uruguay (Nov. 18th, 2004)

Changes in the shorebird community in function of the rice crop cycle

When analyzing changes in the parameters of the shorebird community in relation to the rice crop cycle, we found significant differences between stages, in the species richness (Kruskal-Wallis test H [4,N= 338]= 153.44, p< 0.001), as well as in the total abundances (Kruskal-Wallis test H [4, N= 338] 162.48, p < 0.001), a pattern that was repeated when considering the Nearctic (Kruskal-Wallis test H [4, N= 338]= 111.84, p < 0.001)

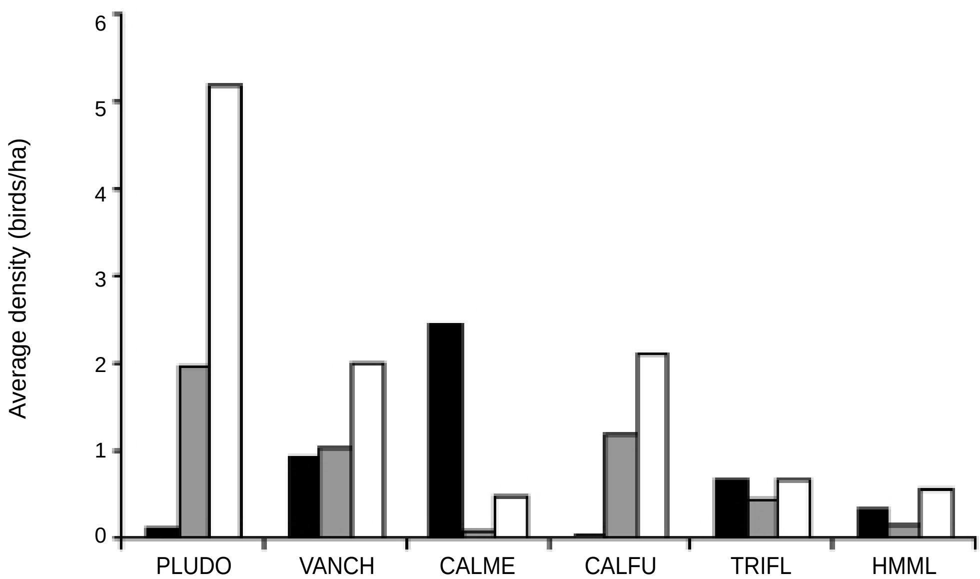


Figure 4.- Average densities of the most common shorebirds in spring in the rice fields of Argentina (black), Brazil (grey) and Uruguay (white): American Golden Plover (*Pluvialis dominica;* PLUDO), Southern Lapwing (*Vanellus chilensis;* VANCH), Pectoral Sandpiper (*Calidris melanotos;* CALME), White-rumped Sandpiper (*Calidris fuscicollis;* CALFU), Lesser Yellowlegs (*Tringa flavipes;* TRIFL) and White-backed Stilt (*Himantopus melanurus;* HIMML).

and the Neotropical species separately (Kruskal-Wallis test H [4, N= 338] 138.62, p < 0.001) (Figure 5).

The species richness was highest at the immature rice stage (X=3.79±2.11, N=142), with decreasing values for the stages of green rice (X=2.54±1.61, N=67), unflooded germinated rice (X=1.48±1.67, N=35) and rice stubble (X=1.39±1.30, N=49) (Figure 5). The minimum value corresponded to the milky / mature rice stage (X=0.22±0.42, N=45). When applying multiple comparisons, significant differences were observed between the stages of immature rice and green rice and the remaining stages (p < 0.00001), and between the stages of milky / mature rice and the rice stubble (p= 0.00071).

The total abundances reached a peak at the immature rice stage (X=9.64±10.94 birds/ha, N=142), decreasing notably to densities of < 4 birds/ha for the rest of the crop cycle stages (Figure 5). Minimum values corresponded to the milky / mature rice stage (X=0.19±0.56, N=45). When applying multiple comparisons there were significant differences between stages of immature rice and green rice and the remaining stages (p < 0.00001), and between stages of milky / mature rice and rice stubble (p= 0.00169), as happened in the case of species richness.

Changes of species abundance in function of the rice crop cycle

When analyzing abundances of the most common species in function of the rice crop cycle, significant differences were found between stages, for the Southern Lapwing (Kruskal-Wallis test H [5, N= 164]= 48.70, p < 0.0001), Pectoral Sandpiper (Kruskal-Wallis test H [5, N=164]= 63.48, p < 0.0001) and Lesser Yellowlegs (Kruskal-Wallis test H [5, N= 164]= 30.27, p < 0.0001).

Southern Lapwing – This species was recorded in all stages of the rice cycle, reaching a peak of abundance at the immature rice stage (X=1.39±2.55 birds/ha, N=48), with intermediate densities in paddies with green rice (X=0.56±0.49 birds/ha, N=36) and unflooded germinated rice (X=0.52±0.51 birds/ha, N=20), and lower densities in the later stages of the rice cycle (Figure 6). Minimum values were obtained in the stage

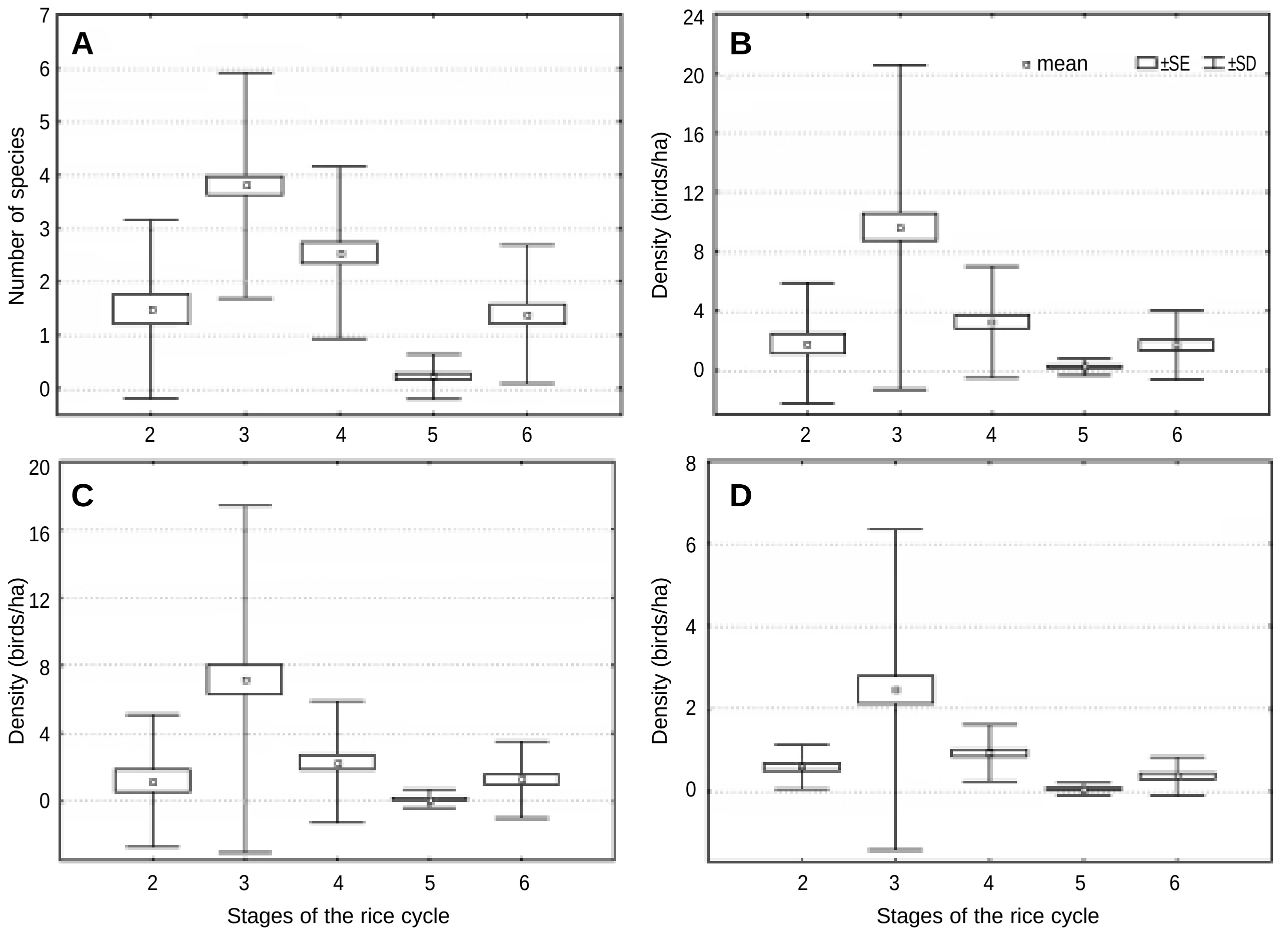


Figure 5.- Shorebird richness (A), total abundance (B) and abundance of Nearctic (C) and Neotropical (D) species, in function of the rice cycle in southern South America (Argentina, Brazil and Uruguay). Stages of the rice cycle are: 2) unflooded germinated rice, 3) immature rice, 4) green rice, 5) milky / mature rice and 6) rice stubble. SE: standard error; SD: standard desviation.

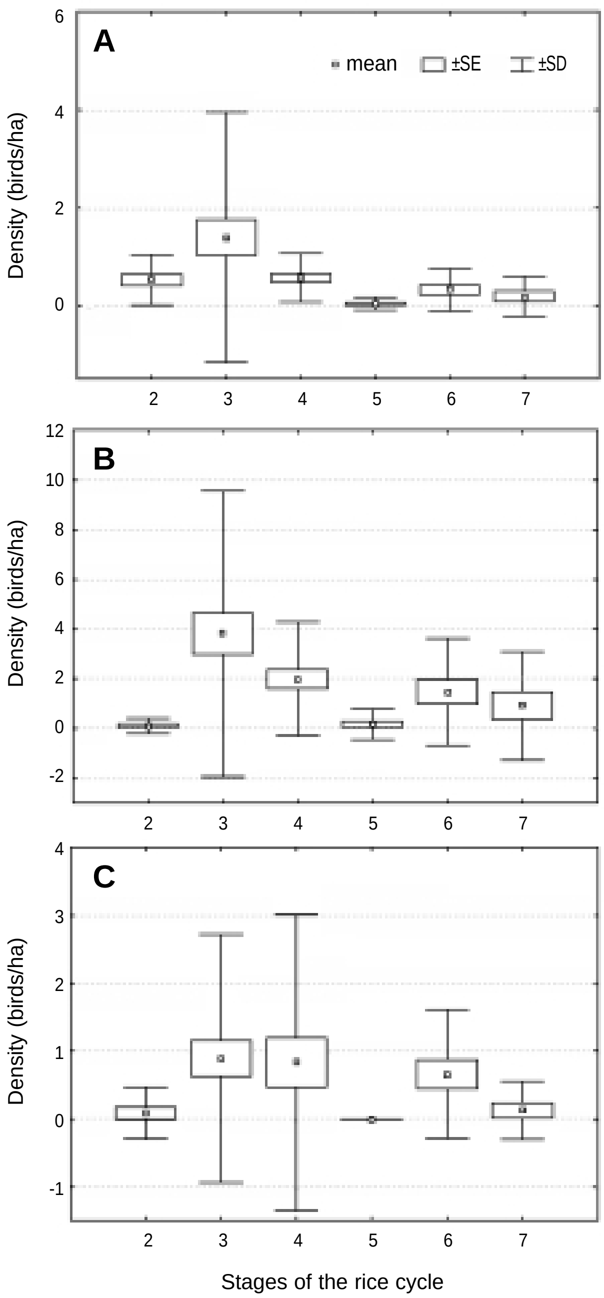


Figure 6.- Shorebird abundances: A) Southern Lapwing (*Vanellus chilensis*), B) Pectoral Sandpiper (*Calidris melanotos*) and C) Lesser Yellowlegs (*Tringa flavipes*), in function of the rice cycle in the central-east part of the Santa Fe province, Argentina. Stages of the rice cycle are: 2) unflooded germinated rice, 3) immature rice, 4) green rice, 5) milky / mature rice, 6) flooded rice stubble and 7) dry rice stubble. SE: standard error; SD: standard desviation.

of milky / mature rice. When multiple comparisons were applied, significant differences were found between the immature rice and green rice and the remaining stages ($p < 0.001$), which suggests greater use of rice fields at early crop stages during spring. It should be pointed out that in contrast to the majority of shorebirds, the lapwing frequently used paddies with dry ground (Figure 6). Accordingly, significant differences were found in the species abundance when comparing fields of unflooded germinated rice and dry rice stubble ($p= 0.0072$) and a preference for the former habitat type was observed.

Pectoral Sandpiper – A peak in the abundance of this species was reached at the immature rice stage (X=3.80±5.75 birds/ha, N=48, maximum value=35.65 birds/ha), with decreasing values in paddies with green rice (X=1.98±2.28 birds/ha, N=36) and flooded rice stubble (X=1.47±2.16 birds/ha, N=20) (Figure 6). In the other stages, the abundance was < 1 bird/ha and in many cases they corresponded to birds flying over the rice field. When applying multiple comparisons, significant differences were observed between the stages of immature rice and green rice and the remaining stages ($p < 0.001$), while greater use of flooded rice fields at early stages of the rice cycle were observed during spring.

Lesser Yellowlegs – The maximum abundance of this species was reached at the immature(X=0.89±1.83 birds/ha, N=48) and green rice (X=0.83±2.18 birds/ha, N=36) stages, with intermediate values at the stage of flooded rice stubble (X=0.66±0.95 birds/ha, N=20) and low values in paddies with dry ground (unflooded germinated rice and dry rice stubble). In the latter case, the majority of birds were flying (Figure 6). The species was not seen in paddies of milky / mature rice. When applying multiple comparisons, no significant differences were observed between the immature and green rice stages, but there were significant differences between these two separately and the remaining stages ($p < 0.0001$). Significant differences were also found between flooded and dry rice stubble ($P=0.011$), suggesting the importance of this variable in the generation of a favorable feeding habitat for this species.

CHAPTER 5

Other bird species that use rice fields

Apart from shorebirds, another 103 bird species were recorded (including 42 waterbird species and 61 non-waterbird species) over all the surveys undertaken in the rice fields of Argentina and Uruguay.

Waterbird species

Apart from shorebirds, a total of 42 waterbird species (10 families) were recorded. Important variations in the species abundances were observed between countries and seasons (see Annex 1).

The most abundant species in both countries (>50 birds counted), in order of importance, were: White-faced Ibis (*Plegadis chihi;* 3,932 birds), Southern Screamer (*Chauna torquata;* 309), White-faced Whistling-Duck (*Dendrocygna viduata;* 194), Cattle Egret (*Ardea ibis;* 130), Rosy-billed Pochard (*Netta peposaca;* 127), Speckled Teal (*Anas flavirostris;* 106), Brazilian Teal (*Amazonetta brasiliensis;* 97), Maguari Stork (*Ciconia maguari;* 95), Bare-faced Ibis (*Phimosus infuscatus;* 85), Fulvous Whistling-Duck (*Dendrocygna bicolor;* 66), Ringed Teal (*Callonetta leucophrys;* 55) and Great Egret (*Ardea alba;* 52)(see Annex 1).

The most notable groups were the herons (Ardeidae), storks (Ciconiidae), ibises (Threskiornithidae) and the Anseriformes (Anhimidae and Anatidae) (Annex 1, Figure 1). When comparing the data from spring and summer, remarkable seasonal changes in the relative abundance and incidence were observed for most families, with a general increasing trend observed for the incidence in the summer months (Figure 1).

Phalacrocoracidae.- The Neotropic Cormorant (*Phalacrocorax brasiliensis*) was recorded in Argentina almost exclusively over the summer surveys (Annex 1, Figure 1), and in all cases, the birds were observed in flight at the survey point. This species was not recorded inside the rice fields, but feeding in the irrigation canals and resting on the embankments that surround the fields.

The herons (family Ardeidae) were dominant species in rice fields, mainly at the early stages of the rice cycle.

B. López-Lanús

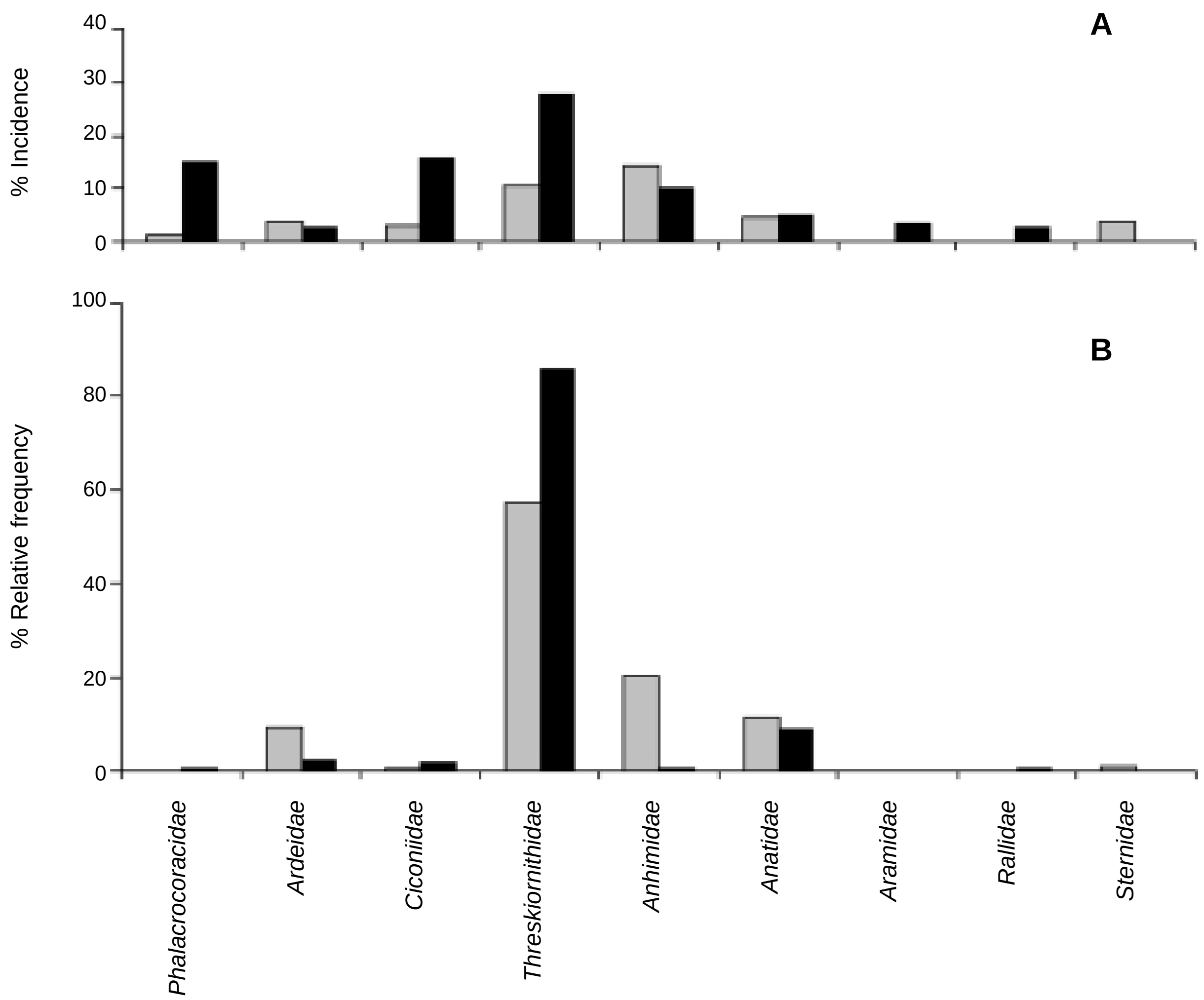


Figure 1.- The average incidences (A) and relative frequencies (B) of waterbirds per family in the rice fields of Santa Fe (Argentina), in the austral spring (grey) and summer (black).

Ardeidae.- Ten species of herons were recorded (see Annex 1), including the Little Blue Heron (*Egretta caerulea*) –a species rarely recorded in Argentina– as well as two species with cryptic habits that were observed as additional species outside the surveys: the Pinnated Bittern (*Botaurus pinnatus*) and Stripe-backed Bittern (*Ixobrychus involucris*). This group was especially significant in Argentina during the austral spring (Figure 1), due to the higher abundance of the Great Egret, Cattle Egret and Snowy Egret (*Egretta thula*) in the early stages of the rice cycle (Annex 1). These species were seen feeding in the rice fields.

Ciconiidae.- Two species were recorded in both countries (Annex 1). In Argentina, the highest incidence occurred in the summer (Figure 1), due to an increase in the records of American Wood Storks (*Mycteria americana*), primarily birds flying over the survey points (68% of observations). Both species were also recorded in the summer surveys in Uruguay, where the abundance of the Maguari Stork was remarkable, with records of the species in 21% of the survey points (Annex 1).

Threskiornithidae.- The most abundant group with four species recorded (Annex 1). The abundance of the White-faced Ibis (3,932 birds) and the record of Plumbeous Ibis (*Theristicus caerulescens*) in Uruguay are especially noteworthy. In Argentina, the dominance of this family in respect to other waterbird groups was evident, as well as the remarkable differences in incidence between seasons (Figure 1), due primarily to an increase in the abundances of the White-faced and Bare-faced ibises in summer (Annex 1). A total of 2,310 White-faced ibises were recorded in the March 2005 surveys (Annex 1), of which 94% were birds flying over the survey points (1,368 birds), thus suggesting that considerable local movements were taking place at the time.

Big numbers of Southern Screamers (*Chauna torquata*) in a rice field of San Javier, Santa Fe province, Argentina.

Anhimidae.- The Southern Screamer was recorded in both countries, with a total count of 309 birds recorded and an incidence in the surveys that varied between 10% and 15% (Annex 1). The species was mainly recorded in Argentina with remarkable differences in abundances between seasons, with a total count of 289 birds recorded in the austral spring (Annex 1, Figure 1). During this season and outside of survey points, hundreds of screamers were observed in the rice fields at early stages of the crop cycle.

Anatidae.- Ten duck species were recorded in the rice fields, among which the White-faced Whistling-Duck and Speckled Teal in Uruguay and the Rosy-billed Pochard in Argentina were especially notable for their abundance (Annex 1). At the group level, no important variations were observed in the relative abundances and incidences when comparing both seasons (Figure 1). However, in Argentina, some species were more abundant (Brazilian Teal) or only recorded (Ringed Teal) in the austral spring, while others were more abundant (Rosy-billed Pochard) or only recorded (Fulvous Whistling-Duck) in summer (Annex 1).

Aramidae.- The Limpkin (*Aramus guarauna***)** was recorded exclusively in the summer surveys and mainly in Uruguay (Annex 1, Figure 1).

Rallidae.- Eleven species of rails were recorded in both countries, of which seven were seen outside the survey points as additional species (Annex 1)[1]. It should be noted that this group has probably been underestimated, due to their cryptic habits. Another aspect that should be mentioned is the use of rice fields as a breeding habitat, which was confirmed for the Purple Gallinule (*Porphyrio martinicus*) based on observations of juvenile birds.

Laridae.- Only one species recorded, the Brown-hooded Gull (*Larus maculipennis*), in 15% of survey points and only in the rice fields of Uruguay (Annex 1). In 95% of cases the observations were of birds flying over the survey points.

Sternidae.- Only one species recorded, the Large-billed Tern (*Phaetusa simplex*), exclusively in the spring surveys in Argentina (Annex 1). Observations involved birds feeding in the rice fields and resting on the field borders.

[1] Most of the species of the Rallidae were detected by their calls and/or by observation after flushing. In the alter case observations were made from a combine harvester. Three or four combines start to harvest side by side at the outside edge of the field and move inwards in the form of a spiral. In doing this they “herd” a large percentage of the Rallidae present towards the centre of the stand of rice. Which resulted in an excellent opportunity for observing the species of the Rallidae that are found in the rice fields.

Non-waterbird species

A total of 61 non-waterbird species were recorded during the surveys and included birds within eight taxonomic orders. As for waterbirds, important variations in abundances among countries and between seasons were observed (Annex 2). More than half of the recorded species were passerines (38 species). Other groups that were notable for their species richness were the birds of prey (13 species) and pigeons (5 species) (Annex 2).

The most abundant species in both countries (>50 birds counted), in order of importance, were: Chestnut-capped Blackbird (*Agelaius ruficapillus;* 3,736 birds), Bobolink (*Dolichonyx oryzivorus;* 916), Yellow-winged Blackbird (*Agelaius thilius;* 273), White-rumped Swallow (*Tachycineta leucorrhoa;* 185), Grassland Yellow-Finch (*Sicalis luteola;* 173), Brown-chested Martin (*Progne tapera;* 164), Eared Dove (*Zenaida auriculata;* 106), Snail Kite (*Rosthramus sociabilis;* 77), Barn Swallow (*Hirundo rustica;* 77), Monk Parakeet (*Myiopsitta monachus;* 67), Southern Crested-Caracara (*Caracara plancus;* 63) and White-browed Blackbird (*Sturnella superciliaris;* 57) (Annex 2).

The abundances of the Passeriformes should be noted here. The relative frequencies of passerines in the Argentine surveys varied between 70% in spring and 93% in summer, followed by the birds of prey (Order Falconiformes) and the pigeons (Order Columbiformes) (Annex 2, Figure 2). Seasonal changes in the contribution of the different orders were most evident, with an increase in abundances of passerines and a decrease in the abundances of birds of prey and pigeons during the austral summer season (Figure 2).

With respect to the Passeriformes, important seasonal variations in their abundances were observed (Figure 3). In the austral spring the families Hirundinidae, Icteridae and Tyrannidae were noteworthy for their abundances (Figure 3). Over the summer months, the dominance of the family Icteridae was clearly noticeable, with an increase in its relative frequency from 34% in spring to 93% in summer, reflecting an important increase in the abundance of this family, mainly the Chestnut-capped Blackbird (Annex 2, Figure 3).

The Chestnut-Capped Blackbird (*Agelaius ruficapillus*) was noteworthy due to its abundance.

R. Güller

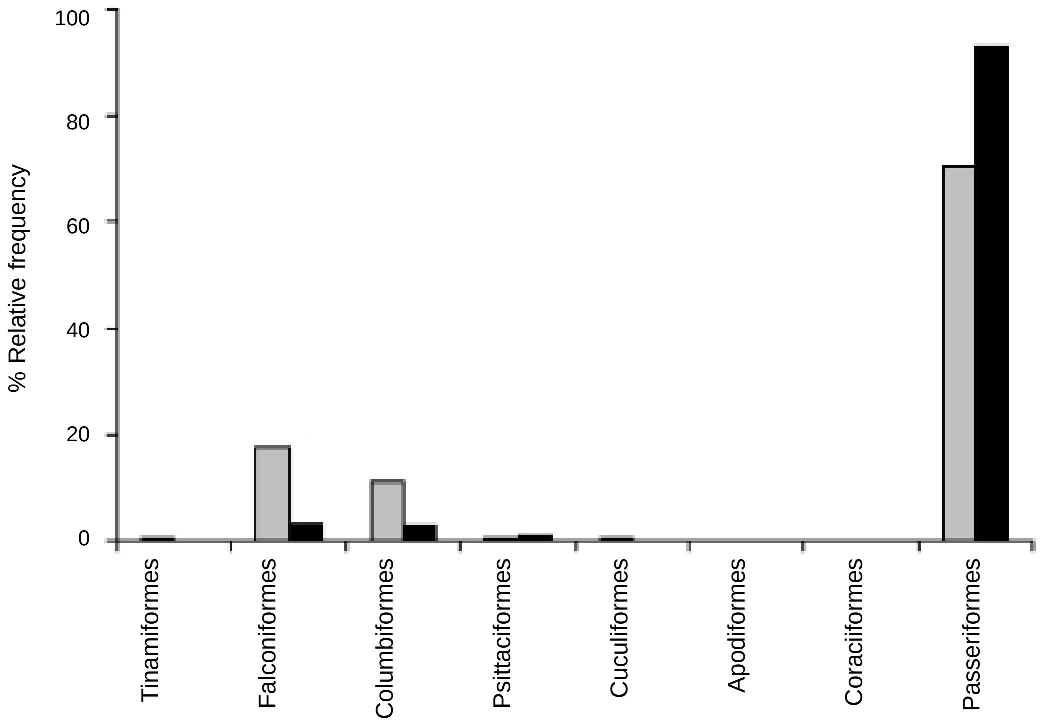


Figure 2.- Relative frequencies of non-waterbird species grouped by Order, in the rice fields of Santa Fe (Argentina), in the austral spring (grey) and summer (black).

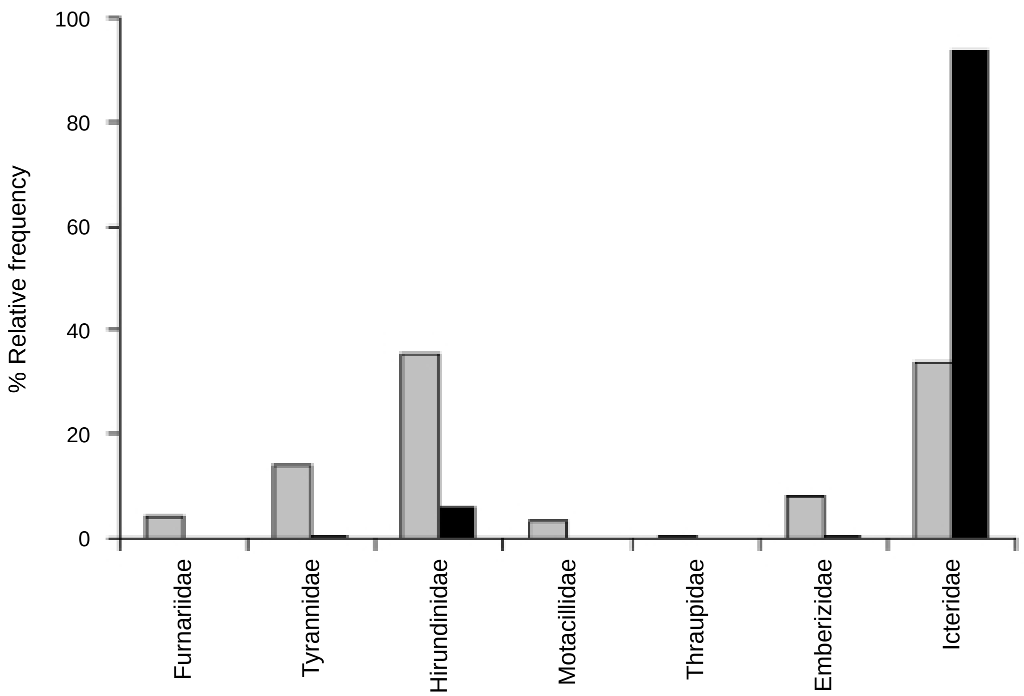


Figure 3.- Relative frequencies of passerines grouped by family, in the rice fields of Santa Fe (Argentina), in the austral spring (grey) and summer (black).

Annex 1.- Other waterbirds recorded in the rice fields of Argentina and Uruguay. For each species we indicate the total count (all survey points) and the incidence (in brackets) by country and season, and the general count (in bold the most abundant species = general count > 50 birds). (nr) = not recorded and (ad) refers to additional species recorded in rice fields but outside the surveys.

Species	Argentina spring (N=106)	Argentina summer (N=60)	Uruguay summer (N=34)	General Count (N=200)
Phalacrocoracidae				
Phalacrocorax brasiliensis	1 (1%)	12 (15%)	(nr)	13
Ardeidae				
Ardea cocoi	(ad)	(ad)	4 (9%)	4
Ardea alba	**39 (9%)**	**8 (10%)**	**5 (9%)**	**52**
Ardea ibis	**75 (7%)**	**46 (3%)**	**9 (3%)**	**130**
Butorides striatus	(ad)	2 (2%)	(nr)	2
Egretta caerulea	(ad)	(nr)	(nr)	(ad)
Egretta thula	15 (4%)	(nr)	5 (9%)	20
Syrigma sibilatrix	3 (3%)	(nr)	(nr)	3
Nycticorax nycticorax	(nr)	1 (2%)	1 (3%)	2
Botaurus pinnatus	(nr)	(ad)	(nr)	(ad)
Ixobrychus involucris	(nr)	(ad)	(nr)	(ad)
Ciconiidae				
Mycteria americana	1 (1%)	31 (15%)	12 (9%)	44
Ciconia maguari	**8 (5%)**	**12 (17%)**	**75 (21%)**	**95**
Threskiornithidae				
Theristicus caerulescens	(nr)	(nr)	4 (9%)	4
Phimosus infuscatus	**6 (2%)**	**21 (18%)**	**58 (26%)**	**85**
Plegadis chihi	**812 (29%)**	**2,310 (62%)**	**810 (59%)**	**3,932**
Ajaia ajaja	(nr)	3 (3%)	5 (12%)	8
Anhimidae				
Chauna torquata	**289 (14%)**	**14 (10%)**	**6 (15%)**	**309**
Anatidae				
Dendrocygna bicolor	**(nr)**	**66 (7%)**	**(nr)**	**66**
Dendrocygna viduata	**24 (2%)**	**31 (3%)**	**139 (6%)**	**194**
Dendrocygna autumnalis	(ad)	(nr)	(nr)	(ad)
Coscoroba coscoroba	(nr)	(nr)	1 (3%)	1
Callonetta leucophrys	**41 (8%)**	**(nr)**	**14 (21%)**	**55**
Amazonetta brasiliensis	**73 (11%)**	**19 (12%)**	**5 (3%)**	**97**
Anas flavirostris	**(nr)**	**(nr)**	**106 (12%)**	**106**
Anas versicolor	17 (4%)	(nr)	22 (12%)	39
Anas georgica	(nr)	(nr)	(ad)	(ad)
Netta peposaca	**6 (3%)**	**121 (8%)**	**(ad)**	**127**
Aramidae				
Aramus guarauna	(nr)	2 (3%)	8 (12%)	10
Rallidae				
Laterallus melanophaius	(nr)	(ad)	(nr)	(ad)
Aramides ypecaha	(nr)	(nr)	(ad)	(ad)
Porzana albicollis	(nr)	(ad)	(nr)	(ad)
Neocrex erythrops	(nr)	1 (2%)	(nr)	1
Pardirallus maculatus	(nr)	(ad)	(nr)	(ad)
Pardirallus sanguinolentus	(nr)	2 (3%)	(nr)	2
Porphyrio martinicus	(nr)	4 (2%)	(nr)	4
Gallinula chloropus	(nr)	(ad)	(nr)	(ad)
Gallinula melanops	(nr)	8 (3%)	(nr)	8
Fulica armillata	(nr)	(nr)	(ad)	(ad)
Fulica rufifrons	(nr)	(ad)	(nr)	(ad)
Laridae				
Larus maculipennis	(nr)	(nr)	39 (15%)	39
Sternidae				
Phaetusa simplex	15 (4%)	(nr)	(nr)	15

Annex 2.- Non-waterbirds recorded in the rice fields of Argentina and Uruguay. For each species we indicate the total count (all survey points) and the relative frequency (in brackets) by country and season and the general count (in bold the most abundant species = general count > 50 birds). (nr) = not recorded.

Species	Argentina spring (N=106)	Argentina summer (N=60)	Uruguay summer (N=34)	General Count (N=200)
Tinamiformes				
Nothura maculosa	1 (0.30)	(nr)	(nr)	1
Falconiformes [1]				
Coragyps atratus	(nr)	13 (0.27)	(nr)	13
Cathartes aura	(nr)	(nr)	3 (0.26)	3
Cathartes burrovianus	(nr)	32 (0.66)	(nr)	32
Rosthramus sociabilis	**37 (11.18)**	**40 (0.83)**	**(nr)**	**77**
Circus buffoni	(nr)	11 (0.23)	4 (0.34)	15
Buteogallus urubitinga	1 (0.30)	2 (0.04)	(nr)	3
Buteogallus meridionalis	5 (1.51)	4 (0.08)	(nr)	9
Parabuteo unicinctus	(nr)	1 (0.02)	(nr)	1
Buteo magnirostris	(nr)	4 (0.08)	(nr)	4
Caracara plancus	**13 (3.93)**	**49 (1.01)**	**1 (0.09)**	**63**
Milvago chimango	2 (0.60)	(nr)	12 (1.03)	14
Falco femoralis	(nr)	1 (0.02)	(nr)	1
Falco peregrinus	(nr)	(nr)	1 (0.09)	1
Columbiformes				
Columba picazuro	1 (0.30)	4 (0.08)	4 (0.34)	9
Columba maculosa	4 (1.21)	5 (0.10)	6 (0.51)	15
Zenaida auriculata	**17 (5.14)**	**89 (1.84)**	**(nr)**	**106**
Columbina picui	15 (4.53)	19 (0.39)	1 (0.09)	35
Columbina talpacoti	(nr)	16 (0.33)	(nr)	16
Psittaciformes				
Myiopsitta monachus	**1 (0.30)**	**34 (0.70)**	**32 (2.74)**	**67**
Cuculiformes				
Guira guira	1 (0.30)	(nr)	5 (0.43)	6
Apodiformes				
Trochilidae	(nr)	2 (0.04)	(nr)	2
Coraciiformes				
Ceryle torquata	(nr)	1 (0.02)	(nr)	1
Passeriformes				
Furnarius rufus	10 (3.02)	1 (0.02)	(nr)	11
Schoeniophylax phryganophila	(nr)	2 (0.04)	1 (0.09)	3
Cranioleuca sulphurifera	(nr)	(nr)	1 (0.09)	1
Spartonoica maluroides	(nr)	(nr)	1 (0.09)	1
Phleocryptes melanops	(nr)	2 (0.04)	1 (0.09)	3
Serpophaga nigricans	(nr)	(nr)	2 (0.17)	2
Hymenops perspicillatus	3 (0.91)	(nr)	(nr)	3
Satrapa icterophrys	(nr)	1 (0.02)	(nr)	1
Machetornis rixosus	2 (0.60)	1 (0.02)	1 (0.09)	4
Tyrannus melancholicus	(nr)	1 (0.02)	(nr)	1
Tyrannus savana	7 (2.11)	2 (0.04)	(nr)	9
Pitangus sulphuratus	21 (6.34)	7 (0.14)	17 (1.45)	45
Progne chalybea	(nr)	1 (0.02)	(nr)	1

[1] The family Cathartidae was considered in the Order Falconiformes.

(Annex 2. Continuation)

Species	**Argentina spring** (N=106)	**Argentina summer** (N=60)	**Uruguay summer** (N=34)	**General Count** (N=200)
Passeriformes (cont)				
Progne tapera	**39 (11.78)**	**89 (1.84)**	**36 (3.08)**	**164**
Tachycineta leucorrhoa	**40 (12.08)**	**46 (0.95)**	**99 (8.46)**	**185**
Notiochelidon cyanoleuca	(nr)	(nr)	8 (0.68)	8
Riparia riparia	(nr)	43 (0.89)	(nr)	43
Petrochelidon pyrrhonota	(nr)	13 (0.27)	(nr)	13
Hirundo rustica	**4 (1.21)**	**73 (1.51)**	**(nr)**	**77**
Anthus correndera	4 (1.21)	(nr)	4 (0.34)	8
Anthus lutescens	3 (0.91)	(nr)	(nr)	3
Anthus sp.	1 (0.30)	4 (0.08)	3 (0.26)	8
Thraupis sayaca	(nr)	3 (0.06)	(nr)	3
Thraupis bonariensis	1 (0.30)	(nr)	(nr)	1
Sporophila collaris	1 (0.30)	(nr)	(nr)	1
Sicalis flaveola	(nr)	6 (0.12)	(nr)	6
Sicalis luteola	**2 (0.60)**	**2 (0.04)**	**169 (14.44)**	**173**
Embernagra platensis	(nr)	1 (0.02)	5 (0.43)	6
Paroaria capitata	2 (0.60)	(nr)	(nr)	2
Paroaria coronata	12 (3.63)	2 (0.04)	(nr)	14
Ammodramus humeralis	2 (0.60)	(nr)	(nr)	2
Agelaius thilius	**2 (0.60)**	**9 (0.19)**	**262 (22.39)**	**273**
Agelaius ruficapillus	**71 (21.45)**	**3246 (67.00)**	**419 (35.81)**	**3736**
Agelaius sp.	1 (0.30)	(nr)	(nr)	1
Pseudoleistes virescens	(nr)	4 (0.08)	34 (2.91)	38
Agelaioides badius	1 (0.30)	11 (0.23)	1 (0.09)	13
Molothrus bonariensis	(nr)	10 (0.21)	2 (0.17)	12
Molothrus sp.	3 (0.91)	(nr)	(nr)	3
Dolichonyx oryzivorus	**(nr)**	**916 (18.91)**	**(nr)**	**916**
Sturnella superciliaris	**1 (0.30)**	**22 (0.45)**	**34 (2.91)**	**57**
Carduelis magellanica	(nr)	(nr)	1 (0.09)	1

CHAPTER 6

Discussion

Numerous papers document the importance of rice fields as a foraging habitat for waterbirds in the Northern Hemisphere and in particular for migratory shorebirds (Martínez-Vilalta 1985, Fasola & Ruiz 1996, Shuford *et al.* 1998, Elphick & Oring 1998, 2003; Manley 1999, Elphick 2000, USGS 2000, Tourenq *et al.* 2003; see review in Czech & Parsons 2002). However, available information for the Southern Hemisphere and in particular for South America and Central America, is still scarce, with only a few studies analyzing this phenomenon in detail, among which those of Suriname (Hicklin & Spaans 1992), Cuba (Acosta 1998, Mugica 2000) and Brazil (Burger & Dias 2005) should be noted. Results of these studies document significant use of rice fields by migratory shorebirds in agreement with observations in the Northern Hemisphere. Our results point in the same direction and confirm the value of rice fields as an alternative feeding habitat for waterbirds, with at least 59 species recorded.

Among waterbirds recorded in rice fields of Argentina, Brazil and Uruguay, the shorebirds were especially noteworthy, with a total of 17 species, surpassing herons (10 species), Anatidae (10 species) and rails (11 species). As indicated by Hicklin & Spaans (1992) and Tourenq *et al.* (2003), shorebirds constitute the dominant group of waterbirds in the rice fields under study, due to the species richness and abundance. In Suriname, for example, shorebirds were the most numerous group, reaching 62.2% of all the birds counted in the SML rice fields near Wageningen (Hicklin & Spaans 1992).

D.E. Blanco

The White-faced Ibis (*Plegadis chihi*) was the most abundant waterbird species.

Rice field biodiversity

According to the results of our study, a total of 120 bird species use rice fields in southern South America (Argentina, Brazil and Uruguay), including 59 waterbirds among which are: 17 shorebirds, 10 herons, 10 ducks and 11 rails. Moreover 61 non-waterbird species were recorded, including 13 birds of prey, five pigeons and 38 passerines. Among the passerines, the abundance of icterids should be highlighted, mainly the Chestnut-capped Blackbird (*Agelaius ruficapillus*) and the Bobolink (*Dolichonyx oryzivorus*).

The most common shorebirds in the studied rice fields were those typically encountered in inland freshwater wetlands and humid grassland, including some species of particular interest for conservation, e.g. Buff-breasted Sandpiper (*Tryngites subruficollis*) (CMS-UNEP 1999, Brown *et al.* 2001, Donaldson *et al.* 2001). When the abundances of shorebirds recorded in the three countries were compared, significant differences were observed in many cases, reflecting the different migratory habits of the species. Some species were notably more abundant in Uruguay and Brazil e.g. American Golden Plover (*Pluvialis dominica*) and White-rumped Sandpiper (*Calidris fuscicollis*), showing the great importance of the coastal plains of southern Brazil and northeast Uruguay to these species during migration periods and the non breeding season. On the other hand, the Pectoral Sandpiper (*Calidris melanotos*) and Lesser Yellowlegs (*Tringa flavipes*) –both species which prefer inland fresh-water marshes and migrate along the Paraguay-Paraná corridor (Antas 1983)-, were more abundant in the province of Santa Fe, in Argentina.

Therefore rice fields act as temporary artificial wetlands, providing feeding habitats to numerous waterbird species, at least during certain portions of the crop's cycle. However, they do not substitute natural wetlands since even the most abundant species are dependant on natural marshes for breeding and roosting (Dias & Burger 2005). Moreover, only a few species found in the Neotropics have been recorded nesting in rice fields (Causey & Graves 1969, McKay 1981, Mugica 2000, Mugica *et al*. 2003, Dias & Burger 2005; see review in Czech and Parsons 2002).

Seasonal changes and the rice cycle

Rice fields provide a succession of microhabitats throughout the crop-growing cycle, which differ in their environmental characteristics and species richness. In the rice fields of Cuba, for example, the microhabitat used by the highest number of species during the year was the muddy ground before sowing (46 species) and the one with the lowest number of species was the mature rice (15 species) (Mugica *et al.* 2000).

Different microhabitats are used by different waterbird groups according to their particular requirements, which often limits them to temporary use. According to Tourenq *et al.* (2001), rice fields in the Camargue were used intensely by shorebirds during only a very short period in spring.

Our results are in agreement with other authors, who have also documented significant variations in the intensity of the use of rice fields by shorebirds in relation to the rice cycle (Martinez-Vilalta 1985, Shuford *et al.* 1998). In our study, the earlier stages of the crop cycle were most used by birds, with a striking decrease in the abundance of all species with the development of the crop and the consequent increase in plants' height and biomass, as was observed by Shuford *et al.* (1998) and Mugica *et al*. (2003). In the advanced stages, the rice field does not provide appropriate conditions for shorebirds to forage. Shuford *et al.* (1998) suggest that the variations in use are partly due to rain and water management. The rice fields of Suriname were more attractive to shorebirds during the first weeks and the period shortly after flooding (Hicklin & Spaans 1992).

Mosaic of "espinal" habitat and rice fields in San Javier, Santa Fe province, Argentina.

A. Parera

Other species such as herons also showed greater abundance in the early stages of the crop, as was observed in Cuba by Mugica *et al.* (2000).

The analysis of seasonal changes in the use of rice fields in relation to the crop-growing cycle can be approached by studying changes in important parameters of the habitat, such as the presence, permanence and depth of water, availability of prey and height of the rice, which are of great importance in providing appropriate conditions to shorebirds for feeding (Elphick & Oring 1998, 2003; Mugica *et al.* 2000, Dias & Burger 2005). Dias & Burger (2005) identified the height and density of rice, the depth of water, food availability and disturbance due to human activities as limiting factors in the use of rice fields by birds. The authors concluded that, independent of the cropping system, the increase of the water level and the growth of vegetation can result in the exclusion of the majority of shorebird species, especially the smaller ones. On the other hand, Collazo et al. (2003) confirmed the importance of shallow water for the small-sized shorebirds, such as the Dunlin (*Calidris alpina*) and Semipalmated Sandpiper (*C. pusilla*), with bird abundance increasing with an increase in the availability of sectors with up to 4 cm of water.

Although the depth of water was not analyzed in detail, our results confirmed that the majority of shorebirds were associated with flooded rice fields, with the exception of the Southern Lapwing (*Vanellus chilensis*), which also used paddies with dry ground. On the other hand, the Upland Sandpiper (*Bartramia longicauda*) was observed exclusively in unflooded germinated rice fields and in abandoned paddies.

Another aspect to be considered when analyzing seasonal changes in the use of rice fields by birds is the overlap between the rice cycle and the phenologies of the migration of the different species. As rice sowing times vary with latitude, the availability of appropriate feeding habitats for shorebirds also varies latitudinally as well as regionally. In Uruguay, for example, the rice harvest starts at the end of March and early April, providing a post-harvest stubble feeding habitat for Nearctic shorebirds when the majority of the species have already left the region on their northward migration. Therefore the period during which rice fields would provide foraging habitats for shorebirds is limited to the austral spring.

Another key factor regarding the use of rice fields by shorebirds is the climatic variability. In our study area the rice remains flooded during the austral spring-summer season, when the water levels of the natural wetlands decreases because of rising temperatures. This situation increases the value of rice fields as an alternative feeding habitat for waterbirds. In this sense, the notable abundance of waterbirds recorded in the rice fields of Santa Fe (Argentina) in the spring 2004, could be explained by the great drought in this region in that year. We estimate that in years with more rains and, consequently, more natural wetlands, the intensity in the use of rice fields would be lower, while in dry years they would act as waterbird “refuges” (Fasola & Ruiz 1996).

Threats and conservation implications

Rice (*Oryza* spp.) is a major crop in today’s world, covering around 11% of arable land on the planet (Fasola & Ruiz 1997). In particular, the cultivated areas in Argentina and Uruguay in 2004, reached 172,000 ha and 190,000 ha respectively. In both countries the area cultivated with rice has increased since the early 1960s (Figure 1). The expansion of the rice crop has caused the loss and destruction of natural wetlands, grassland and native forests.

This increasing trend in the cultivation of rice has resulted in the loss of native wetland habitats, resulting in a greater use of rice fields by waterbird populations and in particular by migratory shorebirds.

Nevertheless, it remains very difficult to calculate the size of Nearctic shorebird populations that use rice fields in southern South America during the non-breeding season. Extrapolations are not recommended due to the high mobility of these birds (Hicklin & Spaans 1992, A. Farmer pers. comm. 2005). In Suriname for example, Hicklin and Spaans (1992) observed that birds feeding in one rice paddy for a couple of days would later move to another field and, for this reason, these authors disagree with using extrapolations to estimate the numbers of shorebirds present over a larger area where rice might be cultivated. However, considering the densities obtained in the present study (which for some species reaches values of 5 birds/ha), we may assume that perhaps tens or hundreds of thousands of Nearctic shorebirds use rice fields in southern South America during the non-breeding period.

The majority of available studies on the use of rice fields by waterbirds were carried out over months of crop inactivity (see review in Czech & Parsons 2002). Information on the use of these agroecosystems during the rice-growing cycle, when a higher level of conflict is generated and when shorebirds may become exposed to agrochemicals is still very scarce.

Rice fields are managed with agrochemicals and waterbirds feeding on them are exposed to lethal and sub-lethal doses of toxic products. Furthermore the use of agrochemicals generally produces invertebrate mortality, thus reducing the supply of available prey for shorebirds (Shuford *et al.* 1998, Tourenq *et al.* 2003), and decreasing the overall quality and health of the feeding habitat.

The use of pesticides aims to control species of birds that are considered damaging to rice crops, such as various ducks, blackbirds and pigeons; besides, rails and the Southern Screamer (*Chauna torquata*) can trample the plants (Bucher 1983, Menegheti *et al*. 1990). However, migratory shorebirds are not considered harmful species, although they are exposed to the use of agrochemicals and can be affected in the same way as the rest of the other birdlife. This is especially true for those species which are abundant when herbicides and insecticides are applied. According to Hicklin and Spaans (1992), small shorebirds are among the species

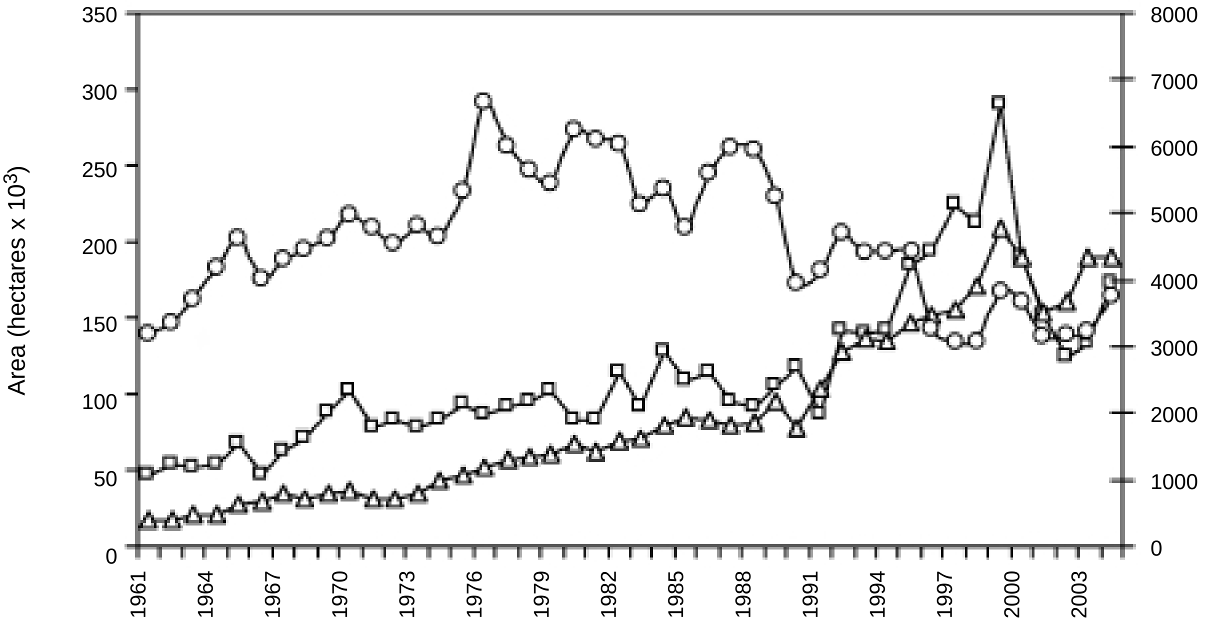


Figure 1.- Area cultivated with rice in Argentina (squares, left axis), Brazil (circles, right axis) and Uruguay (triangles, left axis), over the period 1961-2004.

that are most vulnerable to contamination by agrochemicals applied at the beginning of the rice crop in Suriname.

High waterbird mortality on rice fields has been documented in the past (Vermeer *et al.* 1974, Littrell 1988, Hicklin & Spaans 1992, M.E. Zaccagnini pers. comm. 2005), as a result of the irresponsible use of agrochemicals. Currently, in some regions a reduction in their uses has been observed, due to higher costs, but also as a result of greater awareness associated with their toxicity to wildlife and humans. In Cuba, for example, the use of agrochemicals has been reduced by approximately 50% in the last 15 years, which has contributed to converting rice fields into important waterbird feeding areas (Mugica 2005).

We do not know with any accuracy the impacts of agrochemical uses on shorebird populations which feed in rice fields in southern South America, but we do know that there are impacts and that these should be considered in waterbird conservation strategies. It should be noted that during our surveys, we did not record any events of bird mortality, but we know that they have occurred in the past in our study area (see Zaccagnini & Mathern 1991, M. Serra pers. comm.).

On one hand rice fields act as important feeding areas for waterbirds, while on the other hand they may constitute toxic traps due to the use of agrochemicals associated with rice cultivation. For this reason, it is important to develop a biodiversity conservation strategy for rice field habitats, involving all interested parties, with the main objective of reducing the use of agrochemicals, together with the effective elimination of all prohibited products and those that are highly toxic to wildlife from the market.

IBA SF07 San Javier

Among recent conservation actions, the declaration of the rice belt in the province of Santa Fe, Argentina, as the IBA (Important Bird Area) SF07 “San Javier” (López-Lanús & Blanco 2005), should be mentioned, due to the high numbers of migratory shorebirds and other waterbirds, and to the remarkable abundance of bobolinks in the area (López-Lanús *et al*. in prep.). This is an unusual case, as in general the IBAs are declared for the conservation of natural habitats. A similar case exists in Cuba where two IBAs were recently declared in rice fields and neighboring coastal sectors (Mugica 2005).

D.E. Blanco

Fish mortality in a drainage channel of a rice field.

CHAPTER 7

Recommendations

Research and management

- Continue research on the use of rice fields by migratory shorebirds and other waterbirds in southern South America and extend the studies to other countries in the region, including:
  - detailed analysis of how this use varies with parameters of the habitat, such as the food supply, depth of water and height of the rice.
  - analysis of the long term use to show between-year variations in function of the climatic conditions.
  - estimations of population sizes.
  - analysis of lethal and sub-lethal effects on birds and biodiversity in general resulting from the use of agrochemicals.
- Study the use of rice fields by non waterbird species of conservation interest e.g. the Bobolink (*Dolichonyx oryzivorus*).
- Develop a plan for ecotoxicological monitoring of birds in rice fields and associated wetlands, in the frame-work of on-going initiatives, such as the "Ecotoxicological Monitoring of Birds" project (INTA)
- Evaluate and promote management practices for rice cultivation and water resources that benefit biodiversity conservation as well as rice production.
- Assess the impact of wind-farms in rice cultivation areas, due to the risk of collisions by birds.

Management and control

- Advise and cooperate with governmental institutions concerning the implementation of policies and actions for the conservation of migratory shorebirds and other birdlife inhabiting rice fields.
- Cooperate with technical and legal institutions in order to control the use of agrochemicals in rice fields.
- Promote systems of rice production of low environmental impact and certification schemes used in other parts of the world.

Dissemination and exchange of information

- Organize technical workshops to promote the exchange of information and experiences between research workers of different countries in the Americas and the world.
- Carry out public awareness campaigns and extension activities for rice farmers about:
  - the importance of rice fields for the conservation of migratory shorebirds and biodiversity in general, and
  - environmental conservation and the use of production systems with low levels of contamination.
- Produce material on biodiversity conservation in rice fields for dissemination.
- Carry out environmental education activities.

CHAPTER 8

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Misión:

Preservar y restaurar los humedales, sus recursos y biodiversidad, para las futuras generaciones.

Mission:

To sustain and restore wetlands, their resources and biodiversity for future generations.

Las arroceras funcionan como humedales artificiales brindando hábitat de alimentación a numerosas especies de aves acuáticas al menos durante una parte del ciclo del cultivo, pero al mismo tiempo pueden resultar una seria amenaza dado el uso de agroquímicos asociado a la producción de arroz.

Esta publicación evalúa el uso de arroceras por chorlos y playeros migratorios en el sur de América del Sur, aportando información inédita y valiosa para su conservación. Está dirigida principalmente a tomadores de decisión y técnicos que trabajan en la conservación de la biodiversidad en agroecosistemas y comprende una revisión del conocimiento actual sobre el uso de arroceras por aves acuáticas, incluyendo datos de abundancias de chorlos y playeros en arroceras de Argentina, Brasil y Uruguay, y un análisis de uso en función del ciclo del cultivo. En la discusión se contrastan los resultados encontrados con los resultados de otros autores y se presenta una serie de recomendaciones.

Rice fields function as artificial wetlands, providing feeding habitat for numerous waterbird species, at least during part of the lifecycle of the crop, but at the same time they may result as a serious threat due to the use of agrochemicals associated with rice production.

This publication assess the use of rice fields by migratory shorebirds in southern South America, contributing valuable unpublished information for their conservation. Is mainly for decision makers and technicians who work in biodiversity conservation in agroecosystems and comprises a revision of current knowledge on the use of rice fields by waterbirds, including data on shorebird abundance in rice fields of Argentina, Brazil, and Uruguay, as well as an analysis of use in function of the crop's cycle. Our results are compared with those of other authors and a series of recommendations are presented.

Para mayor información puede visitar nuestro sitio en Internet o contactar nuestras oficinas:

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