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Why Study Birds in Rice Fields?

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Abstract.—Rice (*Oryza sativa*) is one of the world's most important crops. The crop is grown in at least 114 countries, occupies over 156 million ha of land annually, is a primary source of nutrition for over half the world's human population and constitutes over a fifth of the global grain supply. Rice is generally grown under flooded conditions and, if managed appropriately, can provide important habitat for wetland species. Waterfowl, wading birds, shorebirds and other waterbirds use rice fields, foraging on a variety of prey, nesting in the crop and in fringing vegetation, and staging during migration. Conflicts also exist, with some cropping practices harmful to birds and some bird activity detrimental to yield production. Much early research on waterbirds in rice fields was conducted in Mediterranean Europe with only scattered work elsewhere. More recently, there has been a growing focus on the conservation value of rice fields, with studies from most of the major regions where rice is grown. The body of research has included: community studies of the range of birds that use rice fields, detailed studies of endangered species, behavioral studies of reproductive success, foraging ecology and movement, and applied studies of cropping techniques. As the world's natural wetlands diminish, researchers studying waterbirds in rice fields are working to globalize interactions with each other. Also, some researchers are working closely with conservation groups and rice growers to identify ways to maximize the benefits of agricultural wetlands while minimizing the agronomic costs.
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Rice (*Oryza sativa*) was first cultivated by humans approximately 10,000 years ago, and has spread from Asia to become one of the world's most important crops. The crop is grown in at least 114 countries around the world, occupies over 1% of the Earth's ice-free land surface, and provides about 21% of the calories and 15% of the protein consumed by humans (Maclean *et al.* 2002). In 2007, over 156 million ha of land were planted in rice, producing a global yield of over 650 million t (FAOSTAT 2008). Collectively, the world's ricelands occupy an area similar in size to Mongolia; only 19 of the world's countries occupy larger areas.

Rice production continues to be greatest in Asia, where 90% of the crop is grown (Fig. 1). Nine of the top ten rice-producing countries are Asian, with China and India alone accounting for about half of production (Maclean *et al.* 2002; FAOSTAT 2008). The crop's importance is also growing in Africa (Fig. 1; Wymenga and Zwarts 2010) and elsewhere. Although rice production is concentrated in the tropics, the crop is also grown in a number of low-latitude temperate regions, including parts of the USA, Europe, Japan, Korea, Australia and southern South America. These temperate areas have some of the highest global yields, producing up to 5-10 t/ha (global average was 4.15 t/ha in 2007; FAOSTAT 2008).

Rice production takes many forms, but most rice is grown under flooded conditions (Maclean *et al.* 2002). Flooding helps control weeds and buffer seedlings against temperature extremes. Flooding also is key to the conservation value of rice fields as flooded paddies provide conditions that are somewhat similar to certain natural wetland habitats. Irrigation is used to flood fields or to augment rainfall in about half of the world's rice fields, and can substantially improve yields by managing the water supply in ways that benefit production. Another third of all rice fields rely on less predictable rain-fed systems to supply water to fields. The world's remaining flooded ricelands constitute smaller areas of deepwater rice, in which tidal inundation, flash floods, or depths of more than 1 m, reduce productivity. Finally, about a tenth of the world's rice is farmed in dry upland conditions (Maclean *et al.* 2002).

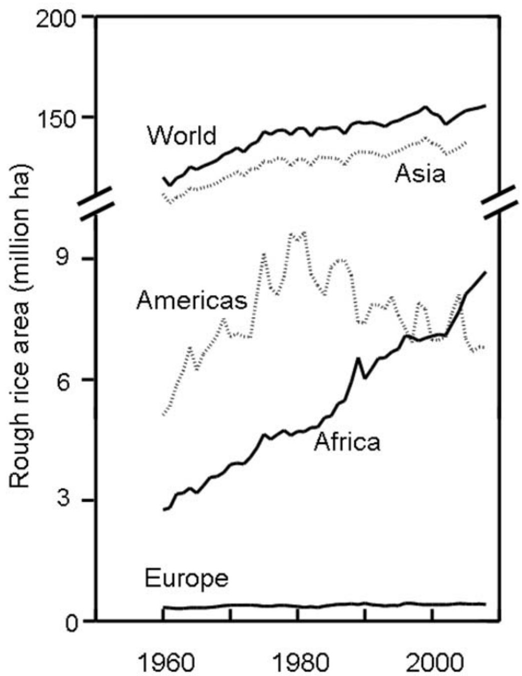

Figure 1. Changes in area of rough rice grown throughout the world, 1960/61-2008/09 (USDA). Source: IRRI World Rice Statistics 2009. Data for Oceania omitted because line too close to the x-axis to be distinguished. Note break in y-axis.

In temperate zones, where most wildlife-related research has been conducted, rice is grown during the warm summer period and fields are left fallow during winter. In tropical areas, where most rice is grown, multiple cropping cycles are common, sometimes with two or even three rice crops a year. In some cases, rice is produced in conjunction with other crops. Sometimes this involves rotational plantings that alternate between rice and other row crops (Street and Bollich 2003). In other situations, wetland animals, such as crayfish (Huner 1994) and fish (Halwart and Gupta 2004), are grown in conjunction with the rice. Rice fields are also used to graze various livestock, ranging from cattle (e.g. in South America; Stenert *et al.* 2009) to ducks (e.g. in China; Muzaffar *et al.* 2010).

Given the extent of flooded riceland, the crop has received growing attention from ecologists and conservation groups interested in wetland species, starting with detailed studies of herons in Europe (e.g. Fasola *et al.* 1981; Fasola 1983). Wetland areas have declined and become degraded worldwide (Moser *et al.* 1996). Habitat loss has often been caused by drainage to create farmland, and degradation is often associated with agricultural runoff. Simultaneously though, flooded rice fields have proven capable of providing important habitat for many waterbirds (Fasola and Ruiz 1997; Eadie *et al.* 2008). Although it is clear that rice fields will never provide the diversity of habitats that natural wetlands create (Tourenq *et al.* 2001a), it is also clear that they can play an important role in wetland bird conservation (Elphick and Oring 1998; Elphick 2000). Thus, characterizing this role under current conditions, and determining how to extend the benefits of rice farming to wildlife, without hampering the economic viability of the agronomic system or its ability to provide food security to millions of people who depend on rice for survival, are important objectives for conservation scientists and advocates of environmental sustainability.

BIRD USE OF RICE

Numerous bird species have been documented to occur in rice fields, often in very large numbers. Many of the earliest studies focused on species that were viewed as crop pests (Neale 1918; Ellis 1940; Piper 1944; Neff 1957), or as predators on weed seeds (McAtee 1923). Increasingly, ecologists have focused on birds as members of rice agroecosystems in their own right (Fasola and Ruiz 1996; Acosta and Mugica 2006; Eadie *et al.* 2008; Amano 2009). The most common groups of species using rice fields are, not surprisingly, those that are associated with shallow wetlands. Waterfowl (whistling ducks, geese, swans, ducks), long-legged wading birds (herons, egrets, bitterns, ibises, storks), shorebirds (plovers, sandpipers, gulls, terns) and gruiforms (cranes, rails, crakes, coots, gallinules) tend to be the most common groups of birds, although exactly which families dominate varies among regions (Acosta *et al.* 2010). [Throughout this volume we follow the taxonomy and names recommended by the International Ornithological Congress (Gill *et al.* 2009).]

Although species traditionally considered "waterbirds" are generally most common in rice fields, a wide diversity of other species also use this habitat (Elphick 2004). These include wetland-associated "landbirds" such as kingfishers and wagtails, marsh-nesting songbirds such as *Acrocephalus* warblers, prinias and cisticolas, granivorous birds that feed on spilled rice after harvest, and the raptors and owls that are attracted by concentrations of smaller birds and high densities of small mammals.

Most of these birds use rice fields for foraging. Species diversity and abundances often peak during non-growing periods in temperate zones, where migrants often occupy rice fields during the nonbreeding season (Eadie *et al.* 2008; Fujioka *et al.* 2010). Foraging bird use at these times can be intensive, with 100,000s-1,000,000s of waterfowl, 10,000s-100,000s of shorebirds and 1,000s of wading birds using rice fields (e.g. Remsen *et al.* 1991; Shuford *et al.* 1998; Eadie *et al.* 2008; Amano 2009). Most birds feed on spilled grain and aquatic invertebrates, but a range of other foods are also used (Stafford *et al.* 2010). Migrants from temperate regions also greatly influence waterbird communities in tropical areas (Acosta *et al.* 2010). Use of rice fields tends to be lowest when rice is growing, especially when stalk density is high, and only a small percentage of the species found in rice fields actually breed in them (Pierluissi 2010).

Although very large numbers of birds can be found in rice fields, use is highly variable in both time and space (Fasola and Brangi 2010), complicating quantification and analysis of the factors influencing use (Elphick *et al.* 2007). Although use of individual fields can vary tremendously, certain rice growing areas are well known to support internationally important numbers of birds, including, among others: in Europe, the Albufera de Valencia, Doñana and Ebro Delta areas of Spain, and the Camargue in France (Longoni 2010); in the USA, the Central Valley of California, Mississippi Alluvial Valley and Gulf of Mexico coastal states (Eadie *et al.* 2008); and in Asia, the area around Izumi, Kagoshima in Japan and the Han estuary in Korea (Fujioka *et al.* 2010). Various endangered species also use rice fields, including the Crested Ibis (*Nipponia nippon*) (Wood *et al.* 2010), several cranes and storks (Fujioka *et al.* 2010; Sundar and Subramanya 2010), and many regionally rare species (van der Weijden 2010).

BIOLOGICAL QUESTIONS

Rice agroecosystems are of interest because of their use in investigating both basic and applied ecological questions. Compared to natural wetlands, rice fields are simple habitats with very low heterogeneity. They are dominated by a single plant species, often have uniform water depths (especially when fields have been laser-leveled) that fluctuate on similar schedules, and experience predictable disturbance patterns. Typically, they are well replicated, with many very similar—yet discrete—units, placed across a landscape. The combination of relative uniformity and abundant replication provide "petri dish-like" experimental conditions that are rarely found at large spatial scales in natural ecosystems, and effectively create what ecologists seek in a system of mesocosms (Odum 1984) without the need to resort to mesoscales. Of course, the agronomic function of these fields means that researchers are not free to manipulate them at will; nonetheless, normal variation in field management and cooperative landowners often allow some level of experimental control (e.g. Elphick and Oring 1998). These same features apply to other agroecosystems as well, but the diversity of bird species that use rice fields, make rice habitats especially suitable for exploring questions about behavioral, population, community and landscape ecology. Moreover, the pattern of local replication is itself repeated in many places around the world. Although it would be a mistake to ignore regional differences in the way that rice is grown, there are substantial similarities among regions—at least, much more so than one finds in most natural habitats—which allow one to also consider larger-scale biogeographic questions.

As a habitat, rice presents a double-edged sword for waterbird conservation. The creation of rice fields frequently contributes to wetland losses (e.g. Cho 2007; Razafimanjato *et al.* 2007), but once wetlands have been drained in a region, rice fields can provide the best habitat that remains. While rice fields are not replacements for natural wetlands, in parts of the world where much natural habitat has been lost they are often all the habitat that remains for wetland species, imbuing them with high conservation value. For this reason, much of the research that has taken place on birds in rice fields has had applied underpinnings.

The tension between rice as a threat to natural habitats and as a crop of conservation value raises a number of key questions. How valuable is rice as the primary habitat for wetland species (e.g. Shuford *et al.* 1998)? How important is it as a buffer against natural habitat loss (e.g. Sánchez-Guzmán *et al.* 2007)? How does value differ among regions? Or among species? How do waterbirds respond to mixed landscapes of natural wetlands and rice habitats (King *et al.* 2010)? How are behavioral responses—such as diet (Jónsson and Afton 2006), timing of reproduction (Longoni *et al.* 2007; Sundar 2009), migration patterns (Sánchez-Guzmán *et al.* 2007), etc., affected by the spread of rice farming? And do behavioral responses translate into population-level effects (Fleury and Sherry 1996; Sutherland 1996; Lawler 2001)? Perhaps most importantly, in a world where wetland habitats are increasingly threatened (Mitsch and Gosselink 2007) and many wetland-associated species are declining (Delaney and Scott 2006), are there ways that the management of rice fields can be altered to improve their conservation value? Seeking out simple changes in agronomic practices that do not affect the economic value of the land will be increasingly important as global demand for food and pressure on natural habitats continue to increase.

AGRONOMIC QUESTIONS

Beyond the many ecological questions that arise when considering waterbirds in rice habitats, there are a host of questions about the ways in which ecological concerns interact with the goals of rice growers. Foremost in the minds of most farmers are probably questions relating to the detrimental impacts of birds on rice production. Trampling of crops by larger species including geese, ibises, flamingos and cranes (e.g. Tourenq *et al.* 2001b; Sundar 2009), grazing on young plants by waterbirds such as coots and ducks (e.g. Piper 1944; Lane *et al.* 1998), rice depredation by granivores such as doves, blackbirds and weavers (Subramanya 1994; Cummings *et al.* 2005), and damage to internal field levees used to control water depth (e.g. by swans), are all examples of concerns. In particular, it is important to quantify just how severe such effects are in terms of reduced yield and revenue (e.g. Borad *et al.* 2001). When economic impacts are realized, applied ecologists should help to seek ways to mitigate their consequences. When effects are localized, the most efficient solutions might simply involve compensating individual farmers or setting aside certain areas of crop specifically for birds (Vickery *et al.* 1994; Wagner *et al.* 1997), but more widespread problems may require more involved solutions. In other cases, the actual impacts of wildlife might be less severe than is perceived (Lane *et al.* 1998; Borad *et al.* 2001). When this is the case, there is a role for better dissemination of research results.

In addition to the potential ways in which birds can damage crops, there are various ways in which they can potentially improve production. Possibilities include reducing weed pressure (e.g. when birds feed on weed seeds; Street and Bollich 2003), reducing the effects of animal pests (e.g. egret predation on the crustacean *Triops cancriformis*, Fasola *et al.* 1981; cf. also effects of captive ducks on insect and snail pests; Teo 2001; Men *et al.* 2002), and improving nutrient cycling (Bird *et al.* 2002). Wildlife also can provide benefits to farmers by providing supplemental sources of revenue through hunting (Hobaugh *et al.* 1989; Guadagnin *et al.* 2007) and potentially ecotourism (Jackson and Jackson 2002). Where rice farming is known to benefit birds, there also is potential to market rice as "wildlife-friendly," which can broaden the perceived societal value of the crop's production (Hartman and Stafford 1998; Livesey *et al.* 2009) and in some cases enable farmers to obtain premium rates (Elphick *et al.* 2010). Research on many of these topics, however, remains rudimentary or isolated to individual case studies, and it is often unclear how well such benefits might scale up to entire rice industries.

WHAT DO WE KNOW?

Our special issue of *Waterbirds* has its origins in a symposium held at the 31st annual meeting of the Waterbird Society in Barcelona, late in 2007. At that symposium, many of the talks provided reviews of particular topics related to the ecology and conservation of birds in rice fields. Some reviews focused on specific regions where rice is grown, while others focused on more conceptual issues such as foraging ecology, pesticide impacts or the effect of landscape structure on birds in rice fields. Each of those review talks has been expanded into a comprehensive paper summarizing all that is known on the topic for inclusion in this volume. Additional reviews, on topics that were not covered in the symposium, were also sought and have been included with the goal of producing the first global overview of what is known about birds in rice fields.

The special issue is organized around three groups of papers. Seven papers summarize what is known about the bird use of rice fields in different regions of the world: Korea and Japan, China, the Indian subcontinent, Australia, Mediterranean Europe and the Middle East, West Africa and the Americas. Authors of these papers were asked to focus on identifying the species that use rice fields and the ways in which they use them. These papers provide agronomic context for understanding bird use within each region and include information—when available—on species abundance, community composition, timing of use, activities for which rice fields are used and the use of rice relative to natural wetlands. We also asked authors to highlight any species of high conservation interest, or pressing management concerns, in the regions about which they were writing.

These "regional" papers are then followed by four papers that examine the impacts of rice cultivation on birds, addressing: reproduction, foraging ecology, responses of birds to landscape-level features and the population-level consequences of rice farming. The volume closes with four papers that focus more explicitly on the interactions between avian ecology and human activities in rice fields. Two address the ways in which field management in the growing and non-growing season, respectively, affects birds. The third examines the effects of pesticides on birds in rice fields, and the fourth focuses on the role that rice agriculture might play in the spread of avian influenza. Finally, we close with a concluding paper that summarizes the main findings of the volume, identifies major gaps in current knowledge and examines issues that ecologists and conservation managers interested in the topic should consider in the future.

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LITERATURE CITED

Acosta, M. and L. Mugica. 2006. Aves en el ecosistema arrocero. Pages 108-135 *in* Aves Acuáticas en los Humedales de Cuba (L. Mugica, D. Denis, M. Acosta, A.

Jiménez and A. Rodríguez, Eds.). Editorial Científico-Técnica, La Habana, Cuba.
Acosta, M., L. Mugica, D. Blanco, B. López-Lanús, R. Antunes Dias, L. W. Doodnath and J. Hurtado. 2010. Birds of rice fields in the Americas. Waterbirds 33 (Special Publication 1): 105-122.
Amano, T. 2009. Conserving bird species in Japanese farmland: past achievements and future challenges. Biological Conservation 142: 1913-1921.
Bird, J. A., A. J. Eagle, W. R. Horwath, M. W. Hair, E. E. Zilbert and C. van Kessel. 2002. Long-term studies find benefits, challenges in alternative rice straw management. California Agriculture 56: 69-75.
Borad, C. K., A. Mukherjee and B. M. Parasharya. 2001. Damage potential of Indian Sarus Crane in paddy crop agroecosystems in Kheda district Gujarat, India. Agriculture, Ecosystems and Environment 86: 211-215.
Cho, D.-O. 2007. The evolution and resolution of conflicts on Saemangeum Reclamation Project. Ocean and Coastal Management 50: 930-944.
Cummings, J. L., S. S. Shwiff and S. K. Tupper. 2005. Economic impacts of blackbird damage to the rice industry. Proceedings of the 11th Wildlife Damage Management Conference. (D. L. Nolte and K. A. Fagerstone, Eds.) 11: 317-322.
Delaney, S. and D. Scott. 2006. Waterbird Population Estimates. Fourth Edition. Wetlands International, Wageningen, Netherlands.
Eadie, J. M., C. S. Elphick, K. J. Reinecke and M. R. Miller. 2008. Wildlife values of North American ricelands. Pages 7-90 *in* Conservation in Ricelands of North America (S. W. Manley, Ed.). The Rice Foundation, Stuttgart, Arkansas.
Ellis, N. S. 1940. Ducks and the rice industry. Emu 39: 200-206.
Elphick, C. S. 2000. Functional equivalency between rice fields and seminatural wetland habitats. Conservation Biology 14: 181-191.
Elphick, C. S. 2004. Assessing conservation trade-offs: Identifying the effects of flooding rice fields for waterbirds on non-target bird species. Biological Conservation 117: 105-110.
Elphick, C. S. and L. W. Oring. 1998. Winter management of Californian rice fields for waterbirds. Journal of Applied Ecology 35: 95-108.
Elphick, C. S., A. F. Zuur and E. N. Ieno. 2007. Investigating the effects of rice farming on aquatic birds with mixed modelling. Pages 417-434 *in* Analyzing Ecological Data (A. F. Zuur, E. N. Ieno, and G. M. Smith, Eds.). Springer, New York, New York.
Elphick, C. S., P. J. Baicich, K. C. Parsons, M. Fasola and L. Mugica. 2010. The future for research on waterbirds in rice fields. Waterbirds 33 (Special Publication 1): 231-243.
Fasola, M. 1983. Nesting populations of herons in Italy depending on feeding habitats. Bollettino di Zoologia 50: 21-24.
Fasola, M. and X. Ruiz. 1996. The value of rice fields as substitutes for natural wetlands for waterbirds in the Mediterranean region. Colonial Waterbirds 19 (Special Publication 1): 122-128.
Fasola, M. and X. Ruiz. 1997. Rice farming and waterbirds: integrated management in an artificial landscape. Pages 210-235 *in* Farming and Birds in Europe: The Common Agricultural Policy and its Implications for Bird Conservation (D. J. Pain and M. W. Pienkowski, Eds.). Academic Press, San Diego, California.
Fasola, M. and A. Brangi. 2010. Consequences of rice agriculture for waterbird population size and dynamics. Waterbirds 33 (Special Publication 1): 160-166.
Fasola, M., P. Galeotti, G. Bogliani and P. Nardi. 1981. Food of Night Heron (*Nycticorax nycticorax*) and Little Egret (*Egretta garzetta*) feeding in rice fields. Rivista Italiana di Ornitologia 51: 97-112.
FAOSTAT 2008. Data from FAOSTAT Database. FAO, Rome. Available on IRRI (International Rice Research Station) World Rice Statistics Web Site. http://beta.irri.org/solutions/index.php?option=com_content&task=view&id=250, accessed 28 Sept 2009.
Fleury, B. E. and T. W. Sherry. 1996. Long-term population trends of colonial wading birds in the southern United States: The impact of crawfish aquaculture on Louisiana populations. Auk 113: 613-632.
Fujioka, M., S. D. Lee, M. Kurechi and H. Yoshida. 2010. Bird use of rice fields in Korea and Japan. Waterbirds 33 (Special Publication 1): 8-29.
Gill, F., M. Wright and D. Donsker. 2009. IOC World Bird Names (version 2.1). Available at http://www.worldbirdnames.org/, accessed 12 May 2009.
Guadagnin, D. L., L. F. C. Perello and J. O. Menegheti. 2007. A situação atual da caça de lazer e manejo de áreas úmidas no Rio Grande do Sul (Current situation of leisure hunting and wetland management in Rio Grande do Sul State, South Brazil). Neotropical Biology and Conservation 2: 63-70.
Halwart, M. and M. V. Gupta (Eds.). 2004. Culture of Fish in Rice Fields. FAO, Rome, Italy and The World Fish Center, Penang, Malaysia.
Hartman, C. L. and E. R. Stafford. 1998. Crafting "enviropreneurial" value chain strategies through green alliances. Business Horizons 41: 62-72.
Hobaugh, W. C., C. D. Stutzenbaker and E. L. Flickinger. 1989. The rice prairies. Pages 367-384 *in* Habitat Management for Migrating and Wintering Waterfowl in North America (L. M. Smith, R. L. Pederson and R. M. Kaminski, Eds.). Texas Tech University Press, Lubbock, Texas.
Huner, J. V. (Ed.). 1994. Freshwater Crayfish Aquaculture in North America, Europe, and Australia: Families *Astacidae*, *Canbaridae*, and *Parastacidae*. The Haworth Press, Binghamton, New York.
IRRI (International Rice Research Institute) World Rice Statistics. 2009. Available at http://beta.irri.org/solutions/index.php?option=com_content&task=view&id=250, accessed 28 Sept 2009.
Jackson, D. L. and L. L. Jackson. 2002. The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems. Island Press, Washington, D.C.
Jónsson, J. E. and A. D. Afton. 2006. Different time and energy budgets of Lesser Snow Geese in rice-prairies and coastal marshes in Southwest Louisiana. Waterbirds 29: 451-458.
King, S., C. S. Elphick, D. Guadagnin, O. Taft and T. Amano. 2010. Effects of landscape features on waterbird use of rice fields. Waterbirds 33 (Special Publication 1): 151-159.
Lane, S. J., A. Azuma and H. Higuchi. 1998. Wildfowl damage to agriculture in Japan. Agriculture, Ecosystems and Environment 70: 69-77.
Lawler, S. P. 2001. Rice fields as temporary wetlands: a review. Israel Journal of Zoology 47: 513-528.
Livesey, S. M., C. L. Hartman, E. R. Stafford and M. Shearer. 2009. Performing sustainable development through eco-collaboration: The Ricelands Habitat

Partnership. Journal of Business Communication 46: 423-454.

Longoni, V., D. Rubolini and G. Bogliani. 2007. Delayed reproduction among Great Bitterns *Botarus stellaris* breeding in ricefields. Bird Study 54: 275-279.

Longoni, V. 2010. Rice fields and waterbirds in the Mediterranean region and the Middle East. Waterbirds 33 (Special Publication 1): 83-96.

Maclean, J. L., D. C. Dawe, B. Hardy and G. P. Hettel. 2002. Rice Almanac: Source Book for the Most Important Economic Activity of Earth. CABI Publishing, Wallingford, UK.

McAtee, W. L. 1923. Ducks useful in Arkansas as scavengers of red rice. Auk 40: 527-528.

Men, B. X., B. R. Ogle and J. E. Lindberg. 2002. Studies on integrated duck-rice systems in the Mekong Delta of Vietnam. Journal of Sustainable Agriculture 20: 27-40.

Mitsch, M. J. and J. G. Gosselink. 2007. Wetlands. John Wiley & Sons, Inc., Hoboken, New Jersey.

Moser, M., C. Prentice and S. Frazier. 1996. A global overview of wetland loss and degradation. Pages 21-31 *in* Technical Session B of Proceedings of the 6th Meeting of the Conference of Contracting Parties, Brisbane, Australia. Ramsar Convention Bureau, Gland, Switzerland.

Muzaffar, S. B., J. Y. Takekawa, D. J. Prosser, S. H. Newman and X. Xiao. 2010. Rice production systems and avian influenza: Interactions between mixed-farming systems, poultry and wild birds. Waterbirds 33 (Special Publication 1): 219-230.

Neale, G. 1918. Ducks vs. rice. California Fish and Game 4: 70-72.

Neff, J. A. 1957. Blackbirds and the Arkansas rice crop. Agricultural Experiment Station Publication, University of Arkansas, Fayetteville, Arkansas.

Odum, E. P. 1984. The mesocosms. BioScience 34: 558-562.

Pierluissi, S. 2010. Breeding waterbirds in rice fields: a global review. Waterbirds 33 (Special Publication 1): 123-132.

Piper, S. E. 1944. Depredations on crops by mudhens. California Department of Food and Agriculture Preliminary Report B-26, Sacramento, California.

Razafimanjato, G., T. S. Sam and R. Thorstrom. 2007. Waterbird monitoring in the Antsalova region, Western Madagascar. Waterbirds 30: 441-447.

Remsen, J. V., Jr., M. M. Swan, S. W. Cardiff and K. V. Rosenberg. 1991. The importance of the rice-growing region of south-central Louisiana to winter populations of shorebirds, raptors, waders, and other birds. Journal of Louisiana Ornithology 1: 35-46.

Sánchez-Guzmán, J. M., R. Morán, J. A. Masero, C. Corbacho, E. Costillo, A. Villegas and F. Santiago-Quesada. 2007. Identifying new buffer areas for conserving waterbirds in the Mediterranean basin: the importance of the rice fields in Extremadura, Spain. Biodiversity and Conservation 26: 3333-3344.

Shuford, W. D., G. D. Page and J. E. Kjelmyr. 1998. Patterns and dynamics of shorebird use of California's Central Valley. Condor 100: 227-244.

Stafford, J. D., R. M. Kaminski and K. J. Reinecke. 2010. Avian foods, foraging, and habitat conservation in world rice fields. Waterbirds 33 (Special Publication 1): 133-150.

Stenert, C., R. C. Bacca, L. Maltchik and O. Rocha. 2009. Can hydrologic management practices of rice fields contribute to macroinvertebrate conservation in southern Brazil wetlands? Hydrobiologia 635: 339-350.

Street, J. E. and P. K. Bollich. 2003. Rice production. Pages 271-296 *in* Rice: Origin, History, Technology, and Production (C. W. Smith and R. H. Dilday, Eds.). John Wiley & Sons, Hoboken, New Jersey.

Subramanya, S. 1994. Non-random foraging in certain bird pests of field crops. Journal of Biosciences 19: 369-380.

Sundar, K. S. G. 2009. Are rice paddies suboptimal breeding habitat for Sarus Cranes in Uttar Pradesh, India? Condor 111: 611-623.

Sundar, K. S. G. and S. Subramanya. 2010. Bird use of rice fields in the Indian subcontinent. Waterbirds 33 (Special Publication 1): 44-70.

Sutherland, W. J. 1996. From Individual Behaviour to Population Ecology. Oxford University Press, Oxford, UK.

Teo, S. S. 2001. Evaluation of different duck varieties for the control of the Golden Apple Snail (*Pomacea canaliculata*) in transplanted and direct seeded rice. Crop Protection 20: 599-604.

Tourenq, C., R. E. Bennetts, H. Kowalski, E. Vialet, J.-L. Lucchesi, Y. Kayser and P. Isenmann. 2001a. Are ricefields a good alternative to natural marshes for waterbird communities in the Camargue, southern France? Biological Conservation 100: 335-343.

Tourenq, C., S. Aulagnier, L. Durieux, S. Lek, F. Mesléard, A. Johnson and J.-L. Martin. 2001b. Identifying rice fields at risk from damage by the Greater Flamingo. Journal of Applied Ecology 38: 170-179.

Van der Weijden, W. 2010. Rice fields. Pages 63-81 *in* Farmland Birds Across the World (W. van der Weijden, P. Terwan and A. Guldemond, Eds.). Lynx Edicions, Barcelona, Spain.

Vickery, J. A., A. R. Watkinson and W. J. Sutherland. 1994. The solution to the Brent Goose problem: an economic analysis. Journal of Applied Ecology 31: 371-382.

Wagner, K. K., R. H. Schmidt and M. R. Conover. 1997. Compensation programs for wildlife damage in North America. Wildlife Society Bulletin 25: 312-319.

Wood, C., Y. Qiao, P. Li, P. Ding, B. Lu and Y. Xi. 2010. Implications of rice agriculture for wild birds in China. Waterbirds 33 (Special Publication 1): 30-43.

Wymenga, E. and L. Zwarts. 2010. Use of rice fields by birds in West Africa. Waterbirds 33 (Special Publication x): 97-104.