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CHAPTER 21

RELATIONSHIPS BETWEEN BIRD DISTRIBUTION AND LAND USE IN AN AGRICULTURAL LANDSCAPE, BALI, INDONESIA

By

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ABSTRACT

We investigated the distribution of bird species in an agricultural landscape in the central part of Bali, Indonesia. Terraced rice (*Oryza sativa*) paddies and mixed gardens cover slopes with an elevation ranging from 150 to 500 m above sea level in the study area. We conducted bird surveys from 19 to 22 December 2003 (the rainy season) and 5 to 9 September 2005 (the dry season). In September 2005, we focused on the relationship between bird distribution and cropping stage in the rice paddies. We recorded all species, the number of individuals of each species, and the first observed positions. We found 16 species and 290 individuals in 2003, and 8 species and 305 individuals in 2005. The Olive-backed Sunbird (*Nectarinia jugularis*) and Oriental White-eye (*Zosterops palpebrosus*) were only observed in mixed gardens. The Javan Pond-heron (*Ardeola speciosa*) significantly preferred plowed fields ($\chi^2 = 16.6$, $p < 0.001$). The Scaly-breasted Munia (*Lonchura punctulata*) significantly preferred post-harvest fields ($\chi^2 = 58.9$, $p < 0.0001$), whereas the Javan Munia (*Lonchura leucogastroides*) significantly preferred the pre-harvest and post-harvest stages ($\chi^2 = 34.0$, $p < 0.0001$)..

Key Words: agricultural landscape, Bali Island, bird populations, land use, mixed garden, rice paddy.

INTRODUCTION

Traditional agricultural landscapes have maintained their biodiversity because human intervention reduced interspecies competition (Washitani 2003) and provided a range of landscape elements as habitat (Kuramoto & Sonoda 2003). Many agricultural land uses and landscape elements have been reported to provide important habitat for plant and animal species,

especially in Europe; examples include coppice woodland (e.g., Buckley 1992), hedgerows (e.g., Burel & Baudry 1990), rough pasture (e.g., Haase *et al*. 1992), and ponds (e.g., Wood *et al.* 2003).

In eastern and southeastern Asian countries, rice (*Oryza sativa*) paddies are the dominant land use in most agricultural areas. The traditional agricultural landscape consists of coppice woodlands, irrigation canals and ponds, paddy levees, and dry fields in addition to the rice paddies; this is called the *Satoyama* landscape in Japan (Takeuchi 2003). Especially in Japan, many studies have been conducted in the *Satoyama* landscape, and the results have indicated that many organisms have adapted to agricultural activities and that traditional landscape elements play an important role as habitat for birds (Ichinose & Katoh 1998; Natuhara & Imai 1999), amphibians (Osawa & Katsuno 2003), insects (Kato 2001), fish (Tanaka 1999), aquatic plants (Ishii & Kadono 2004), and a range of flora (Washitani 2001). Recently, similar studies have been conducted in Korea and China, but few studies have been carried out in southeast Asian countries, especially in tropical areas. To provide some of the missing information, we focused on the distribution of birds in a traditional agricultural landscape on Bali, an island east of Java, Indonesia (Figure 1).

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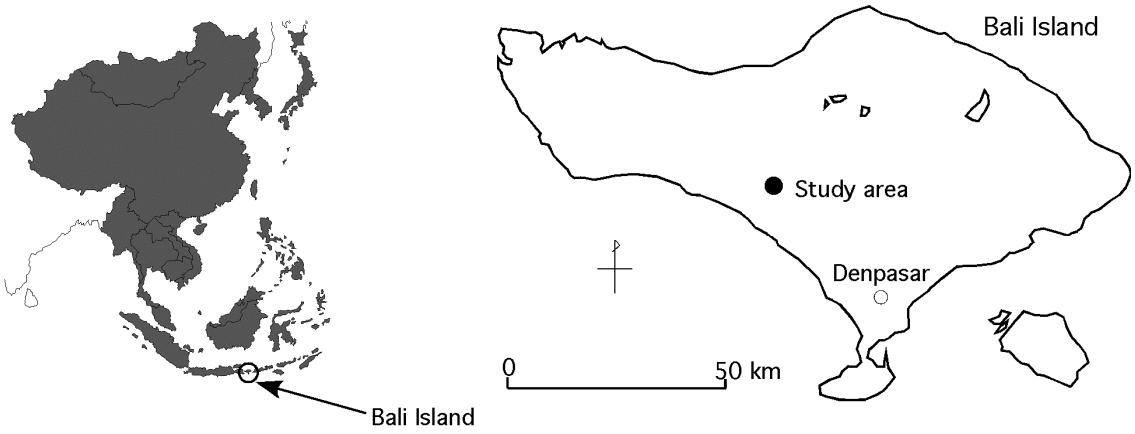

Figure 1. Location of the study area.

The heterogeneous traditional landscapes of Bali consist of terraced rice paddies and mixed gardens. Cropping patterns have been arranged traditionally by irrigator associations called *subak*. Recently, a change from subsistence agriculture to intensive market-oriented production has brought changes in the patterns of agricultural activity and land use on Bali. Especially since the introduction of new rice varieties around 1967, crop failures have frequently occurred due to widespread pest attacks (Sutawan 2002). At present, many rice paddies have been changed into mixed gardens because this approach reduces the risk of total crop failure and allows the production of cash crops. Mixed gardens, called *kebun* in Indonesia, comprise perennials integrated with an area of annual crops outside a residential area. Wood is provided by pruning or felling perennials, including fruit trees, other trees, and bamboo. The leaves and small branches are burned or mixed with dung and composted, with the compost used to fertilize the annual crops (Whitten *et al.* 1996). Recently, diversity has been lost as economically attractive crops such as widely spaced mandarin orange and clove trees have been planted. Mixed gardens have traditionally provided diversity, complexity, multiple use, and stratification, but have recently begun changing towards monocultures with a simple structure because of intensive production of a single species, such as cloves, orchids, or cassava (Michon & Mary 1990).

The main objectives of the present study were to investigate bird distribution in an agricultural landscape on Bali Island and to examine the relationship between the distribution of birds and land-use patterns, especially rice cropping.

METHODS

Study area

We conducted our study in four small neighboring villages in the central part of Bali: Belimbing (8º23´20˝S, 115º2´7˝E), Tiyinggading (8º27´50˝S, 115º1´26˝E), Lumbung (8º28´31˝S, 115º0´46˝E), and Antosari (8º29´45˝S, 115º0´29˝E) (Figure 1). The area is located on the slopes of Batukaru Mountain, with elevations of 150 to 500 m above sea level, and has a typical agricultural landscape for Bali Island, which consists of a mosaic of terraced rice paddies and mixed gardens. Some rice paddies have been abandoned or changed into dry fields. On Bali Island, it is possible to produce rice crops several times per year because of the tropical climate. The timing of crops depends on the water supply. In our study area, farmers produce rice twice per year. The cultivation of rice progresses from upper paddies to paddies lower on the slope as a result of the management of water resources by irrigator associations. Rice plants need a large water supply for a few weeks just after transplanting. The standard practice is for an association of farmers higher on the slopes to finish irrigating its paddies after transplanting, followed by use of the water by an association lower on the slope. As a result of this irrigation system, a wide range of rice cropping stages is typically visible simultaneously in this area.

Mixed gardens comprise a mixture of annual and perennial crops such as durian (*Durio zibethinus*), coconut (*Cocos nucifera*), coffee (*Coffea canephora*), cloves (*Eugenia aromatica*), jackfruit (*Artocarpus heterophyllus*), banana (*Musa paradisiaca*), and taro (*Colocasia esculenta*).

Bird surveys

We investigated bird populations from 19 to 22 December 2003, during the rainy season, and from 5 to 9 September 2005, during the dry season. We prepared four census routes in December 2003, which covered most of the study area, to examine relationships between the distribution of various species and land-use types. In September 2005, we particularly focused on the relationship between distribution and cropping pattern in rice paddies. Previous investigations had revealed little difference between bird species composition during the dry and rainy seasons in the study area (T. Ichinose & M. Kataoka, unpublished data), so our two surveys focused on different aspects of species distribution rather than on seasonal differences.

We investigated birds within the first 3 hours after sunrise by walking slowly along the census routes. We visually identified all individuals observed within a 25-m radius from the observers using 8 × 25 or 8 × 30 binoculars. We recorded the species, number of individuals, and the first observed location of each individual within three or four categories in 2003 and 2005, respectively, according to the land-use type and stage of rice production; these categories were rice paddy, mixed garden, and residential area in 2003, and plowed (before transplanting), planted (up to 2 months after transplanting), pre-harvest (from 2 months after transplanting to harvest), and post-harvest (after harvesting was complete) stages in 2005.

Interview with the leader of an irrigator association

We interviewed the leader of one irrigator association in Belimbing village on 9 August 2002 to inquire about the management of rice paddies, mixed gardens, and water resources.

RESULTS

Relationships between bird distribution and land-use type

We recorded 16 species and 290 individuals in December 2003. The relationships between bird appearances and land-use types are shown in Table 1. All Barn Swallows (*Hirundo rustica*) and two Golden-headed Cisticola (*Cisticola exilis*) were observed in the air. The ratios of land-use types for each species for which we observed at least 10 individuals are shown in Figure 2. The Javan Munia (*Lonchura leucogastroides*) was recorded only in rice paddies. The Olive-backed Sunbird (*Nectarinia jugularis*) and the Oriental White-eye (*Zosterops palpebrosus*) were observed only in mixed gardens. Many individuals of the Olive-backed Sunbird were observed sucking the nectar of coconut trees. The Spotted Dove (*Streptopelia chinensis*) and the Scaly-breasted Munia (*Lonchura punctulata*) were recorded in both rice paddies and mixed gardens and in both rice paddies and residential areas, respectively.

Table 1. Relationships between bird appearances (number of individuals observed) and land-use types in 2003

Name of species		Paddy	Mixed garden	Residensial area
White-breasted Waterhen	*Amaurornis phoenicurus*	2	-	-
Cinnamon Bittern	*Ixobrychus cinnamomeus*	1	-	-
Spotted Dove	*Streptopelia juncidis*	20	6	-
White-collared Kingfisher	*Halcyon chloris*	-	2	-
Barn Swallow	*Hirundo rustica*	5	-	-
Yellow-vented Bulbul	*Pycnonotus goiavier*	1	8	-
Zitting Cisticola	*Cisticoloa juncidis*	7	-	-
Golden-headed Cisticola	*Cisticola exilis*	4	-	-
Bar-winged Prinia	*Prinia familiaris*	-	1	-
Orange-belled flowerpecker	*Dicaeum trigonostigma*	-	2	-
Oriental White-eye	*Zosterops palpebrosus*	-	39	-
Olive-backed Tailorbird	*Orthotomus septum*	6	-	-
Olive-backed Sunbird	*Nectarinia jugularis*	-	31	-
Scaly-breasted Munia	*Lonchura punctulata*	75	-	3
Javan Munia	*Lonchura leucogastroides*	75	-	-
Tree Sparrow	*Passer montanus*	2	-	-

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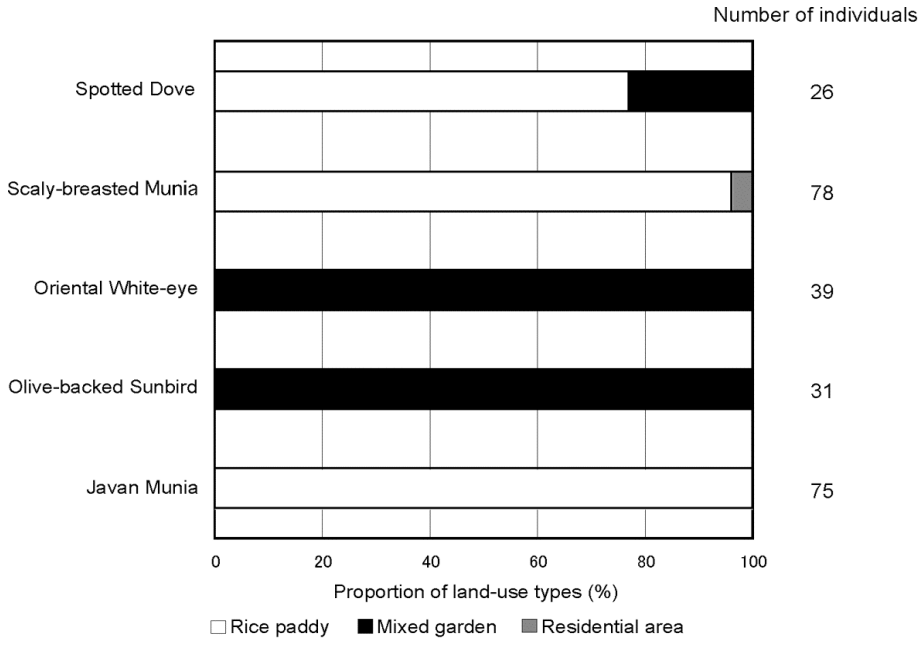

Figure 2. Fisrt observed land uses type for species for which we observed 10 or more individuals during the 2003 survey.

Relationships between bird distribution and rice cropping stage

We recorded 8 species and 305 individuals in September 2005. The relationships between bird appearances and rice cropping stages are shown in Figure 3. All individuals of the Cave Swiftlet (*Collocalia linchi*) were observed in the air. The Javan Pond-heron (*Ardeola speciosa*) and the White-breasted Waterhen (*Amaurornis phoenicurus*) were only found in plowed and planted paddies, whereas the Javan Munia was observed only in pre-harvest and post-harvest paddies. Some Scaly-breasted Munia individuals used planted paddies in addition to pre-harvest and post-harvest paddies.

We observed one or more individuals in 42 rice paddies. The proportions of plowed, planted, pre-harvest, and post-harvest stages during our study period were (11.90%), (54.76%), (2.38%), and (31.95%), respectively. This proportion could be considered as a "control proportion" for the cropping stages so that we could compare actual species appearances against the expected proportion if a species had no preference among cropping stages. We conducted chi-squared tests to examine whether a species for which we observed 5 or more individuals preferred particular cropping stages. The Cave Swiftlett and the Zitting Cisticola (*Cisticola juncidis*) did not differ significantly from the control (Cave Swiftlet, $\chi^2 = 6.7$, $p = 0.08$; Zitting Cisticola, $\chi^2 = 1.5$, $p = 0.69$). The Javan Pond-heron significantly preferred the plowed stage ($\chi^2 = 16.6$, $p < 0.001$). The Scaly-breasted Munia significantly preferred the post-harvest stage ($\chi^2 = 58.9$, $p < 0.0001$), whereas the Javan Munia significantly preferred the pre-harvest and post-harvest stages ($\chi^2 = 34.0$, $p < 0.0001$).

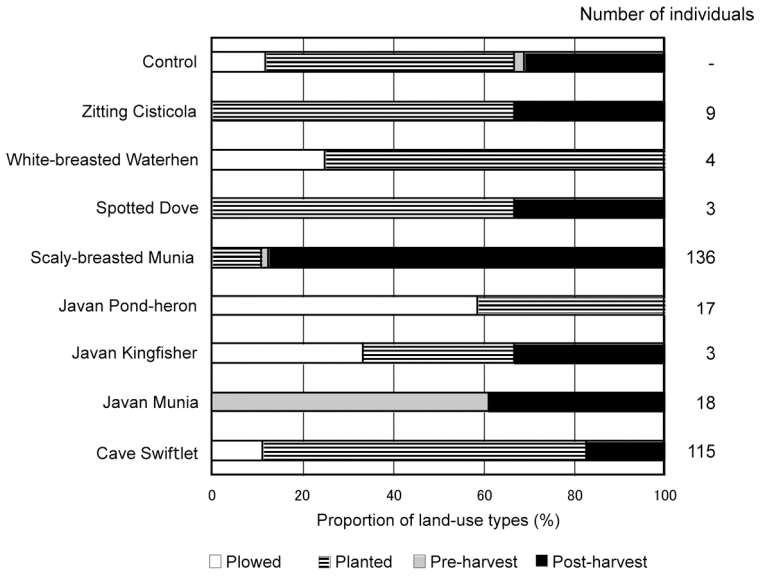

Figure 3. First observed rice cropping stage for bird species observed in 2005.

Management of rice paddies and mixed gardens

As a result of our interview with the leader of an irrigator association in Belimbing village, we determined that the area of rice paddy in the village was 417 ha in 2002, which had decreased from 420 ha in 2000. The area of paddy has gradually decreased recently because many farmers are changing from rice paddies to mixed gardens, which are more profitable. His association manages 87 ha of rice paddy and 227 ha of mixed garden, which are farmed by 116 people. A typical household has 0.25 to 0.40 ha of rice paddy and 1 to 6 ha of mixed gardens. The most popular crop in the mixed gardens is coconuts, followed by cacao (*Theobroma cacao*). In Belimbing village, rice is produced twice per year. The first production period is from January to April and the second is from July or August to October through November. Rice yields are typically 4 to 5 t/ha. Around 70% of the yield is consumed by the farmers and the remaining 30% is used to pay taxes and purchase fertilizer. The compost produced by farmers is not used in rice paddies but is instead reserved for use in the mixed gardens. Income from the mixed gardens is about 1 million Indonesian rupiah (around USD$110) per hectare per year, and this is the most important source of income for farmers. Therefore, they manage their mixed gardens intensively.

DISCUSSION

Bird distribution in an agricultural landscape

In total, we recorded 19 species in 2003 and 2005. MacKinnon (1988) reported that 216 bird species inhabit Bali, which suggests that the species richness in the agricultural landscape was not high compared with the total number of bird species found on Bali. Also, we recorded no rare or endangered species in our surveys. However, the results showed that some species had adapted to agricultural land uses and human activities. We recorded 7 species in mixed gardens in 2003. Waltert *et al*. (2004) reported a mean of nearly 5 species in the agroforestry systems in Sulawesi, which consist of many cacao trees and some coconut palm trees. Two Orange-bellied Flowerpeckers (*Dicaeum trigonostigma*) were recorded in mixed gardens, and this species has been reported to prefer dense wooded forests (Strange 2001). Therefore, mixed gardens may provide a substitute for natural woodland. Olive-backed Sunbirds and Oriental White-eyes were found only in mixed gardens. Thiolly (1995) showed that Olive-backed Sunbirds were founded only in the damar-tree agroforests, which are the tollest of the traditional agroforest types and the densest at canopy level in Sumatra. We observed many number of Olive-backed Sunbirds visiting coconut flowers, which are nectar feeders (MacKinnon 1988). Oriental White-eyes, which use frequently primary and secondary vegetation (MacKinnnon 1998), were also recorded in coffee plantations with the native tree cover in India (Bhagwat et al. 2005).

Javan Pond-herons particularly used plowed and planted paddies. The Cinnamon Bittern (*Ixobrychus cinnamomeus*) and the White-breasted Waterhen tended to do the same, though their numbers were small. Whitten *et al*. (1996) indicated that the Javan Pond-heron and the Cattle Egret (*Bubulcus ibis*) eat mainly dragonfly and water beetle larvae, mole crickets, and spiders in rice paddies just after they have been plowed and planted, and thus play a role in controlling rice pests. On the other hand, the two Munia species are considered to be rice pests because they were mostly observed eating rice in pre-harvest and post-harvest rice paddies. Farmers often drive these birds out of fields by drumming and shouting.

Relationships between bird distribution and agricultural activities

Rice is usually produced once per year in most temperate areas of Asia, including Japan, because of temperature constraints on the length of the growing season. Rice plants are transplanted in the spring and harvested in late summer or early autumn. During the rice production period, farmers must control water levels in the paddies. Many organisms have adapted to traditional agricultural activities, thus agricultural landscapes have maintained biodiversity (Takeuchi 2003). In tropical areas such as the study sites in the present study, rice is produced twice or more per year (Sutawan & Sedana 1999). Rice production depends on the availability of water rather than on temperature. In most areas of Bali, rice can be produced throughout the year. Thus, all stages of rice cropping can be seen simultaneously in areas such as our study area. Bird species can thus use their preferred cropping stages rather than being forced to deal with a single available stage. Mixed gardens with complex vegetation structures also provide food and habitat for forest birds. Our study results suggested that the traditional agricultural landscapes in tropical areas may contribute to the preservation of biodiversity. However, the modern agricultural landscape in Bali is changing. Rice paddies are being replaced by mixed gardens to produce more profitable cash crops, but at the same time, the diversity offered by traditional mixed gardens is being lost as a result of the introduction of economically advantageous monocultures. These changes will likely affect biodiversity in these agricultural landscapes.

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