

**THE RICE AGROECOSYSTEM, CUBAN FULVOUS WHISTLING
DUCKS AND AVIAN CONSERVATION**

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The Rice Agroecosystem, Cuban Whistling ducks and Avian Conservation

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Abstract

Fulvous whistling ducks (FWD; *Dendrocygna bicolor*) are alleged to have a large negative economic impact on rice crops. We studied the feeding ecology and habitat use of FWD in Cuban rice paddies. Rice and seeds of 12 weed species were found in the diet. Rice was a major constituent of the diet, comprising 35% by mass of the stomach contents collected throughout the study period, but it was a relatively minor component during sowing (when rice was most available). We estimated that only 1.2% (95% confident intervals: 0.5-1.6%) of sown rice was consumed by FWD. Moreover, most of the rice consumed by FWD in the fall was waste rice from flooded stubble fields, and FWD were observed using mainly fields with standing rice during the breeding season. We thus conclude that FWD caused only minor damage to the rice crop.

We assessed the diversity and abundance of the bird community associated with the rice culture. Seventy species were observed using the paddies (36% were winter migrants). Ciconiiformes, Anseriformes and Charadriiformes were the best represented orders. Cattle egret, FWD, blue-winged teal, glossy ibis and morning dove were the most abundant species. The relevance of the rice agroecosystem for waterbird conservation is discussed.

To Karen, Susy and Panchito
For the precious hours taken from family life

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CHAPTER I

GENERAL INTRODUCTION

Rice (*Oriza sativa* L.) is a widespread crop in tropical and subtropical countries and known to occur in the diet of waterfowl for a long time (Givens *et al.* 1964). To grow rice requires modification of the natural environment, such as the filling or draining of ponds and marshes and the maintenance of a constant flow of water to the rice fields from artificial or natural sources which are also unavoidably affected. Consequently, the development of the rice industry has altered the wintering areas of waterfowl and, indirectly, the habits of the birds which must cope with this anthropic ecosystem (Hobaugh *et al.* 1989). In addition to the usual dramatic impact of loss of wetlands on waterfowl, the flooded-drying regime used in the newly created rice areas may have important positive consequences for waterfowl. Hobaugh (1984) pointed out that each year thousands of geese wintering in the Texas rice prairies are dependant on the agricultural practices and land-use patterns associated with rice farming. Flickinger and King (1972) related that the rice-growing region in the Gulf Coast is considered an important nesting habitat for many bird species, whereas others that are nesting in nearby areas, feed in rice fields in the breeding season. Thus, the rice prairies are important not only for wintering habitat but for many birds that utilize its resources throughout the year.

The creation of this specialized habitat may have facilitated an increase in the range of whistling ducks (Bolen and Rylander 1983). In fact, the first time that the fulvous whistling ducks (*Dendrocygna bicolor*, Vieillot) populated Louisiana apparently coincided closely with the beginning of rice farming (Lynch 1943). The same effect was observed in Texas (Carroll 1932), Arkansas (Meanley and Neff 1953; Baird 1963), Sacramento Valley, California (Wetmore

1919), and in Cuba, where it became an established and common species in the 1960's with the development of the rice industry. Although about 70 species of birds occur in Cuban rice paddies during the course of a year (personal observation), using both wet and dry fields, the fulvous whistling duck is the only species that is classified as a pest, because of its abundance and feeding habits.

General Ecology of Fulvous Whistling Ducks

DISTRIBUTION. --- The fulvous whistling duck (FWD; previously known as fulvous tree duck), is widely distributed. It is one of only a few waterfowl species that breed on all continents except Australia, over a huge and discontinuous range (Terres 1980). It occurs in five widely separated populations in tropical and subtropical regions: India, east and west Africa including Madagascar, southeastern South America, West Indies, northern South America, southern United States and northern Mexico (Kortright 1943; Jones 1966; Bellrose 1978; Sibley and Monroe 1990).

Remarkably, despite its wide and discontinuous distribution, only one cosmopolitan species, without any subspecific status, has been recognized (Terres 1980; Bolen and Rylander 1983 and Sibley and Monroe 1990). Bellrose (1978) suggested the existence of two races, while Peters (1931, in: Bolen and Rylander 1983) and Friedman (1947, in: Bolen and Rylander 1983) maintained that the North American population is a different subspecies (as is recognized by the A.O.U.), but in general this scheme has little support. Apparently, due to the species' nomadic tendencies, the different populations have never had the necessary isolation to differentiate into distinct races. The species appears to be quick to colonize new areas (Jones 1966), and the ocean does not appear to be an effective barrier to dispersal (Bellrose 1978).

Many early studies in North America showed the rapid expansion of FWD, in close association with the development of the rice culture (Carroll 1932; Meanley and Meanley 1959; Jones 1966; Landers and Johnson 1976; Palmer 1976). In Louisiana, where the species had been recorded since 1892 (Beyer 1900, in: Bolen and Rylander 1983), the "explosion" began in late 1949 - early 1950 (Palmer 1976), while the winter of 1955-1956 was apparently the start of the range expansion in North America (Baird 1963, in: Bolen and Rylander 1983). This expansion included dispersal to the Atlantic coast (Jones 1966).

Few data are available on range expansion in Africa but it seems that similar patterns have been observed there. The literature until 1983 refers to the species as being confined to the east, south and central part of the continent (Bellrose 1978; Terres 1980; Bolen and Rylander 1983). Nevertheless, a population of 1,000 to 5,000 individuals has become established throughout the year in the rice paddies of the Senegal Delta (Trecu 1986) and it is reported that small populations of 100 individuals were observed in 1963 (Trecu 1992), so the northwest coast of Africa is now considered a part of the species' range (Sibley and Monroe 1990).

The FWD was observed for the first time in Cuba in 1943 (Bond 1979) and until 1967 it was considered a migratory species. The first nest was discovered in 1967 in a rice field of Sur del Jibaro, southcentral mainland Cuba (Garrido and Garcia 1975).

Apparently, in response to the development of the rice culture in several provinces of Cuba, the population of the FWD began to rise in the 1960's. This interpretation corresponds with Lynch's (1943) claim that the extension of the nesting range of FWD into Louisiana was due to the rice culture, "since the region was a prairie prior to cultivation." The population in Cuba had

expanded so much by 1967 that big hunting parties were organized by rice farmers to control it (Garrido 1984). Palmer (1976) suggested that "the great increase in numbers in Cuba may have been a causal factor in the extraordinary spread of this bird throughout the Bahamas and Antilles from 1960 to 1965." Of course, Palmer (1976) did not have any knowledge about the corresponding expansion of the rice industry in Cuba during that decade.

At about the same time, a drastic decline in population was reported for Texas and Louisiana (Bellrose 1978), where by the late 1960's only a few thousands birds were counted in early fall. Much of this regional decline was attributed by Flickinger and King (1972) to mortality caused by the consumption of aldrin-treated rice seeds sown in newly planted rice fields. Alternatively, the decline in population size may be attributable to the migration of large flocks of ducks to the newly created rice fields in Cuba. Baird (1963) suggested that the movements of the FWD populations could be related to the insecticide applications. The migration corridors thus may be not only as described by Bellrose (1978) but may also include an eastward migration. This possibility was suggested by Bellrose (1978) and received some support from a study by Flickinger *et al.* (1973) who reported that four of 165 immature FWD color-marked in Texas moved eastward. FWD that move eastward could ultimately follow the Atlantic flyway, a common route for waterfowl in North America, but so far there is no evidence to support this view. However, direct band recoveries have shown that there is considerable migration from Florida to Cuba during the winter (79% of all the FWD recovered between 1983 and 1987 were from Cuba; Turnbull *et al.* 1989). In addition, the first breeding record in Florida was obtained at Lake Okeechobee in 1960 (Johnsgard 1975) with a dramatic increase of the population occurring in the early 1970's.

HABITS. --- Fulvous whistling ducks appear to be either mainly diurnal or mainly nocturnal according to various reports. In Buena Vista lake, California, they were largely diurnal with a small amount of nocturnal activity (Dickey and Rossem 1923), while Clark (1978) described the feeding periods as being restricted to 2 h following dawn and 2 h preceding dusk. Hasbrouck (1944), Kortright (1943), Meanley and Meanley (1959) and Johnsgard (1975) reported only night feeding in various rice cultures. Palmer (1976) considered this duck to be active during both day and night, as they are in Cuba (personal observation). Considering that FWD are closely associated with an anthropic environment, nocturnal activity may reflect a tendency to avoid human disturbance which is restricted to the day.

FWD occur typically in ricefields and shallow marshes and ponds, and occur rarely in deep water (Palmer 1976). Meanley and Meanley (1959) observed a progressive movement of the ducks toward rice paddies when the rice reached a height of 20-25 cm in the spring. During this period, fields heavily infested with weeds, shallow bodies of water and many potholes were used for both feeding and resting (Palmer 1976). A reduced flock size was reported by Zwank and Mckenzie (1988) in Louisiana during May and June corresponding with pair formation and nesting activity, which is in agreement with Lynch's (1943) report that "by the middle of July small flocks can be seen here and there in the rice fields, but at this time of the year the birds are secretive and widely dispersed." In late August and early September, the birds fly to large ponds and flooded rice stubble. Aggregations of several hundred ducks may occur in these feeding places (Dickey and Rossem 1923; Carroll 1932; Lynch 1943 and Bellrose 1978).

REPRODUCTION. ---The breeding period varies with location. In Cuba, breeding takes place between April and August (Acosta *et al.* 1989), and in North America from May to August (Meanley and Meanley, 1959). In general, because nesting occurs during a certain stage in the development of the rice, the stage of the rice strongly influences the timing of breeding, either advancing or delaying the breeding season (Lynch 1943; Meanley and Meanley 1959). Rice plants are the main nest material in rice fields (Meanley and Meanley 1959; Acosta *et al.* 1989).

Clutch size is highly variable because several females may lay eggs in the same nest, but most authors report clutches of 10-16 eggs (Dickey and Rossem 1923; Kortright 1943; Lynch 1943; Bellrose 1978). Incubation lasts 24-26 days and is shared by the members of the mated pair (Palmer 1976; Bellrose 1978; Acosta *et al.* 1989).

YOUNG. --- Ducklings are flightless for 63 days posthatch (Meanley and Meanley 1959) during which they stay hidden in the rice fields (using the vegetation for protection and feeding). Predation rates on ducklings can be high when the fields are drained prior to harvesting and the ducklings are forced to seek cover in nearby flooded fields (Palmer 1976).

FOOD. --- Studies of the food habits of FWD are especially relevant because the ducks are known to eat rice, which could result in appreciable economic loss for the rice industry. For that reason most studies on the feeding ecology of FWD have been carried out on rice plantations in various regions throughout the world where rice is an important crop. Such studies have been conducted in California, Texas, Louisiana and Florida (Dickey and Rossem 1923; Carroll 1932; Leopold, 1959; Meanley and Meanley 1959; Landers and Johnson 1976;

Turnbull *et al.* 1989), in Venezuela (Bruzual 1976; Casler *et al.* 1981; Rios Soto *et al.* 1981; Bruzual and Bruzual 1983), and in Cuba (Acosta *et al.* 1988). In Africa, the diet of FWD has been documented in the context of a larger study on the damages caused by waterfowl to the rice culture in the Senegal Delta (Trecu 1986), and some aspects of FWD feeding behavior have been studied in a flooded farm area in South Africa (Clark 1978). Until 1980, all research on this topic was based on observations of feeding birds or, with the exception of Meanley and Meanley (1959), on small samples of stomach contents.

FWD feed largely on the seeds of grasses and weeds common to their aquatic habitat. There is general agreement that rice is the most important item in the diet when they use rice paddies as feeding sites, but seeds of 22 species of weed are eaten as well. In Cuba, seeds of *Echinochloa* spp. are the second most important item (Acosta *et al.* 1988) and rice was not uniformly important as a food source throughout the year. In the breeding season, seeds of various weed species were best represented although rice also occurred, and in the fall, rice was consumed at higher levels (Rios Soto *et al.* 1983; Trecu 1986; Acosta *et al.* 1988 Turnbull *et al.* 1989).

FEEDING BEHAVIOR. --- FWD are aquatic feeders. They extract food from the water by means of a sieve-like mechanism (Rylander and Bolen 1974a).

Different feeding behaviors have been described, depending on whether the ducks feed on mature rice and water grass, and on whether they feed in mud, shallow water or, least commonly, deep water. Carroll (1932) pointed out that while feeding on mature plants, "the plant is bent over by the weight of the bird's body and the head containing the grains is completely nibbled off," while Johnsgard (1975) stated that the birds instead pull down and strip the seed. This latter method is commonly used by FWD breeding in rice paddies where

they tend to stay near the nest, usually feeding on the plants that surround potholes, thereby enlarging the potholes. In muddy or marshy places, the ducks walk and feed at the same time, moving the bill from side to side in the mud (Kortright 1943). In shallow water, the birds often look for the food with their head and neck submerged and by dabbling. In deep water, they feed primarily by "tipping" (Meanley and Meanley 1959), although they spend some time diving (Siegfried 1973).

MOLT. --- Unlike Anatidae in general, FWD have only one postnuptial molt (Delacour 1945). Both sexes molt during September-October and the birds are flightless for about 3 weeks (Palmer 1976; Bellrose 1978).

RICE DAMAGE. --- The economic impact of FWD on the rice harvest has been poorly studied. Opinions vary widely as reflected by claims that FWD benefit the rice culture by consuming weeds and contradictory claims that FWD have a detrimental effect (Palmer 1976).

The only assesment of the damage caused by FWD in rice culture was made by Casler *et al.* (1981) in Venezuela. They estimated that FWD and white face whistling ducks (*D. viduata*) caused a 1.8-2.6% reduction in the annual rice crop, 1.2 -1.6% in the rainy season (May-October) and 6.2-9.0% in the dry season (November-April), and that the number of ha damaged by the whistling ducks represented 45% of the total yearly damage to rice.

Meanley and Meanley (1959) related the losses in spring to the way the rice was sown. The birds took more rice when the fields were flooded at the time of sowing than when the rice was sown by drilling. Hasbrouck (1944) reported that FWD were exceedingly injurious to rice when broadcast sowing was used, and he stated that FWD never touched the sprouted rice or the

growing crop. By contrast, Carroll (1932) and Meanley and Meanley (1959) pointed out that they fed mostly on ripening rice.

Turnbull *et al.* (1989) found that they eat more rice in the fall but that most of this was waste rice that the birds collected from among reflooded rice stubble. The most important cue for the birds when they used rice plantations was the aquatic environment (Bruzual and Bruzual 1983) as they can feed on many plant species other than rice (Rios Soto *et al.* 1981). Thus, the impact of FWD on weed plants should be taken into account in a possible control program.

Finally, Treca (1986) analyzed the impact of FWD on rice paddies and found that they inflicted little damage, apparently because their numbers are small. He claimed that the farmers could overcome the losses during sowing by increasing the amount of rice seeds sown by one third.

Rice culture in Cuba

Rice is grown in two periods, the spring sowing and the winter sowing. Because water is a critical limiting factor, the precise date of each sowing depends on the water supply. Therefore, all information about the phenology provided below applies to the period (May to December) and the area under study (Sur del Jibaro) in 1992.

RICE PHENOLOGY. --- The variety of rice used during the study has a life cycle of 120 days. During this period the rice field will go through different stages.

Pre-sowing. Before sowing by broadcasting (water planting), the fields are flooded for at least a week. During the last 2 or 3 days of the flooding period, tractors prepare a homogeneous, muddy mixture of water and soil.

Sowing. To sow the rice, seeds are released from an airplane onto the irrigated paddies. The fields are drained the following day. The seeds stay on the surface until germination takes place 4-5 days later. Sowing took place between May and August in 1992.

Sprouting. The field is kept dry for 25 days following sprouting. If it does not rain during this period, the field is reflooded each fifth day and dried again the same day. This procedure is used to maintain a certain level of moisture.

Fields were in this stage from May to September.

Sprouting (wet). On the 26th day following sowing, the paddies are reflooded to a depth of at least 10 cm and are then maintained in this state almost until the end of the cycle. Weeds are uncommon during this stage. Fields were in this stage from May to October.

Sprouting (wet with weeds). The rice paddies continue to be under irrigation. Weeds are very common and thus their seeds are available. Potholes and weedy areas are very common. At this stage, the farmers usually assess the level of infestation of weeds and use this information to decide which fields need the application of herbicides. However, because of the economic crisis in Cuba in 1992, the farmers were unable to control weeds in the usual way, which accounts for the continued presence of weeds in subsequent stages. Fields were in this stage from May to November.

Fared rice (wet with weeds) This stage is similar to the prior stage except for the presence of green (unripe) rice. When half of the rice has ripened, the field is drained again to prepare the soil for the combine harvester. Drainage usually takes place 20 days before the end of the cycle.

Mature rice. At this stage, the field is dry and contains weeds. Fields in this stage contain an abundance of food and are heavily infested with rodents, which are considered the most important pest in Cuban rice paddies.

Stubble fields. Following the harvest of the first crop the field may be flooded again for a variable number of days depending on the sowing schedule or may be allowed to lie fallow (for the soil to recover). Waste rice (lost during mechanical harvesting) and weed seeds are readily available in such fields but waterfowl feed on them only if the fields are reflooded, otherwise pigeons feed on the rice and seeds.

WEEDS. --- Weeds are unavoidably associated with any cultivated plant. Economic losses due to weeds are very high. They are considered the main pests in rice in the United States because they reduce yield (and quality) by an estimated 17%, compared with about 8 and 7% reductions caused by insects and diseases, respectively (Smith and Hill 1990). In Louisiana, herbicide application, reduced yield and quality owing to weeds, and increased costs in land preparation and harvesting combine to produce an average cost of \$172 U.S./ha/year (Crawford *et al.* 1990).

The harmful effects of undesirable species of plants upon the rice take three forms. First, weeds compete with rice for water, light and nutrients. This competition reduces the yield. Second, weeds can serve as hosts for pests and diseases. Third, weeds interfere with operational techniques such as irrigation and harvesting (Zoschke 1990).

Many weed pests have been described in Cuban rice fields (Francois *et al.* 1972) but three members of the Gramineae family are the most numerous and troublesome: red rice (*Oriza sativa*), barnyardgrass (*Echinochloa crus-galli*) and junglerice (*Echinochloa colonum*). The two *Echinochloa* species are among the 18 most serious agricultural weeds in the world (Anderson 1977).

Red rice. This is a degenerated variety of rice that has remained on the farm. The seed is similar to the rice seed; the difference is in the color under the skin,

which is white in the commercial rice and red in the red rice. Red rice with its high levels of infestation, is considered the most troublesome weed in Cuban rice paddies. Red rice readily releases its seeds, which ensures high infestation levels because most of the seeds stay in the field (though many are harvested together with the commercial rice). It is an annual grass, with a life cycle that is shorter than that of cultivated rice (90-110 days, Francois *et al.* 1972).

Junglerice. This annual grass, usually about 60 cm tall, forms mature seeds about 42-64 days after germination (Kranz *et al.* 1977). The number of seeds produced per plant can be from 8000 (Pancho 1964) to over 42,000 (Mercado and Talatala 1977).

Barnyardgrass. This annual grass can reach heights of 150 cm. It produces mature seeds between 60 and 130 days after germination, and produces 2,000 to 40,000 seeds per plant (Holm *et al.* 1977).

Objectives of the project

Rice is a major crop throughout the world but is particularly important in developing countries, where 95% of production occurs (Wright 1991). The lack of systematic studies regarding the importance of rice paddies to wildlife has probably led to an underappreciation of their significance. As wetlands in general are scarce, and in many cases prone to destruction (Lugo and Bayle 1992), rice cultures provide a new habitat for waterfowl that depend on the aquatic habitat.

The extension of the rice culture to new areas has had a significant positive impact on some species, such as the FWD, which has increased its range in close association with this culture (Lynch 1943; Bolen and Rylander

1983) and is now considered a pest in rice paddies in several regions of the world (Casler *et al.* 1981; Bruzual and Bruzual 1983; Garrido 1984).

In Cuba, rice is an important crop in at least six provinces in the mainland and its significance is increased because of the shape and geographic position of the island, in the middle of migrant corridors, such as the Atlantic flyway.

As agricultural damage by waterfowl is a major concern not only for farmers but for conservationists as well, the purpose of this project is first to study the feeding ecology and the habitat use of the FWD in different periods of the annual cycle in the rice culture, thereby acquiring the information necessary to make a realistic assessment of the FWD's true impact on the rice. The second main objective of this project is to analyze the rice culture as a wetland ecosystem and its importance for waterfowl and other birds.

Study site

The study was carried out in Cuba, in the Agroindustrial Rice Complex Sur del Jibaro (21°35'- 21°45' N, 79°05'-79°25' E). This 24,838-ha area, located in southcentral mainland Cuba in Sancti Spiritus province (Fig. 1.1), is the major rice producing region of the country.

The rice growing region is flat, and is limited on the north side by the Zaza reservoir, which supplies water to the complex. Other crops, such as sugar cane, and small rural communities surround the remainder of the north, east and west side of the rice paddies. Throughout the complex are numerous natural ponds, which are heavily used by waterfowl. In the south, between the rice paddies and the coast, lies a 1-5-km-wide natural area that is covered by sandy marshlands vegetation (mainly mangrove, *Rhizophora mangle*, and *Avicennia germinans*, yana, *Conocarpus erecta*, pataban, *Laguncularia racemosa*, and various species of palm (*Sabal parviflora*,

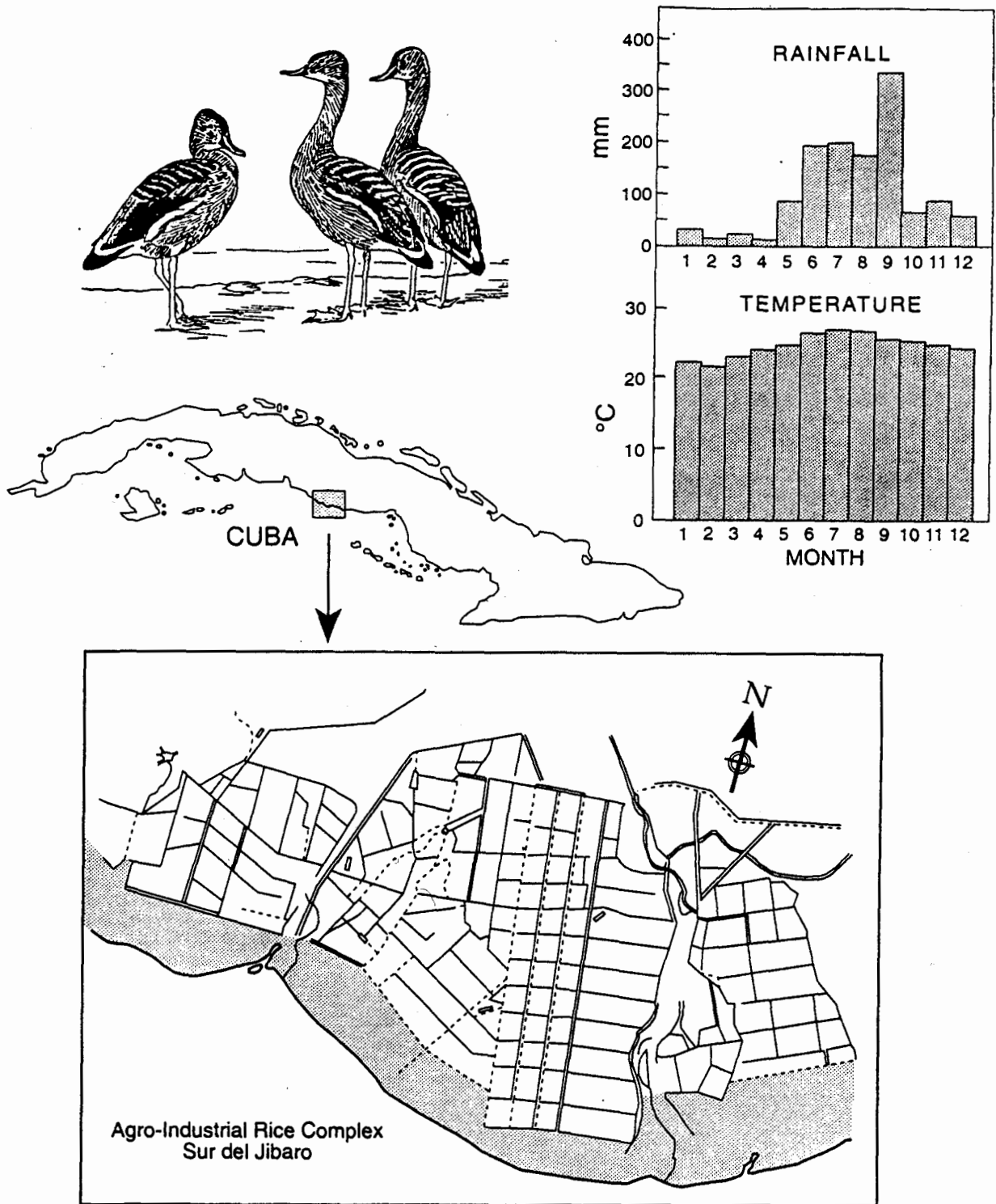


Fig. 1.1 Map of the rice prairie study area in Sancti Spiritus province, Cuba and the natural marshy coast belt (shaded). Temperature and rainfall regimes during the year are shown.

Copernicia spp. etc). This coastal belt of natural vegetation, an area free of human disturbance, serves as a protected area for wildlife.

There is a tropical rainy climate with two clearly defined seasons: the dry season, or winter, which lasts from November to April, and the rainy season, or summer, which lasts from May to October. Mean annual rainfall is 1.2 m. The coldest months are January and February with an average temperature of about 22°C, and the warmest is July, with an average of 28°C. The mean annual temperature is 25°C. Occasionally, during the winter, a cold air mass from the north shifts southward, resulting in lower temperatures.

CHAPTER II

HABITAT USE AND FEEDING ECOLOGY OF FULVOUS WHISTLING DUCKS IN SUR DEL JIBARO RICE PADDIES, IN CUBA

Introduction

Fulvous whistling ducks (FWD) *Dendrocygna bicolor* were first reported in Cuba in 1943 (Bond 1979). They were reported to be rare until the 1950's and they were considered a winter migrant until 1967 (Garrido and Garcia 1975). The development of the rice industry in Cuba in the last 30 years has apparently produced a dramatic increase in the FWD population as the rice paddies are an important source of food and provide nesting and roosting sites. The banding records show that Cuba's winter migrant FWD come from Florida (Turnbull *et al.* 1989; P. Gray personal communication). The great increase of the population first reported in 1967 (Garrido 1984) coincides with the decrease observed in North America in the same decade (Bellrose 1978). Pioneering tendencies of the species and the loss of breeding sites in North America, together with the creation of new habitats, appear to be the main causes of the expansion of the FWD range (Bolen and Rylander 1983).

FWD are alleged to feed extensively on rice, thus rice farmers have been concerned with their control. At the same time, FWD are a popular sport hunting species and so are important to the local economy (Dallmeier 1991). Hence, the management goal is to maintain FWD populations at levels that are low enough so that the damage to the rice crop is inconsequential but high enough that local economies depending on sport hunting are likewise not severely affected (Dallmeier 1991; Bruzual and Bruzual 1983).

Any program created to manage and exploit FWD in a sustainable way should take into account the real impact they have on the rice crop, and should consider the ducks' use of the rice paddy habitat (where a mosaic of fields with different management regimes is available to the birds during the growing cycle of the rice). Rylander and Bolen (1980) pointed out that "stomach analyses and food availability studies must be instigated before conclusions are reached concerning the economic importance of FWD to agriculture." Many studies have focussed on the feeding ecology of FWD in rice cultures in the United States, Venezuela, Cuba and Senegal (Imler 1944, in: Meanley and Meanley 1959; Leopold 1959; Meanley and Meanley 1959; Landers and Johnson 1976; Madriz *et al.* 1981; Rios Soto *et al.* 1981; Bruzual and Bruzual 1983; Treca 1986; Acosta *et al.* 1988; Turnbull *et al.* 1989; Dallmeier 1991; Treca 1993). One study examined habitat use (Zwank and McKenzie 1988), through aerial surveys conducted on rice fields and 14 nearby different habitats. No study has simultaneously examined feeding ecology and habitat use, taking into account the different stages during the rice growing cycle.

Our objectives were to: 1) quantify habitat use of FWD across seasons in a major rice-producing region of Cuba, 2) study their diet in relation to resource availability, and 3) assess rice consumption by FWD, with special emphasis on the sowing period.

Methods

The study was carried out in the Agroindustrial Rice Complex Sur del Jibaro in the Sancti Spiritus province, Cuba (21°35' - 21°45'N, 79°05' - 79°25'E) from May-December 1992.

We conducted surveys from June-December (except during September). The study covered the breeding season (June-August) and 3 months of the

non-breeding period (October-December). Fields were operationally classified according to the stage of the growing cycle of the rice (from sowing to harvesting), or as fallow or flooded fallow fields (Fig. 2.1). Separate tallies of the number of FWD were kept for each category of field.

Censuses were conducted during the first 4 hours after sunrise by walking along two transects for each ~2-ha field. Censuses were conducted on at least 10 days each month. During each census we recorded the number of FWD that flushed, the stage of the field, the water level and the height of the rice (if any). During the breeding period, when we could see the exact spot where the bird had been just prior to flushing, a 0.25 X 0.25-m metal frame was used to sample the composition of the vegetation. A total of sixty-two such samples were taken during the censuses (from June-August).

Using the habitat-use data, we calculated density estimates of FWD (FWD/2 ha), and the frequency of use for each field type (number of fields with FWD/number of fields sampled). We also used a standard habitat use index ($HUI = \% \text{ use} / \% \text{ available}$) to assess habitat type preference (Hobaugh 1984); values >1 indicate preference and those <1 indicate avoidance (Newton and Campbell 1973).

We examined gizzard and crop contents to obtain diet data from May to December. September is the only month during which none were collected and in October only a small number were obtained because there were few adults in the rice. The birds were collected by shotgun between 0700 and 1100. During the hunting season (October-December), all samples were obtained from hunters.

After collection, each gizzard and crop was labelled and placed in an 85% ethylalcohol solution. Food and grit were separated in the laboratory. Food items were sorted under a stereomicroscope, identified (common items to

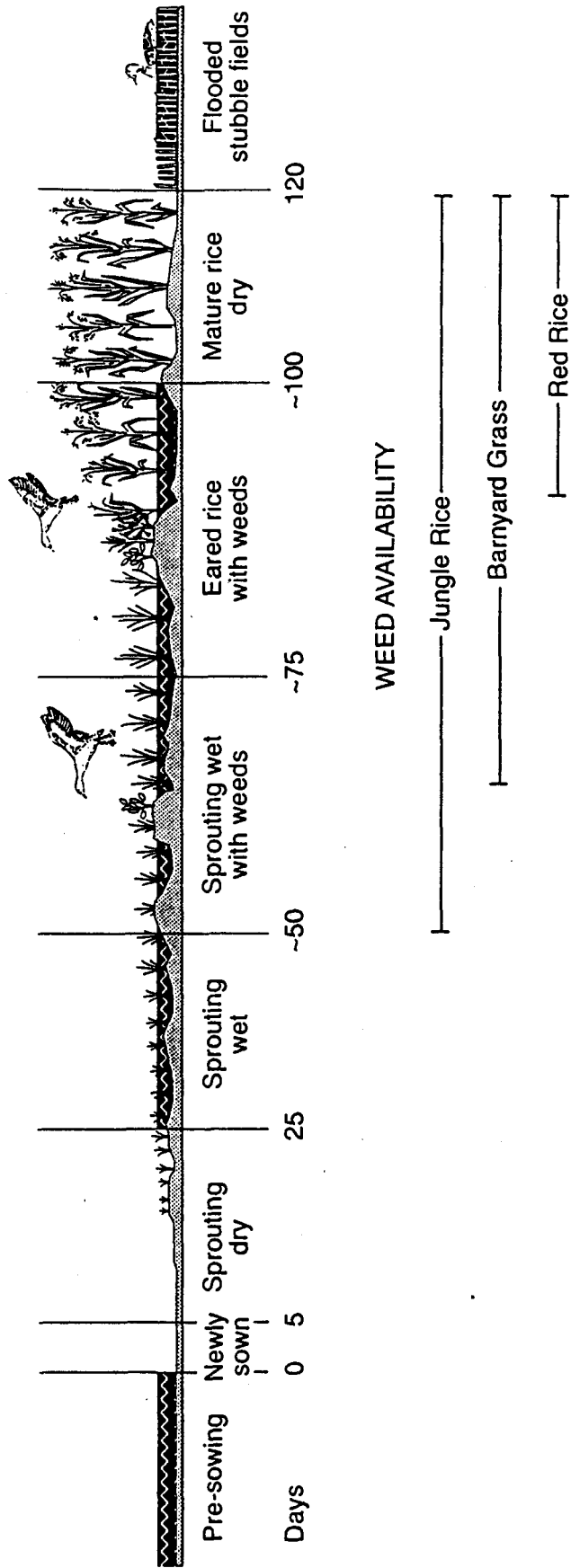


Figure 2.1 Rice phenology with the proximate duration of each stage (habitat) and the flooded regime. Weed availability is represented below.

species level), and weighed. The gross energetic content of the main items in the diet were determined with a Phillipson Microbomb Calorimeter, following Carefoot (1985).

Analysis of food availability was based on information on the sowing schedule, rice phenology, and level of weed infestation provided by the Statistics Department of the rice culture. The degree of infestation of the fields by weeds was determined qualitatively by visual inspection and the fields were classified as low (<50% of field infected) or high (\geq 50%).

Field metabolic rate (FMR), daily food requirements (FR) and 95% Confidence Intervals (CI) were estimated using the allometric equations for birds (Nagy 1987):

$$\text{FMR} = 10.9 \text{ BM}^{0.640} \quad \text{CI -57 to +135 (\% of FMR)}$$

$$\text{FR} = 0.648 \text{ BM}^{0.651} \quad \text{CI -55 to +124 (\% of FR)}$$

where BM is body mass in grams.

Estimates of per capita annual consumption of rice and weeds were calculated as $(\text{FR})(365)(\text{proportion of the overall diet by dry weight})$. Daily rice consumption was estimated for each month. FMR was calculated using the mean body mass by month, except for October (when the average body mass for the entire study was used as it was the only sample that included juveniles). Daily rice consumption (g/FWD/d) was thus calculated as $\text{FMR} / \text{metabolizable energy}$, where the assimilation efficiency was taken to be 83.3% (the value reported for northern pintail (*Anas acuta*); Miller [1987]). Because we lack a value for the conversion efficiency of rice in FWD, we evaluated the sensitivity of our consumption estimates to variation in conversion efficiency. We computed 95% confidence intervals for all estimates.

Because recently sown fields are alleged to be the most vulnerable to FWD, we evaluated the impact of consumption of ungerminated rice seeds during the sowing period on the subsequent rice crop. On the day before sowing (during June and July), we prepared 15, 3 X 3-m exclosures that prevented consumption of rice by birds. Two months later we counted the number of rice plants in a 1 X 1-m metal frame placed in an arbitrary location within the exclosure (n=15) and at three (or, in one case, two) such locations outside the exclosure in each field (n=44). A Wilcoxon signed-ranks test was used to compare the number of rice plants within the exclosures with the average number of rice plants outside the exclosures.

At the same time, we evaluated whether there was a decrease in the number of seeds over the 4 days prior to germination. To accomplish this evaluation, we used a 25 X 25-cm metal frame, which we threw 80 times daily from equidistant points along dikes. We counted the seeds within the frame after each such toss. Heterogeneity across the 4 days was tested using a Kruskal-Wallis test. We stopped the counts as soon as the seeds germinated (usually on the 5th day). This procedure was adopted because the birds were never observed consuming germinated seeds. In the fields selected for the above described sampling scheme, we censused FWD daily during the sowing and germination periods.

FMR for the sowing period (May-August) was estimated for each month as $(10.9BM^{0.641})(\% \text{ rice})(\text{number of days in that month})$. The four monthly values were summed to obtain an estimate of FMR for the whole period. We estimated the mass of rice eaten by the FWD population as $(FMR)(\text{number of FWD}) / 14.65 \text{ KJ/g}$, where the number of FWD was estimated as the density (FWD/ha) of ducks in freshly sown fields multiplied by the number of hectares sown. We calculated 95% C.I.'s for all estimates. The estimated mass of rice

consumed by the FWD population was compared with the mass of rice seeds released from the plane during broadcast sowing to estimate the percentage of sown seeds lost to FWD consumption.

Results

HABITAT USE. --- The number of fields of different types surveyed over the course of the study are given in Table 2.1. The initial sampling scheme had to be modified depending on accessibility of the fields or to avoid human disturbance, thus the number of fields surveyed varied across months. Densities of FWD (individuals / 2 ha) in the different habitats are shown in Table 2.2. Dry fields were never used by the birds (sprouting and dry, between 5 and 25 days, and mature rice the last 20 days at the end of the cycle). Densities in just-sown fields were low, with a trend to increase by the end of the breeding season. Densities in the fields that were flooded 25 days after sowing were also low, though some small flocks used these fields mainly as roosting sites or for maintenance activities during July.

After about 6 weeks, when the rice plants were 30-70 cm high and weeds were evident (sprouting with weeds), FWD were observed on a regular basis. All FWD counted between June and August in the fields that were sprouting (with weeds) or had eared rice (with weeds) were nesting and thus were widely dispersed among the rice. Some juveniles were still hidden in fields with standing rice as late as October. No adult FWD were observed among the rice plants in October and November; the high density estimates for those months are attributable to the use of ponds and potholes by large flocks of feeding or resting ducks.

FWD were commonly observed in fields that were heavily infested with weeds. Assessments of the relative abundance of vegetation types in the

Table 2.1 Number of 2 ha fields sampled by habitat type and month in Sur del Jibaro rice fields.

Habitat	June	July	Aug.	Oct.	Nov.	Dec.	Total
Newly sown	120	93	56	na ^a	na	na	269
Sprouting dry	10	32	16	na	na	na	58
Sprouting wet	7	24	36	7	na	na	74
Sprouting with weeds	15	46	44	26	55	na	186
Eared Rice with weeds	35	21	8	22	53	20	159
Matured Rice	4	17	0	17	15	30	83
Flooded Stubble Fields	3	11	10	12	13	20	69
Total	194	244	170	84	136	70	898

^a Not available at the time of sampling.

Table 2.2 Density of fulvous whistling ducks (FWD/2ha) by habitat in Sur del Jibaro rice fields.

Habitat	June	July	Aug.	Oct.	Nov.	Dec.
Newly sown	0.28	0.34	1.53	na ^a	na	na
Sprouting dry	0	0	0	na	na	na
Sprouting wet	0	6.91	0.08	0	na	na
Sprouting with weeds	1.73	1.30	6.39	103.57 ^b	1454.98 ^b	na
Eared Flice with weeds	2.61	1.71	3.50	0.18	521.30 ^b	0
Matured Flice	0	0	0	0	0	0
Flooded Stubble Fields	1.33	2.60	0.90	27.33	1084.69	34.20

^a Not available at the time of sampling.

^b Observed in ponds inside the field.

vicinity of sightings of FWD (usually resting or feeding), revealed that in 66% of the vegetation plots junglerice was present (median= 61 plants per plot), in 14% (12) barnyardgrass, in 24% (5) *Eichhornia crassipes*, and 8% (4) red rice. Red rice may be underrepresented because, in the vegetative stage, it is hard to distinguish from rice. Flooded, stubble fields were used throughout the year with lower density figures in the summer and higher in the fall and winter. FWD were never observed in dry fallow fields. The overall distribution of densities by month and habitat (stage during the rice phenology) shows (Fig. 2.2) lower densities but higher use of rice paddies in the summer (June-August) and higher densities with a decrease in the use of the paddies in the fall and the winter (October-December).

Newly sown fields were not frequently used, but fields with green or eared rice, weeds and water, were heavily used during spring and summer (Table 2.3).

The habitat-use index (Fig. 2.3) shows that newly sown fields were the only ones with values consistently <1 , indicating that they were used less often than expected on the basis of their availability. Sprouting wet fields were used more often than expected during one month only. Sprouting and eared fields with weeds were selected more often than expected, though this tendency declined over the course of the study. By contrast, the ducks' use of flooded stubble fields increased during the latter months of the study.

FEEDING ECOLOGY

General aspects. Table 2.4 shows the number of FWD collected throughout the study. Mean body mass suggests that they were mostly adults, except in October, when adults were moulting and had apparently sought refuge in the coastal belt.

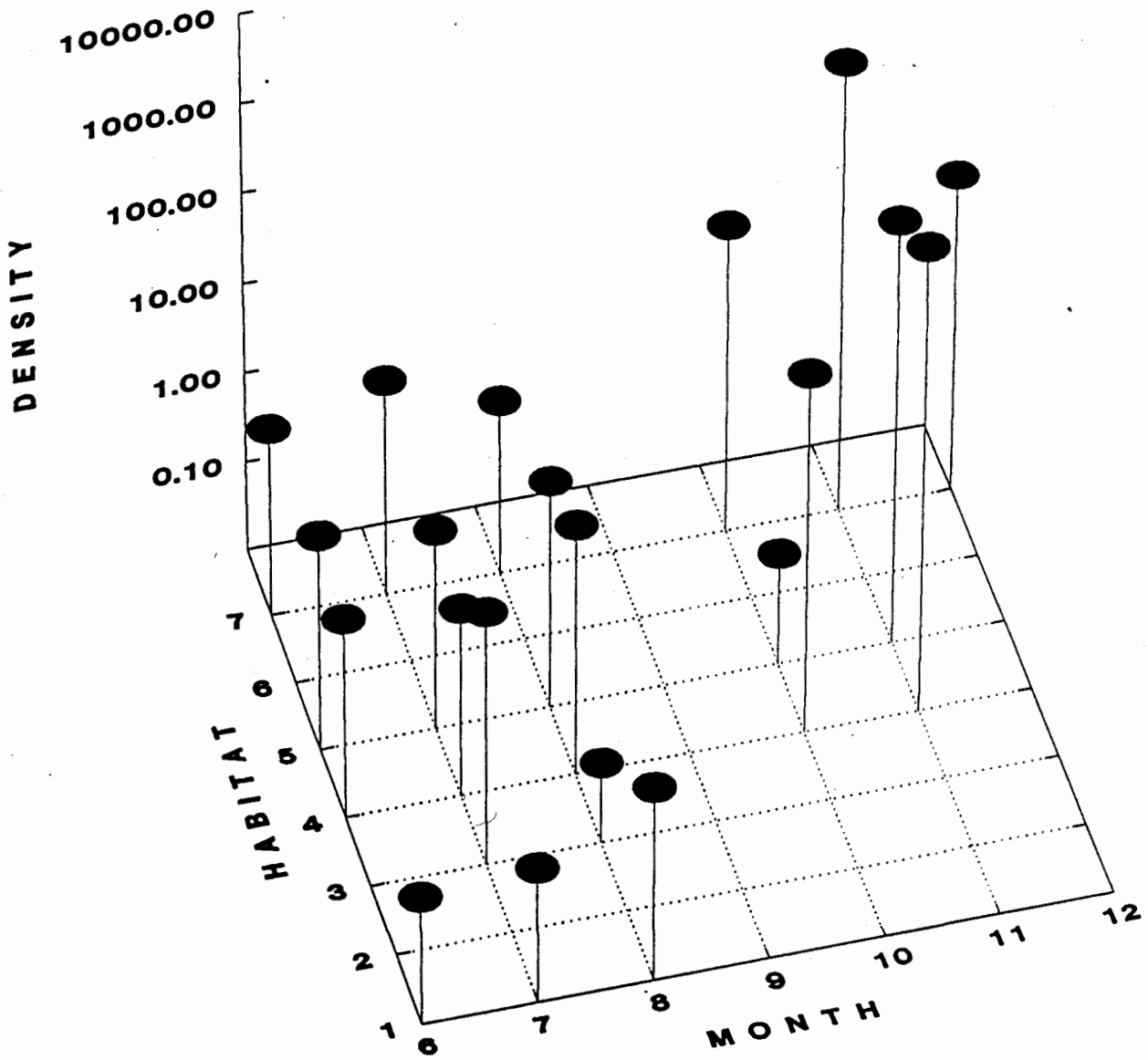


Figure 2.2 Density of fulvous whistling ducks (FWD/2ha) by month and habitat in Sur del Jibaro rice fields. No data were collected in September. Habitats: 1) just sown; 2) sprouting dry; 3) sprouting wet; 4) sprouting wet with weeds; 5) eared rice with weeds; 6) mature rice dry; 7) flooded stubble fields.

Table 2.3 Frequency of use of the different habitats (Fields with fulvous whistling ducks / Fields sampled x 100) by month.

Habitat	June	July	Aug.	Oct.	Nov.	Dec.
Newly sown	5.8	7.5	7.1	na ^a	na	na
Sprouting dry	0	0	0	na	na	na
Sprouting wet	0	75.0	5.5	0	na	na
Sprouting with weeds	66.6	30.0	77.3	26.9	9.1	na
Eared Rice with weeds	82.8	76.0	50.0	9.0	20.7	0
Matured Rice	0	0	0	0	0	0
Flooded Stubble Fields	100	45.0	30.0	33.3	92.0	40.0

^a Not available at the time of sampling.

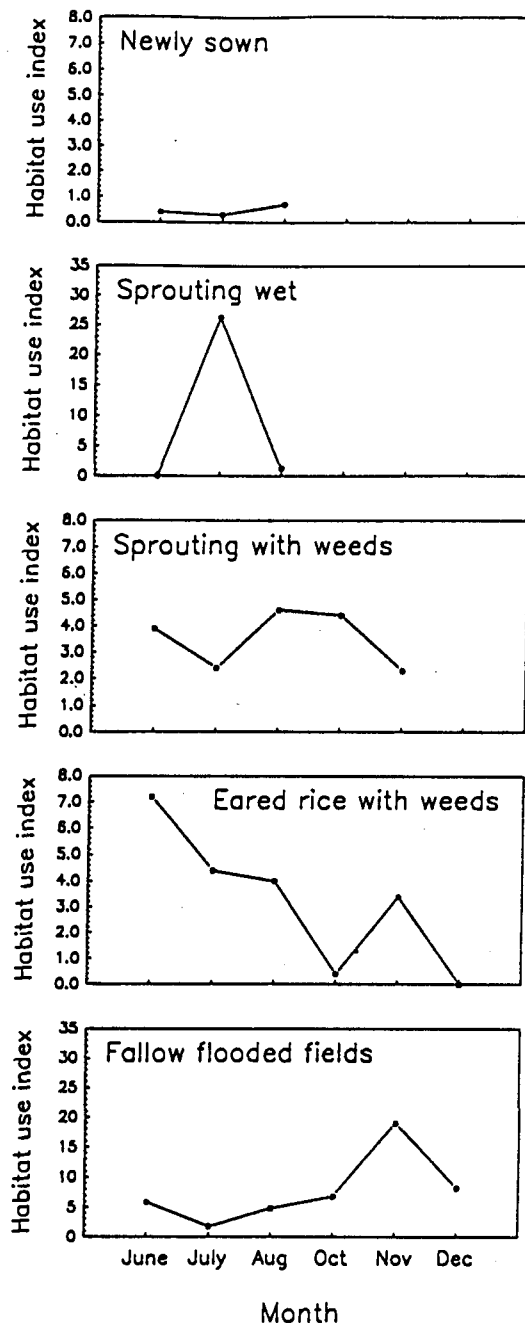


Figure 2.3 Habitat-use index (% use/ % available) per habitat type used by fulvous whistling ducks each month. Use data are from Table 2.3, availability data from Table 2.7.

Table 2.4 Number and mean body mass (g) of fulvous whistling ducks sampled by month and sex in Sur del Jibaro rice fields.

Month	N	Males	Females	Mean Mass \pm SD ^a
May	25	11	14	715.2 \pm 64.5
June	19	8	11	728.1 \pm 68.7
July	21 ^b	8	12	701.0 \pm 76.4
Aug.	20	12	8	748.8 \pm 49.9
Oct.	12 ^b	5	6	624.4 ^c \pm 80.4
Nov.	34	17	17	754.9 \pm 75.1
Dec.	21	14	7	759.0 \pm 78.0
Total	152	75	75	739.8 ^d \pm 66.0

^a Standard deviation.

^b Includes one unsexed individual.

^c 63% of the sample were young of the year.

^d Young of the year were not included

Food was present in all gizzards. Table 2.5 shows seasonal trends in the masses of crop and gizzard contents. The mass of total gizzard contents (G; food plus grit) ($G=6.03+3.69t$, $r^2=0.95$, $P<0.001$), food (F) ($F=1.01+0.132t$, $r^2=0.88$, $P=0.02$), and grit (Gr) ($Gr=0.611+0.138t$, $r^2=0.90$, $P=0.001$) all increased significantly across months (t). In addition, the mass of grit in the gizzard was positively correlated with the mass of food ($Gr=-0.138+0.876F$, $r^2 = 0.72$, $P= 0.015$). Finally, although total gizzard content (food plus grit) was significantly correlated with body mass ($G=-0.321+0.00414BM$, $r^2=0.12$, $P<0.001$), the slope was only marginally positive and the coefficient of variation was small relative to the above described relationships.

Diet. Food contents are presented in Table 2.6 (percent dry weight and percent occurrence) by item and month. FWD ate mostly seeds. Animal material, in the form of crustacean shell, appeared in the diet of only one individual in August. That material may be more appropriately categorized as grit.

Seeds from 13 plant species were identified in the diet (Table 2.6). Red rice (a degenerate variety of *Oriza sativa*, now a weed) and rice (*Oriza sativa*) were the most important items overall. These species, together with junglerice (*Echinochloa colonum*), made up the bulk of the diet. Rice comprised 35% of the total dry weight and was present in more than half of the gizzards analyzed. Rice was an important part of the diet from July through November. Junglerice was the staple food in May and June. Red rice was the most important food in December. Eight other species were included in the remaining category (i.e., others), because they were poorly represented in the diet. FWD consumed the seeds of at least four species of weed in every month. The diet was most diverse in August.

Table 2.5 Mean weight (g) and standard deviation (SD) of crop and gizzard contents of fulvous whistling ducks by month.

Month	Crop		n	Gizzard		
	n	Food content (Mean \pm SD)		Total content (Mean \pm SD)	Food content (Mean \pm SD)	Grit content (Mean \pm SD)
May	0	-	25	1.97 \pm 0.39	1.09 \pm 0.35	0.79 \pm 0.29
June	4	1.13	19	2.30 \pm 0.65	1.22 \pm 0.37	1.02 \pm 0.42
July	10	0.76 \pm 0.88	21	2.41 \pm 0.68	1.53 \pm 0.50	0.91 \pm 0.52
Aug.	3	5.48	20	2.51 \pm 0.55	1.50 \pm 0.39	1.01 \pm 0.38
Oct.	3	5.43	12	3.13 \pm 1.38	1.83 \pm 1.28	1.30 \pm 0.50
Nov.	1	1.7	34	3.13 \pm 0.52	1.66 \pm 0.48	1.47 \pm 0.50
Dec.	16	7.59 \pm 4.05	21	3.58 \pm 0.65	1.93 \pm 0.38	1.65 \pm 0.38

Table 2.6 Monthly crop and gizzard contents of fulvous whistling ducks as a percent of the monthly dry weight. % occurrence is given in brackets. Sample size as in Table 2.4

Food item	Percent Dry Weight (% of occurrence)											
	May	June	July	Aug	Oct.	Nov.	Dec.	Total				
Rice	16.0 (16.3)	9.6 (21.0)	59.6 (76.2)	65.0 (90.0)	62.2 (66.6)	98.5 (100)	tr (4.7)	35.0 (55.9)				
Junglerice	82.0 (88.0)	86.6 (89.95)	12.9 (52.4)	5.4 (30.0)	2.2 (8.3)	1.5 (5.8)	2.0 (42.8)	14.7 (44.7)				
Red Rice	0	0	0	20.4 (30.0)	29.8 (33.3)	0	80.3 (85.7)	38.3 (18.4)				
Water Hyacinth	0.3 (4.0)	3.5 (5.3)	17.8 (33.3)	3.6 (10.0)	5.2 (33.3)	tr ^b (2.9)	0	2.9 (10.5)				
Barnyardgrass	0	0	9.2 (33.3)	0.2 (10.0)	1.5 (25.0)	0	0	0.9 (7.8)				
Mollusca	0	0	0	3.6 (5.0)	0	0	0	0.3 (0.6)				
Others ^a	1.2 (4.0)	1.6 (5.3)	0.4 (4.7)	1.6 (10.0)	0.2 (8.3)	tr (2.9)	17.5 (76.2)	7.9 (15.1)				
Total weight (g)	27.3	28.8	40.7	46.5	38.2	58.3	169.0	408.8				

^a Others include eight unidentified weed seed species.

^b Trace: less than 0.1%.

The caloric content of the most important food items was similar (rice, 17.5 kJ/g; junglerice, 16.8 KJ/g; barnyardgrass, 17.2 KJ/g; red rice, 17.4 KJ/g; and water hyacinth (*Eichhornia crassipes*), 19.1 KJ/g).

FOOD AVAILABILITY. --- During the growing cycle, rice goes through several stages that correspond with varying water levels and weed availabilities (Fig. 2.1). These combinations of phenological stage of the rice, water level, and weed availability create an array of habitat types for FWD. Because different fields were in different stages of the growth cycle from May through August, the entire array of habitats was available throughout that period (Table 2.7). Thereafter, because no more sowing occurred, only fields in the latter stages of the cycle were available in November and December. The proportion given for the flooded stubble fields may be an underestimate owing to incomplete information.

Food availability varied across phases of the cycle. Rice seeds were available mainly in: 1) planted paddies, especially just after sowing (151.3 kg/ha released by aerial application) and while standing water remains on the field, and 2) stubble fields that are reflooded after harvesting (where losses from mechanical harvesting are estimated at 756 kg/ha). These fields thus have five times more rice seeds than freshly sown fields, providing a rich food source during the nonbreeding season.

Fields with eared rice may also be used by FWD for feeding, but green rice was found in only one sample in October (in the gizzard of a juvenile), and in three samples in November (when FWD were collected while they fed in potholes within fields with green, eared rice). The remaining rice that appeared in the diet was mature.

Table 2.7 Percent (%) of habitats represented within the Sur del Jibaro rice fields during the period under study. The figures in each column sum to 100% of the total area (24,837.72 ha).

Habitat	May	June	July	Aug.	Oct.	Nov.	Dec.
Newly sown	14.4	17.9	22.2	9.4	na ^a	na	na
Sprouting dry	11.4	8.2	8.4	16.1	na	na	na
Sprouting wet	2.8	2.1	2.2	4.1	4.0	na	na
Sprouting with weeds	11.5	17.2	12.5	16.8	6.1	4.0	na
Eared Rice with weeds	5.6	11.5	17.2	12.5	24.4	6.1	4.0
Mature Rice	11.1	5.6	11.5	17.2	16.8	24.4	6.1
Flooded Stubble Fields	12.6	16.8	17.0	6.1	4.8	4.8	4.8
Fallow Fields	30.6	20.7	9.0	17.8	43.9	60.7	85.1

^a Not available

The only opportunity FWD have to feed on mature rice directly from the panicles is when it is in the process of maturing and standing water remains on the field. However, this opportunity is available only for a limited time because the farmers drain the fields when about half of the crop has reached maturity. No FWD were seen in dry fields of mature rice during our study.

Weed seeds are present in the soil of recently sown fields. These seeds remain from the last harvest, usually in lower concentration than rice, and when rice begins to germinate many of these seeds remain available for consumption by FWD. Weeds persist throughout the rice cycle unless control methods are used by farmers. Junglerice can produce mature seeds in about 6 weeks, barnyardgrass in about 2 months, and red rice in about 3 months (Fig. 2.1). Many other weed species associated with the rice culture and the potholes also produce edible seeds. Because of the economic crisis in Cuba during our study, farmers made virtually no attempt to control weeds (i.e., apparently few or no herbicides were applied to the fields).

Relatively little rice consumption occurred in May and June, though rice was widely available in just-sown, eared-rice, and flooded, stubble fields during those months (Fig. 2.4). Consumption remained at similar levels during July and August. In October, there was no sowing and a decrease in the flooded, stubble fields, yet this was the month with the highest percent of fields with ears. Finally, rice was the main item in the diet during November, when the three kinds of fields where rice is available were in decline (Fig. 2.4). No significant correlation was found between rice consumption and availability in the three kinds of fields with consumable rice across the 7-month study period ($P's > 0.44$).

Similar analyses were performed for the three most economically important weeds. Junglerice was common in the diet during the spring when it was more available in fields infested with the weed (Fig. 2.5). Marginally

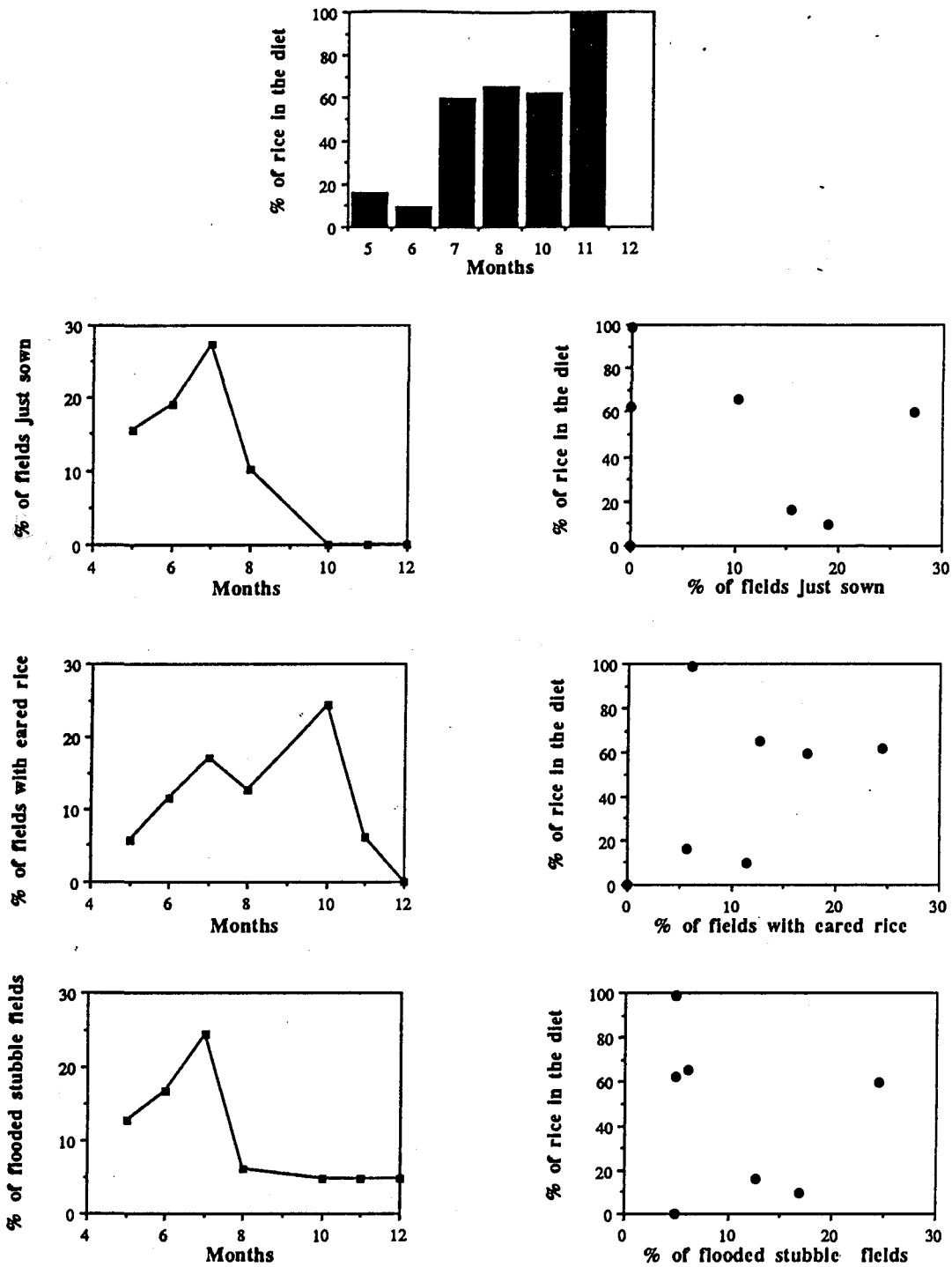


Figure 2.4 Proportion of rice in the diet of fulvous whistling ducks (above), percent of fields with rice seeds available (left column) and rice consumption against rice availability in each kind of habitat (right column)

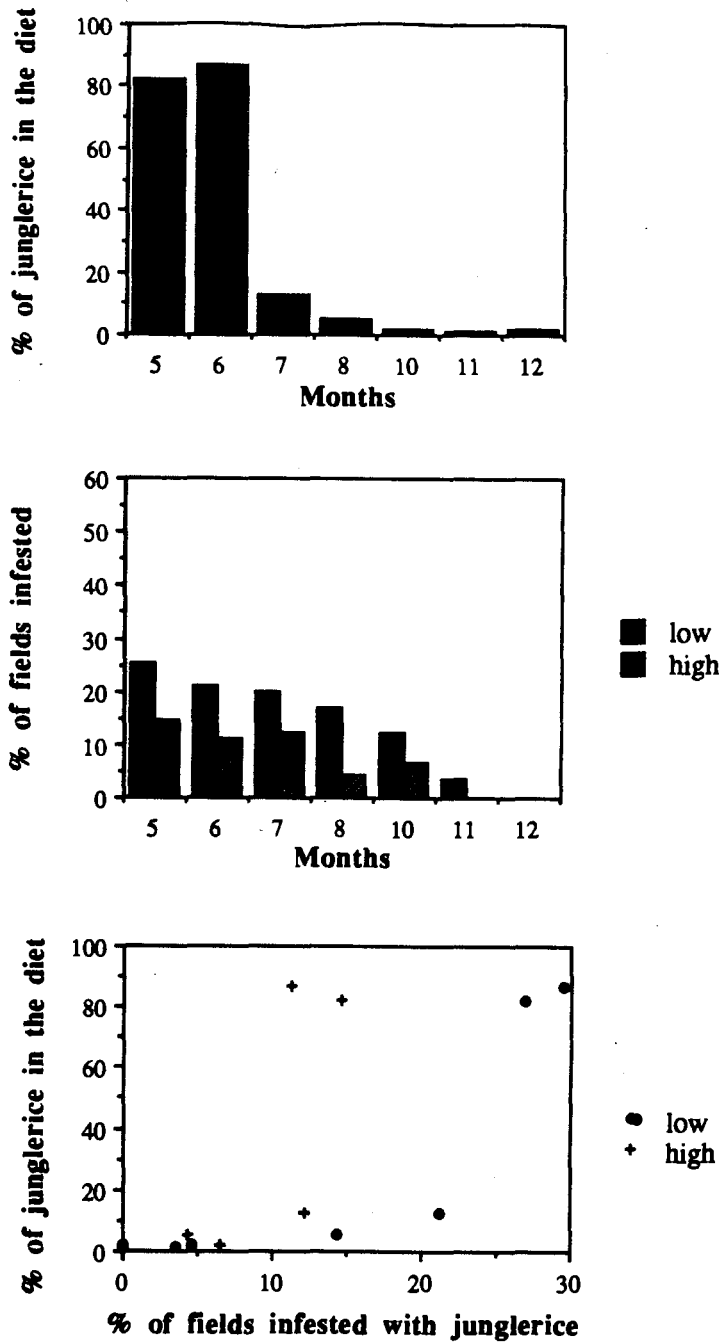


Figure 2.5 Proportion of junglerice in the diet of fulvous whistling ducks (above), proportion of fields with low and high availability of junglerice (middle) and relation between the two variables (bottom).

nonsignificant positive correlations emerged between the amount of junglerice (JR) in the diet during a month and the proportion of fields during that month that had either low (L) or high (H) infestation levels ($JR = -13.7+2.92L$, $r^2=0.49$, $P=0.079$; $JR = -6.7+4.93H$, $r^2 = 55.2$, $P=0.056$). Barnyardgrass was poorly represented (Fig. 2.6) and no significant correlation emerged between the proportion of it in the diet and the proportion of fields infested with that weed (p 's > 0.46). Red rice infested a greater proportion of the fields than did any other weed species, but it was common in the diet during only 3 months, particularly during December (Fig. 2.6). No significant correlation emerged between consumption and infestation level (p 's > 0.19)

ASSESSMENT OF DAILY FOOD INTAKE. --- The Field Metabolic Rate (FMR) was 747.6 KJ/day (95% CI 321.5 to 1756.8 KJ/day) so the annual Metabolic Rate is 272 MJ/year (95% CI 117.3 to 641.2 MJ/day). Daily food requirement was estimated using the general equation for feeding rate for birds given by Nagy (1987), and using the FMR and different published assimilation efficiencies for humans (Souci 1989) and northern pintail (Miller 1987, Table 2.8). Similar values were obtained with the three equations.

The general equation for birds (Nagy 1987) was used to estimate the annual per capita consumption of rice and weeds. Rice accounted for 35% of the overall diet and weeds for the remaining 65%. We thus estimate that annual per capita consumption of rice was 6.1 kg (95% CI: 2.7 to 13.7Kg) and that of weeds was 11.3 kg (95% CI 5.1 to 25.4Kg).

As summarized in Table 2.9, we estimated daily rice consumption for each month, estimating a monthly FMR and using the metabolizable energy for rice (by other waterfowl species) of 3.5 kJ/g (Miller 1987). These estimates are slightly higher than those based on other assumed assimilation efficiencies of

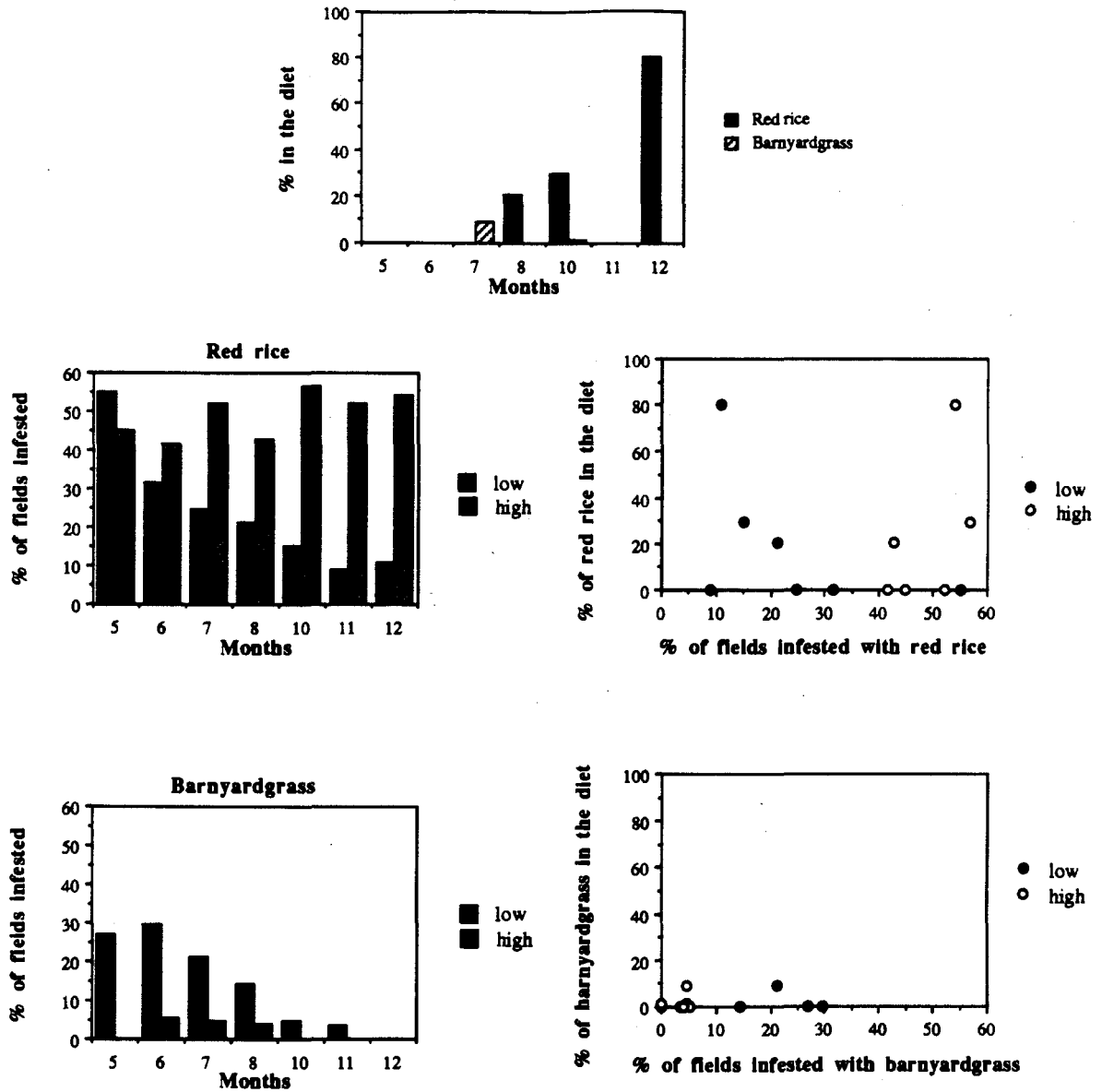


Figure 2.6 Red rice and barnyardgrass consumption by fulvous whistling ducks (above), availability in standing crop (left column) and consumption versus availability for each weed (right column).

Table 2.8 Feeding Rate (g/day) of fulvous whistling ducks on rice, using a general equation (Nagy 1987) and at various efficiency values (FMR of 747.6 KJ/day).

Efficiency (%)	Mean per day (g)	95% Confidence Intervals	Mean per year (Kg)	95% Confidence Intervals
na ^a	47.8	21.5 107.0	17.4	7.8 39.1
97 ^b	43.9	18.9 103.3	16.0	6.8 37.7
83.3 ^c	51.0	21.9 119.9	18.6	8.0 43.7

^a Nagy (1987). Efficiency data were not available

^b Souci (1989)

^c Miller (1987)

Table 2.9 Estimated daily rice consumption per fulvous whistling duck during the period under study.
(FMR = 747.6KJ/day, Metabolizable energy = 14.65KJ/g)

	May	June	July	Aug.	Oct.	Nov.	Dec.
% Rice in diet (dry weight)	16.0	9.6	59.6	65.0	62.2	98.5	tra
FMR x % Rice (KJ/day)	117.0	71.0	430.4	489.7	468.1	745.9	-
95% CI for FMR (KJ/day)	50.3 275.0	30.5 166.9	185.0 1011.5	210.5 1150.8	201.2 1100.0	320.7 1752.9	-
Feeding Rate (g/day)	7.9	4.8	29.3	33.4	31.9	50.9	-
95% CI for Feeding Rate (g/day)	3.4 18.7	2.0 11.3	12.6 69.0	14.3 78.5	13.7 75.0	21.8 119.6	-

^a Traces: less than 0.1%

rice (Table 2.9). An increase in rice consumption was observed from July to November with the peak value in the last month.

RICE CONSUMPTION DURING THE SOWING PERIOD. --- Rice seeds sown by the broadcast method are vulnerable to consumption by FWD during the 4-5 days prior to germination. We thus focussed our attention on recently sown fields from June to August. FWD densities were highest during the first day after sowing, when the field is still flooded, with densities decreasing over the subsequent days (Table 2.10). In August, many FWD were observed in fields the day after sowing, but none were observed during subsequent days.

We detected no significant trends in the density of rice seeds across the days following sowing (Fig. 2.7; Kruskal-Wallis test: June, $H=4.95$, $df=3$, $P=0.18$; July, $H=3.24$, $df=3$, $P=0.36$). The higher variability observed in June than in July may be attributable to the windy conditions that prevailed during that month. By contrast, the number of rice plants in sample plots within exclosures, that prevented consumption of seeds by birds, was significantly greater than the number of plants in plots outside of exclosures (Fig. 2.8; Wilcoxon matched-pairs, signed-ranks test: $Z = -2.50$, $P = 0.006$, one-tailed).

During the four months of sowing, FWD consumed 1.8 kg of rice seeds per hectare (95% CI: 0.8 to 2.4 Kg). Therefore, in the 14,893.4 ha sown, we estimate total rice consumption by FWD at 27,769.9 kg (95% CI: 11,765.8 to 35,893.2 Kg). A total of 151.3 Kg/ha of rice seeds were released during broadcast sowing. Thus, we estimate that the total lost to consumption by FWD was ~1.2% (95% CI: 0.5 to 1.6 %).

Table 2.10 Density of fulvous whistling ducks (FWD /2ha) in just sown fields.

Month	Days after sowing				
	1	2	3	4	5
June	1.20	0.20	0.40	0	0
July	1.35	0.04	0	0.22	0
August	6.14	0	0	0	0

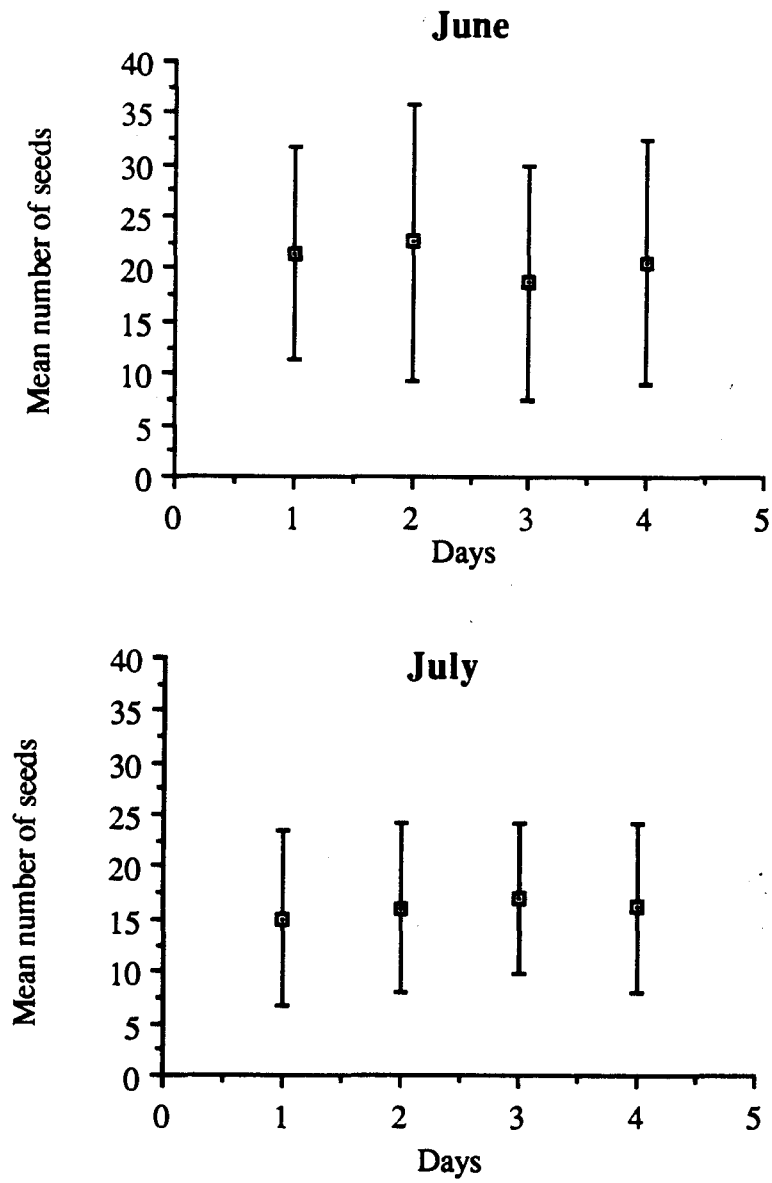


Figure 2.7 Daily mean number of seeds in a 625 cm² metal frame in the just sown fields (from sowing to germination).

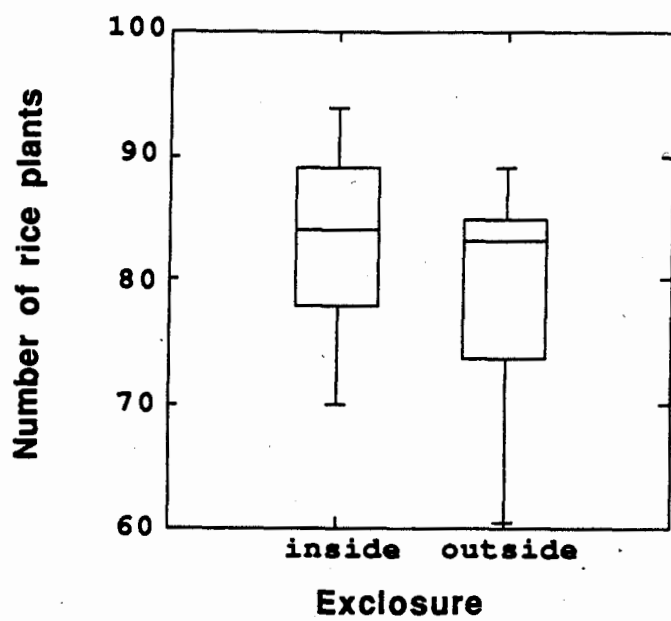


Figure 2.8 Box plots of the number of rice plants present in 1.0 m² plot inside and outside exclosures

Discussion

Our results clearly show that the presence of water was a major cue in habitat selection by FWD during both the breeding and nonbreeding seasons.

Anatomical features of FWD, particularly their large feet, more horizontal posture and the structure of their bill, suggest that they are better adapted to aquatic environments than are other Dendrocygnids (Bolen and Rylander 1974, Rylander and Bolen 1970, Rylander and Bolen 1974, 1974a). In fact, Bruzual and Bruzual (1983) claimed that the presence of water is more important for FWD than is the presence of rice.

Obviously, however, water was not the only important cue in habitat selection during the breeding season, as FWD were widely dispersed in the rice paddies and not restricted to open water (newly sown fields and flooded stubble fields; Table 2.2). Finding food while avoiding predators and seeking nesting materials are the obvious pressures FWD must face. The presence of weeds may provide information about food supply. Fields with heavy infestation levels were preferred for nesting in Louisiana paddies (Meanley and Meanley 1959), which agrees with our findings for Cuban FWD. Such flooded fields may also provide refugia, where risk of attack by mammalian predators (mongoose, *Herpestes auro punctatus*; feral cats, *Felix domesticus*; rodents, *Ratus ratus*, *Mus musculus* and even humans) is reduced. The importance of water in protection from predators has been documented by Mayhew and Houston (1987).

FWD selected different kinds of habitat for different activities. Their habitat use patterns during the breeding season versus nonbreeding season were strikingly different and were not uniformly linked with high availability of rice. In fact, during the sowing period, when the ducks were breeding, FWD

were observed to spend most of their time in flooded fields with standing vegetation, whereas once the FWD finished breeding they were mostly observed in open flooded areas.

FWD formed large flocks during the nonbreeding season. This flocking behaviour may result in a reduction of per capita predation risk because of the "dilution effect" (Hamilton 1971) and because predators are detected earlier. These flocks mainly used flooded stubble fields and ponds with good visibility and plenty of food, and large potholes in the few fields with standing crops. Bourne and Osbourne (1978) described how black-bellied whistling ducks (*Dendrocygna autumnalis*) in Surinam recognized a suitable habitat as those ones with one flock already settled and using it. Similar patterns have been observed for FWD in Cuba (personal observation). During all this period most of the rice consumed by FWD was waste rice (following harvesting) that was made available to the ducks when recently harvested fields were reflooded.

The seasonal increase in the mass of gizzard contents and grit (Table 2.5) corresponded with an increase in food intake, following the annual moult in September and October. This increased intake reflects the annual accumulation of fat reserves (Acosta *et al.* 1989) preceding migration. Similar behaviour was described for European widgeon *Anas penelope* (Bauer and Glutz von Blotzheim 1968). This increase in intake apparently coincided with a decrease in the availability of food, a decrease attributable to farming practices and to the dry season. Thus, in addition to building reserves for migration, the increased intake might also be interpreted in part as a compensatory adjustment to diminishing food availability in the rice fields. The observed correlation between grit and food in the gizzard was also reported by Acosta *et al.* (1988). Evidently the birds somehow regulate the amount of grit they take in relation to the food they need to grind.

Consumption of rice by FWD has been a major concern in rice growing areas where this bird is abundant. While there is no doubt that rice paddies offer a rich source of suitable food, FWD do not choose a monotonous rice diet throughout the year. The higher values of rice consumption in FWD have been reported when small sample size were analyzed (Table 2.11; Imler *et al.* 1944; Madriz *et al.* 1981; Turnbull *et al.* 1989). Studies covering more than one season (Meanley and Meanley 1959; Rios Soto *et al.* 1981; Treca 1986; Turnbull *et al.* 1989) have found a reduction in the amount of rice in the diet during the breeding season (spring) and a dramatic increase in fall and winter. These seasonal trends are consistent with our results, which were unrelated to rice availability (Fig. 2.4), and with those obtained during a previous two-year study in the same rice culture (Acosta *et al.* 1988).

We are unable to determine the basis of diet selection with our present data, but we know that the differing metabolic demands during the breeding cycle can influence the quality and quantity of the food selected. Birds are expected to prefer food of high value both in terms of net metabolizable energy and nutrient content (Jorde and Owen 1988). The gross energetic content of the major weeds in the diet is similar, but we unfortunately lack information about the metabolizable energy content of these seeds for FWD. Miller (1987) reported that rice has a high concentration of soluble carbohydrates (nitrogen-free extract = 78.3%) but only moderate amounts of protein (6.7%). Little published information is available regarding the nutritional value of the major seeds in the diet of FWD. Miller (1987) found that barnyardgrass had 9% crude protein (in the fall) and 9.5% (in the winter) with 50.6% and 69.1% carbohydrates in the fall and winter. Agricultural grains in general have more digestible carbohydrates and less fiber and protein than wild seeds (Middleton 1992; Miller 1987), and protein concentration has been identified as a

Table 2.11 Percent of rice (*Oriza sativa*) in g consumed by fulvous whistling ducks reported in the literature.

Presence of rice in the diet (% dry weight)	n	Place	Source
78%	15	Louisiana Rice Fields	Imler <i>et al.</i> 1944
Traces (spring) 15% (fall)	100 100	Louisiana Rice Fields	Meanley and Meanley 1959
0	5	California Valley	Leopold 1959
0	6	South Carolina	Lander and Johnson 1976
34%	127	Senegal Rice Fields	Treca 1986
79%	37	Central Llanos Venezuela	Madriz <i>et al.</i> 1981
64%	21	Calabozo Rice Fields, Venezuela	Bruzual and Bruzual 1983
65%	20	Rice Fields Venezuela	Dallmeier 1991
37%	73	Rice Fields, Venezuela	Rios Soto <i>et al.</i> 1981
0	15	Hato el Frio Rice Fields, Venezuela	Dallmeier 1991
99.7% (fall) 78.1% (summer) 0% (spring)	19 4 5	Rice Fields Florida	Turnbull <i>et al.</i> 1989
Important in the fall and winter	408	Two Rice Fields Cuba	Acosta <i>et al.</i> 1988
34.87%	131	Rice Fields Senegal	Treca 1993
35%	152	Rice Fields, Cuba	(present study)

relevant factor in food selection for other waterfowl species (Rees 1990, Prins and Ydenberg 1985).

During the breeding period, most FWD were observed in fields with heavy cover and weeds, where they could get nesting material, protection from predators, and food. The opportunity for exploiting mature rice in such fields was limited because the fields were drained when half of the panicles in a field had mature rice. FWD responded by moving to nearby flooded fields. Hasbrouck (1944) stated that FWD feed only on newly sown seeds (prior to sprouting). To feed on rice, FWD thus must seek out newly sown fields or reflooded, recently harvested fields. The travel involved in such a search may likely entail appreciable energetic cost and predation risk. Undoubtedly, multiple factors combine to influence whether FWD during the breeding season feed in fields with standing vegetation or in just-sown and flooded stubble fields. The former habitat type probably is safer but less profitable for feeding. Sometimes only the weed seed heads are available, and the ducks must spend considerable time and energy handling the food (many feeding places with the plants bent down were found during the spring and summer surveys). In contrast, flooded stubble fields are probably riskier (greater human disturbance) but more profitable habitat than those with standing rice.

The diet was most diverse during the rainy season, when resource availability was highest. Similar findings were made by Acosta *et al.* (1988) in Cuba, and Rios Soto *et al.* (1981) and Dallmeier and Rylander (1982) in Venezuela. FWD are clearly opportunistic feeders, including new food items in their diet when they become available. *Echinochloa* spp. are a common item in the diet according to most studies on FWD feeding in rice paddies (in dry weight: 27% *E. colona*, Trecca 1986, 1993; 7% *E. walteri*, Turnbull *et al.* 1989; 45% of those two species combined, Meanley and Meanley 1959; 16% *E.*

colona, Rios Soto *et al.* 1981). Acosta *et al.* (1988) found that seeds from *Echinochloa* sp. were the most common in the diet. The high values in the percent dry weight found in the spring in the present study (82 and 87%), may be attributable to the farmers' lack of control of the weeds. The importance of this weed in the diet of FWD in different regions of the world reflects its abundance as it is considered to be among the worst crop-damaging weeds in world agriculture (Anderson 1977).

Because seeds of weeds comprise the majority of the diet, the role that FWD play in their control may have important agricultural implications. Lynch (1943) reported that FWD are valuable as control agents of rice field weeds, and Rios Soto *et al.* (1981) argued that the impact of FWD on weeds must be considered in any future control program.

Availability seems to be the most important proximate factor influencing diet selection by FWD feeding on weeds (Fig. 2.5 and 2.6). Junglerice was the most common weed in the diet from May through July, yet red rice plants were more abundant (higher percent of moderately and highly infested fields). However, because the seeds of red rice take 3 months to reach maturity and because FWD were feeding (and nesting) in younger rice fields (with mature junglerice and barnyardgrass) during that period, consumable red rice was in short supply. Thus, it appears that FWD fed on the more common of these two weed species during the early months. The more available junglerice was in infested fields, the more FWD fed on this weed (Fig. 2.5). During later months, junglerice seeds were largely replaced in the diet by the later-maturing red rice seeds, which readily released their seeds when the fields were drained. When the fields were then reflooded, these seeds were available in abundance. Such fields were used extensively during winter, when the ducks were in large flocks.

The estimated daily food requirement of 47 g agrees reasonably well with an estimate of 40 g for *Dendrocygna autumnalis* (Borne and Osborne 1978). As that species is about 100 g lighter than *D. bicolor* (Palmer 1976), the lower estimate seems reasonable. Bourns and Osborne (1978) also found that black-bellied whistling ducks have two well defined peak foraging periods each day. Clark (1978) similarly found that FWD in South Africa fed during the summer months in the first 2 hours following dawn and preceding dusk with casual feeding during the remaining daylight hours. In our study, ducks collected early in the day typically had full crops, suggesting that the FWD we studied may have similar diurnal patterns in foraging activity.

The increase in daily rice consumption from July to November (Table 2.9) should be taken into account in any management design to reduce FWD damage. July and August were the 2 months when rice is most susceptible to damage as sowing was still taking place. In August FWD density increased in just sown fields (Table 2.10), sprouting with weeds and eared rice with weeds, in addition a decrease was observed in FWD density in flooded stubble fields (Table 2.2). Clearly this was the month with higher losses due to FWD consumption. In October and November the daily consumption was high as well but it was mainly waste rice from flooded stubble fields.

To date few studies have examined rice consumption and yield losses by FWD (Imler *et al.* 1944, McCartney 1963, Casler *et al.* 1981). Dallmeier (1991) stated that net damage caused by whistling ducks is difficult to estimate accurately because some farms are more susceptible to depredation than others, and because FWD are not the only source of damage. Rodents, for example, are thought to be the primary predators on rice in both Venezuela and in Cuba. In addition, only a fraction of the rice ingested by the ducks can be

taken to imply yield reduction, because many of the seeds ingested are lost during mechanical harvesting.

The higher density of FWD in the first day after sowing (Table 2.10) is related to the fact that the fields are still flooded on that day; in subsequent days density is drastically reduced as the fields are drained and only small flooded potholes may remain. The differences found in the enclosure experiments are in agreement with the rice consumption estimated, mainly in July. This method was more reliable than the seed count in the frame, as the seeds could be counted only in the band near the border of the field.

Our estimate that 1.2% of the sown rice was ingested by FWD is in agreement with previous estimates for black-bellied whistling ducks in 1973 (2%) and in 1974 (0.2% in Guyana; Bourne and Osbourne 1978). McCartney (1963) reported a loss of 1% and Imler *et al.* (1944) reported a loss of 3% (in 30% of the rice fields). Casler *et al.* (1981) reported that 45% of all annual damage was caused by FWD and white-faced whistling ducks (*D. viduata*) (1.8 to 2.6% of the annual crop was lost), though damage varied across seasons. In the rainy season (May-October), they reported 1.2 to 1.6% damage (similar to our estimate), but in the dry season (November-April), they estimated the damage to be as high as 9%, assuming a daily per capita consumption of 65 g and a 60% decline in population size during winter.

Finally, we conclude that the consumption of ungerminated rice during the spring sowing period is not a serious problem for the farmers, but greater damage is probably done during winter sowing, as reported by Casler *et al.* (1981). At least two factors could lead to increased crop damage during winter. First, the Cuban FWD population may increase during winter due to the influx of wintering migrants. At least one feeding flock of 30,000 individuals has been seen in our study area during December. Second, open flooded fields are

preferred for feeding in the nonbreeding season, when FWD gather in large flocks. We suggest that crop damage attributable to FWD could be substantially reduced if the sowing method were changed from water sowing to dry sowing.

Conclusions

- 1) Rice comprised about one third of the overall diet of FWD, though it was a relatively minor part of the diet in the spring. The predation on economically important weeds, such as *Echinochloa* sp. and red rice, can have a positive impact in the control on these undesirable plants.
- 2) In the breeding period, FWD fed preferentially on weeds, although rice availability was highest at that time of year.
- 3) Habitat use varied throughout the year. Habitats that provided more protection were extensively used during the breeding season and those providing more food were extensively used during the nonbreeding season.
- 4) Our findings suggest that crop damages during the spring sowing are low, August being the month with more possible losses. Most of the rice consumed during the nonbreeding period has no bearing on crop yield.

CHAPTER III

THE RICE CULTURE AGROECOSYSTEM AND ITS IMPORTANCE FOR BIRD CONSERVATION

Introduction

Rice paddies are one of the most productive and dependable agricultural systems devised by humans (Odum 1993). They differ from natural ecosystems in some important respects. The operation of a rice farm typically involves the application of fertilizers, pesticides, and herbicides; the use of machinery; and the management of water levels. The dominant plant is under artificial rather than natural selection, and control is external and goal-oriented rather than internal via subsystem feedback (Odum 1984). Despite these and other artificial features of this freshwater marsh ecosystem, rice paddies may be important ecological areas.

Human management greatly reduces biodiversity in most agroecosystems (Odum 1993). In rice cultures, however, alternating periods of flooding and drying during the growth cycle create a structurally complex habitat that retains many features typical of natural ecosystems. Because avian species with specific habitat requirements may be most likely to use those newly created habitats that are most similar to their natural habitat (Cody 1985), the unusually high degree of structural complexity of the rice agroecosystem may promote high avian diversity. In fact, birds are conspicuous components of this agroecosystem (Horn and Glasgow 1964; Hobaugh *et al.* 1989).

There are growing, conflicting concerns regarding the bird community associated with the rice culture. Rice farmers are concerned about crop losses presumed to be caused by birds, whereas conservationists are concerned about the value of the paddies as bird habitat and thus about the implications of

the agricultural management techniques for the bird community. Although the cultivation of rice is an ancient agricultural practice (Grist 1986), and rice is now considered the second most common crop in the world (Hoffman 1993), little attention has been paid to the complex ecological processes involving the interaction between the bird community and the rice crop.

The aims of this paper are: to describe the general features of rice paddies, to report data on the diversity and abundance of birds using rice paddies in Cuba, and to call attention to the need for an integrated approach to rice farming that will consider the management and conservation of waterbirds.

Rice Ecosystems

DISTRIBUTION. --- Domestication of rice seems to have begun between 3200 and 2500 BC in China. Today rice is grown in more than 100 countries and on every continent except Antarctica, from 40°S to 53°N (Lu and Chang 1980). It occupies more surface area worldwide than any other crop (1,500,000 km²; Fores and Comin 1992). The leading producers of rice are China, India, Indonesia, Bangladesh, Thailand, Viet Nam, Burma and Japan (Hoffman 1993). Asia is responsible for 91.1% of the total production, followed by Latin America (3.9%), Africa (2.2%), and the rest of the world combined (2.8%; Chang and Luh 1991).

RICE GROWTH AND DEVELOPMENT. --- The growing cycle of rice spans from 100 to 210 days. Temperature and day length are the two most important environmental factors affecting the development of rice. The life cycle is divided in three main phases: vegetative (from seed germination to panicle initiation), reproductive (from panicle initiation to anthesis), and ripening (from anthesis to full maturity; Vergara 1991).

Based on land and water management practices, ricelands are classified as either lowland (wet preparation of fields) or upland (dry preparation of fields). Based on water regime, lowland fields are classified as rain-fed (5-50 cm of standing water), deepwater (51-100 cm standing water), or floating (from 101 cm and 6 m of standing water; De Datta 1981).

AGRICULTURAL PRACTICES WITH PROBABLE CONSEQUENCES FOR BIRDS. --- Several aspects of modern rice farming seem to have important consequences for the diversity, abundance, and local distribution patterns of birds in rice fields. The following aspects are of key importance: the preparation of fields for planting, the rotation of crops, the staggering of fields (by stage of the growth cycle), and the abundance of weeds (Hobaugh *et al.* 1989).

Field preparation. Flooded fields are plowed to prepare a seedbed (for planting and germination) and to control the growth of weeds (Hobaugh *et al.* 1989) by destroying the weed seeds left in the field. This process usually brings buried macrofauna to the surface, making invertebrate prey readily available to waders.

Field rotation and stage. Continuous rice production on the same land is generally impractical owing to increased production of weeds and decreased fertility of the soil (Hobaugh *et al.* 1989). Thus, when fields are not being used for rice production, they are typically used as cattle pastures, or left as fallow or flooded fallow fields. Some flooded fields are used for growing fish in the United States (Gray personal communication) and in Cuba (personal observation), which may attract large numbers of piscivorous birds (personal observation). In addition, because rice farms comprise a mosaic of parcels that

vary both in the vegetative stage of plants and in the level of water, an array of habitat types is simultaneously available.

Weeds. Weeds can substantially reduce the rice yield. Under moderate competition, weeds may reduce the yield by roughly 40 to 50%, and, under severe competition, may cause complete failure of the crop (De Datta 1981). Among the most troublesome weeds are *Echinochloa* spp., *Cyperus rotundus*, *Eichornia* spp., and *Polygonum* spp. (Hobaugh *et al.* 1989). These species are also important sources of food for waterfowl. Weeds are controlled by hand in some areas, using a short-handled hoe, but this method requires about 300 h of manual labor per hectare. Herbicides are commonly used to control weeds; however, the pollution resulting from this practice may have important adverse effects on the bird community.

Use of cuban rice paddies by birds

INTRODUCTION. --- Rice is the crop with the second highest acreage after sugar cane in the Cuban mainland. It is grown in six provinces: Pinar del Rio, Habana, Matanzas, Sancti Spiritus, Camaguey and Granma. The total area sown comprised 143,000 ha in 1991 (FAO Yearbook 1991). Because of the shape of the island, most of the rice growing areas are near the coast. In some places, the coast belt between the paddies and the sea is natural marsh.

Few data are available on the abundance and diversity of birds in the rice paddies, though several authors have pointed out the importance of the ecosystem, particularly for wintering waterfowl (Singleton 1951; Horn and Glasgow 1964; Flickinger and King 1972; Hobaugh *et al.* 1989). My goal is to provide a preliminary documentation of the diversity and density of birds associated with the rice paddies in Sur del Jibaro Agroindustrial Rice Complex, Sancti Spiritus province, Cuba.

METHODS. --- Data were collected during a study of fulvous whistling ducks (*Dendrocygna bicolor*) in the Sur del Jibaro Rice Culture, Sancti Spiritus province, Cuba. We spent 10 days in the field every month from June to December 1992 (except September) during which we recorded opportunistic sightings of any bird species. To estimate densities, two censuses were conducted, one in June (when most of the birds were breeding) and the other in October (after the arrival of the winter migrants). The counts were made during the first 4 h after sunrise by walking along two transects in each field (~2 ha per field). 205 rice fields were surveyed during June and 80 during October (Total = 570 ha).

RESULTS AND DISCUSSION. --- We recorded 70 bird species representing 12 orders (Table 3.1). Twenty-five of the species are winter (23) or summer residents (2) that arrive from North America along the Atlantic flyway corridor. Thirteen of the species using the rice farms are considered rare in Cuba (Garrido and Garcia 1975). Ciconiiformes, Anseriformes Charadriiformes and Gruiformes were the best represented orders both in numbers of species and in numbers of individuals.

Of the 14 ciconiiform species recorded, 12 were common throughout the study in all kinds of flooded fields, which they used for feeding and resting. By contrast, roseate spoonbills were observed only on one occasion, and flamingos, known to feed in the paddies at night, were never seen during the day. The great blue heron was recorded only in the winter months, which prompts the suggestion that the individuals observed were *Ardea herodias herodias* (the common winter migrant subspecies) rather than *A. h. repens* (the resident subspecies).

Table. 3.1 List of birds observed in Sur del Jibaro rice paddies. R: All year round residents ; W: Winter residents; S: Summer residents; r: rare; as reported in the inventory of Cuban birds (Garrido and Garcia 1975). Unusual observations are in brackets.

ORDER PODICIPEDIFORMES

Least Grebe (*Tachybaptus dominicus*) R

ORDER PELECANIFORMES

Anhinga (*Anhinga anhinga*) R

Olivaceous Cormorant (*Phalacrocorax brasilianus*) R

ORDER CICONIIFORMES

Great Blue Heron (*Ardea herodias*) R

Great Egret (*Casmerodius albus*) R

Snowy Egret (*Egretta thula*) R

Little Blue Heron (*Egretta caerulea*) R

Louisiana Heron (*Egretta tricolor*) R

Cattle Egret (*Bubulcus ibis*) R

Green Heron (*Butorides virescens*) R

Black-crowned Night-Heron (*Nycticorax nycticorax*) R

Yellow-crowned Night-Heron (*Nyctanassa violacea*) R

Least Bittern (*Ixobrychus exilis*) R

Glossy Ibis (*Plegadis falcinellus*) R, r

White Ibis (*Eudocimus albus*) R

Roseate Spoonbill (*Ajaia ajaja*) R

Flamingo (*Phoenicopterus ruber*) R

ORDER ANSERIFORMES

Fulvous Whistling-Duck (*Dendrocygna bicolor*) R & W

Blue-winged Teal (*Anas discors*) W

Northern Pintail (*Anas acuta*) W

Bahama Pintail (*Anas bahamensis*) R
American Wigeon (*Anas americana*) W
Northern Shoveler (*Anas clypeata*) W
Wood Duck (*Aix sponsa*) R
Ruddy Duck (*Oxyura jamaicensis*) R, r
Masked Duck (*Oxyura dominica*) R, r

ORDER FALCONIFORMES

Turkey Vulture (*Cathartes aura*) R
Snail Kite (*Rostrhamus sociabilis*) R
Northern Harrier (*Circus cyaneus*) W, r
Osprey (*Pandion haliaetus*) R, r
Peregrine Falcon (*Falco peregrinus*) W, r
Merlin (*Falco columbarius*) W, r
American Kestrel (*Falco sparverius*) R

ORDER GRUIFORMES

Limpkin (*Aramus guarauna*) R
King Rail (*Rallus elegans*) R
Little Yellow Rail (*Porzana flaviventer*) R
Black Rail (*Laterallus jamaicensis*) W, r (August)
Purple Gallinule (*Gallinula martinica*) R
Common Moorhen (*Gallinula chloropus*) R
American Coot (*Fulica americana*) R

ORDER CHARADRIIFORMES

American Jacana (*Jacana spinosa*) R
Wilson's Plover (*Charadrius wilsonia*) R
Killdeer (*Charadrius vociferus*) R
Black-bellied Plover (*Pluvialis squatarola*) W
Ruddy Turnstone (*Arenaria interpres*) W
Black-necked Stilt (*Himantopus mexicanus*) R
Greater Yellowlegs (*Tringa melanoleuca*) W (June & August)

Lesser Yellowlegs (*Tringa flavipes*) W (June & August)
Willet (*Catophtrophorus semipalmatus*) R
Short-billed Dowitcher (*Limnodromus griseus*) W
Common Snipe (*Gallinago gallinago*) W
Semipalmated Sandpiper (*Calidris pusilla*) W (June & August)
White-rumped Sandpiper (*Calidris fuscicollis*) W, r (June)
Least Sandpiper (*Calidris minutilla*) W
Laughing Gull (*Larus atricilla*) R
Gull-billed Tern (*Sterna nilotica*) S, r (October)
Royal Tern (*Sterna maxima*) R
Black Tern (*Chlidonias niger*) W, r

ORDER COLUMBIFORMES

Mourning Dove (*Zenaida macroura*) R
White-winged Dove (*Zenaida asiatica*) R
Common Ground-Dove (*Columbina passerina*) R

ORDER CUCULIFORMES

Smooth-billed Ani (*Crotophaga ani*) R

ORDER STRIGIFORMES

Barn Owl (*Tyto alba*) R
Short-eared Owl (*Asio flammeus*) W, r (June July & August)

ORDER CORACIIFORMES

Belted Kingfisher (*Ceryle alcyon*) R

ORDER PASSERIFORMES

Purple Martin (*Progne subis*) W, r
Cave Swallow (*Petrochelidon fulva*) S (October)
Northern Mockingbird (*Mimus polyglottos*) R

Palm Warbler (*Dendroica palmarum*) W
Common Yellowthroat (*Geothlypis trichas*) W
House Sparrow (*Passer domesticus*) R

The two most abundant species were the cattle egret and the glossy ibis (Table 3.2). Both populations probably contain several thousand individuals. The cattle egret was first reported in Cuba in the 1940's (Martin *et al.* 1967) and has since become one of the most common birds on the island. The species was characteristically associated with dry fields. On days when fields were being flooded, they were seen foraging along the edge of standing water. On harvesting days, they foraged close to the combine. They also foraged in dry fields with sprouting rice and presumably an abundance of insect pests. The glossy ibis used to be a rare species in Cuba (Garrido and Garcia 1975) but after 1983-1985 (when small flocks were rarely seen in the paddies; personal observation) their numbers have increased dramatically. This increase coincided with the reduction in use of pesticides and herbicides. We frequently observed glossy ibis feeding in close association with herons and egrets in flooded fields, particularly those being prepared for broadcast sowing. Acosta *et al.* (1990) found evidence of differential use of available prey types among six ciconiform species, in correspondence with various morphometric measures of the bill and legs which allow them to exploit different microhabitats. Thus, the glossy ibis, herons, and egrets may have been exploiting different prey while feeding together. Finally, glossy ibis also used mature fields that were being drained, thus making aquatic invertebrates readily available.

The order Anseriformes was represented by nine species, five of them winter migrants (Table 3.1). They used the rice fields for feeding and resting. Two species, FWD and the Bahama pintail also nested in the rice fields. Blue-winged teal, a winter migrant, was the most numerous duck in October (Table 3.2). Flocks of that species were common in potholes in the rice fields and flooded stubble fields. American wigeon, northern pintail, and northern shoveler were also common. Although the FWD population was probably as

Table 3.2 Density of birds (birds/ha) in Sur del Jibaro rice paddies in June (n= 410 ha) and October (n= 160 ha).

Bird species	June	October
Olivaceous Cormorant	0	0.487
Great Blue Heron	0	0.962
Great Egret	0.090	0.937
Snowy Egret	0.536	0.412
Little Blue Heron	0.121	0.306
Louisiana Heron	0.009	0.025
Cattle Egret	2.629	20.793
Green Heron	0.007	0.006
Black Crowned Night-Heron	0.002	0
Yellow Crowned Night-Heron	0.002	0
Least Bittern	0.065	0.006
Glossy Ibis	0.485	4.387
White Ibis	0.014	0.762
Roseate Spoonbill	0	0.050
Fulvous Whistling-Duck	0.402	19.187
Blue-winged Teal	0	70.418
Pintail	0	0.018
Bahama Pintail	0.036	30.012
Northern Shoveler	0	0.993
Wood Duck	0.009	0.012
Ruddy Duck	0	0.012

Table 3.2 Continuation

Masked Duck	0.002	0.006
Snail Kite	0	0.087
Northern Harrier	0	0.006
Osprey	0	0.012
Peregrine Falcon	0	0.012
Merlin	0	0.012
Limpkin	0.043	0.006
King Rail	0.029	0
Purple Gallinule	0.143	0.025
Common Moorhen	0.026	0
American Coot	0.017	0.356
American Jacana	0.004	0.031
Willson's Plover	0.002	0.002
Kildeer	0.014	0.062
Black-bellied Plover	0	0.206
Ruddy Turnstone	0	0.181
Black-winged Stilt	1.402	1.325
Greater Yellowlegs	0.017	0.012
Lesser Yellowlegs	0.009	0.093
Willet	0.012	0
Short-billed Dowitcher	0	0.350
Common Snipe	0	0.018

large as that of the blue-winged teal, their density was lower than that of the teal in October (Table 3.2), apparently because adult FWD were hidden in the coastal belt during their annual molt (FWD seen during October were mostly young of the year). The west indian tree duck (*Dendrocygna arborea*), historically common in the paddies but now in serious danger (Rylander and Bolen 1980), was never observed. Farmers claim that this species is now confined to the coastal belt, but we have no independent evidence.

Most of the falconiform species were observed flying over flooded stubble fields that were being used by the farmers to grow fish, and contained many resting or feeding waterbirds. The endangered peregrine falcon, and the northern harrier and merlin, were rarely seen.

Gruiforms were well represented in the rice paddies (Table 3.1). Coots, gallinules and rails were usually seen in flooded fields with standing rice that offered enough cover. They used the rice plants to build their nests with, and the paddies to feed and rest in.

Eleven of the 18 species seen in the order Charadriiformes were winter migrants. Other species were probably overlooked as these shorebirds form mobile, mixed-species flocks, making field identification of individual species problematical. They used the paddies for feeding, resting and nesting (nests of black-necked stilt were commonly observed in the rice fields). Shallow, flooded fields with exposed clods of soil were heavily used by the shorebirds. The black-winged stilt, the most abundant shorebird in this study (Table 3.2), has increased dramatically in our study area in recent years (personal observation).

The columbiforms were commonly observed feeding on seeds left in fallow dry fields and on the roads to the paddies. All three species were common, but the mourning dove was particularly abundant, with several thousand individuals occurring throughout the study.

Suitable habitat for cuculiforms and passerines appeared to be mostly restricted to shrub-covered dikes, where the smooth-billed ani and several warbler species were usually seen perching.

The short-eared owl has been reported in Cuba as a rare winter migrant (Garrido and Garcia 1975). It was observed frequently in June, July and August. The barn owl is known to feed in the rice farms at night.

Finally, one coraciform species, the belted kingfisher, was observed foraging along the irrigation canals.

Figure 3.1 shows the variation in species richness by month. More species were seen in October than during any other month, due to the arrival of the winter migrants and stop-over species. The decrease observed in November and December corresponded with a reduced availability of flooded areas as most of the fields were fallow and the birds had relocated to nearby ponds and lakes or to the coastal belt.

Taken together, our results highlight the surprisingly wide array of bird habitat types available in the rice culture. This complexity provides suitable habitat for a taxonomically diverse avian community. That several species considered endangered or of special concern used the rice paddies obviously should be taken into account when designing management practices for this habitat. In addition, as migratory waterfowl are an international resource, the study and preservation of suitable habitat for them should be of broad concern. Possible damage to the rice crops may be caused by seed-eating anseriforms, and by coots, but the remaining avian species feed mainly on animal prey, and the columbids feed on waste rice left on dry fields. Clearly, the rice culture ecosystem in Cuba should be recognized as an important wildlife habitat supporting diverse and abundant populations of birds.

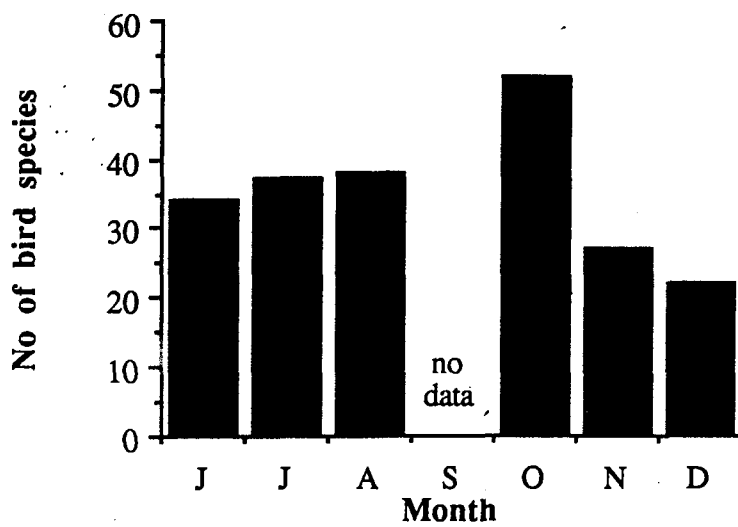


Figure 3.1 Number of bird species observed in Sur del Jibaro rice paddies from June to December, 1992.

Positive Interactions

Rice fields are productive feeding grounds for many bird species. They are also important nesting and resting habitat for other species. Flickinger and King (1972) reported that a tremendous number of migratory bird species use the Gulf Coast rice growing region in Texas. The coastal winter aerial survey (including rice paddies) conducted between 1981 and 1986 registered an average population of 1.05 million geese and 1 million ducks (Fentres 1986). Fasola *et al.* (1993) analyzed the diet of European herons in different regions, including a rice culture. They reported that the prey types represented in the diets of individuals at a heronry corresponded with the availability and abundance of prey items in nearby rice paddies. In southern Europe, rice fields are very important for waterfowl, and several projects regarding waders and food availability in the paddies are in progress (M. Fasola and X. Ruiz, personal communication). Gray *et al.* (personal communication) observed more than 60 species of birds using the paddies in the Everglades Agricultural Area, in Florida, and over 3000 individuals in total during a single census.

The possibility that birds may have a positive effect on the rice fields has received little attention. McCartney (1963) suggested that the ducks' droppings probably enhance the robust growth of rice. This inference was based on his finding that panicles from areas where the FWD were observed feeding were heavier than those from fields where they were not observed feeding (2.6 vs. 1.8 g). In addition, it is well known that the ducks feed largely on the weed seeds (Singleton 1951; Meanley and Meanley 1959; Bolen and Forsyth 1967; Rios Soto *et al.* 1981; Bruzual and Bruzual 1983; Treca 1986; Acosta *et al.* 1988), and doing so in flooded stubble fields reduces the subsequent crop of weeds. Thus, the role of ducks as agents of control of weeds should be taken into account in the design of future management programs (Rios Soto *et al.* 1981).

As many anseriforms are considered game species, their harvest may represent a new income for rice farmers. Hammond (1964) stated that farmers have a surplus of one crop (grain) and a shortage of another crop (ducks). The commercial value of game species can be measured as income from selling, trading or consuming waterfowl species. The total income in a hunting season in Calabozo rice fields, Venezuela, may exceed \$2 million (Dallmeier 1991), not including secondary profits to local businesses generated by the hunters.

Negative Interactions

Consumption of rice seeds is the major negative impact that birds may have on the rice yield. Rice is an important source of food for many waterfowl species in Venezuela (Dallmeier 1991). Singleton (1951) found that rice was the most important item (39.9% by volume) in 238 waterfowl stomachs collected in Texas from November 1946 to January 1947, showing that the birds had increased their consumption of rice as the acreage used for rice production increased. The practices used to grow rice apparently strongly influence the extent of rice consumption by birds but not all the rice consumed yields a net loss in rice production. In fact, much of the rice consumed is waste rice that the birds obtain from newly harvested fields that have been reflooded.

The worst effect of the rice culture on wildlife may be due to the use of pesticides, herbicides and fertilizers which contaminate the food and water supplies, and destroy wildlife. Consequently, there is a growing concern over the use (and overuse) of these agricultural chemicals (Dover and Talbot 1987). The widespread use of aldrin-treated rice seeds was apparently the major cause of the decline in the FWD population along the Texas Gulf Coast, where dead or poisoned birds of many species were commonly found in the rice growing areas (Flickinger and King 1972). Since the cancellation of toxic-

persistent pesticides in the United States, the habitat quality for wintering waterfowl has improved dramatically. Nevertheless, evidence of the use of illegal pesticides that had been forbidden for agricultural use have been found in FWD in South Florida (Turnbull *et al.* 1989a) . The reduction in the use of pesticides and herbicides in Cuba is presumably a main factor in the dramatic increase in the populations of glossy ibis and black-necked stilt in the last few years (personal observation).

The Rice Agroecosystem: Toward an Integrated Approach

Birds are clearly an important biotic component of the rice agroecosystem. A better understanding of the role birds play in the energy flow and nutrient cycle will be essential if an ecological approach to improving agriculture and wildlife is to take hold.

On the other hand, conservationists must appreciate the fact that in this case the bird community is using an antropic ecosystem. Consequently, the control is largely external instead of internal as in natural ecosystems and subsystem controllers are more responsive than external controllers (Odum 1984). In other words, birds probably select this habitat for feeding, breeding or resting based on cues that have been historically associated with reproductive success in similar natural environments (Gavin 1991). However, we should keep in mind that human interference through farming practices has the potential for drastically affecting wildlife associated with this habitat.

Management Implications

Our results emphasize the need for farmers and wildlife biologists to work together toward the goal of minimizing rice loss while enhancing the quality of wildlife habitat. Research projects should be designed to understand the

structure and function of the rice ecosystem, thereby allowing policy makers to tailor their decisions to specific problems.

With the information we have so far, we offer the following recommendations. (1) Recently harvested fields should be reflooded as soon as possible to make waste seeds available for waterfowl. (2) Some number of flooded stubble fields should be kept as a sanctuary with no hunting or human disturbance allowed. These flooded fields could be rotated, which would allow a systematic assessment of the effect of bird droppings on subsequent crop yields. (3) Some stubble fields could be used to grow weeds that produce seeds preferred by waterfowl. (4) The use of chemicals should be carefully monitored to make sure forbidden pesticides are not being used. (5) Awareness of the issues surrounding waterfowl and the importance of rice culture for them should be promoted among farmers and among communities near the paddies.

Conclusions

Rice paddies are coming to be recognized as important habitat for wintering and resident birds in tropical and subtropical areas. During a year in Cuba, at least 70 bird species use the paddies, mainly for feeding. Many of the species (36% in our study) come from the United States and Canada to spend the wintering period. Loss and degradation of habitat is a primary waterfowl management problem in North America (Sparrowe *et al.* 1989). Thus, the rice paddies may be an important habitat in helping to preserve waterfowl populations. Long-term interdisciplinary research is needed on the rice agroecosystem as the future of its bird community will become increasingly dependent upon these managed areas.

CHAPTER IV

GENERAL CONCLUSIONS

Our results showed that to manage FWD populations effectively it is necessary to study the annual cycle of FWD requirements and the habitat use patterns.

Simultaneous studies concerning food consumption and habitat use of FWD in the rice fields resulted in a better understanding of the possible damage they may cause to the rice crop.

Flooded fields, that provided shelter, nesting material and enough food, were preferred by FWD during the breeding season. During the non-breeding period it seemed that the presence of water and food availability were the two more important cues in habitat selection.

Obviously, feeding studies that cover only part of the year may reach misleading conclusions when studying FWD diet. Although rice is an important part of the diet of FWD, it is not equally important throughout the year. In addition, the amount of rice consumed was not related to its availability. Among the weeds, junglerice and red rice were the most common in the diet. In both cases these were the more available weeds in the fields they were using.

Rice consumption was higher in November, but most of the rice consumed in this month was waste rice. The biggest damages were done at the end of the breeding period when larger flocks of FWD were observed in newly sown fields than at the start of the breeding season, and about 50% of the diet was formed by rice. Thus, if any management is to take place to reduce losses, August, and to a lesser degree July, are the two most important months. The estimated losses of only 1.2% of the rice that was released during sowing, suggested low damages by FWD consumption in this period.

Finally, we presented an overview of the main features of the rice ecosystem, and their importance for bird conservation. We reported data on the diversity and abundance of birds in Cuban rice paddies, to highlight the necessity of long term interdisciplinary research that will eventually improve the rice culture and wildlife habitat.

About 70 bird species were using the Sur del Jibaro rice paddies for feeding, nesting or resting. Of the 12 orders represented, Ciconiiformes, Anseriformes, Charadriiformes and Gruiformes were the most important. Winter migrants comprised 36% of the species recorded. An interesting result was the dramatic increase in the population size of the glossy ibis and the black-necked stilt. Apparently, the increase is in response to the reduction in herbicide and pesticide applications in Cuban rice paddies. With the loss and degradation of wetland habitat as an increasing problem, waterfowl will depend more and more upon the rice paddies. Cooperative efforts are necessary to understand the complex ecological interactions that are taking place in the paddies and to enhance this important waterfowl habitat.

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