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Avian species diversity in oil palm plantations of Agusan Del Sur and Compostela Valley, Philippines

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Abstract. Oil palm trees have become the most expanding equatorial crops in the world and their product, palm oil, is produced, traded and used more than any other vegetable oil worldwide. The expansion of oil palm cultivation, however, is frequently cited as a major factor causing deforestation that may result in biodiversity losses in tropical countries. In this study, an assessment of the avifauna in oil palm plantations in Agusan del Sur and Compostela Valley, Mindanao, Philippines was done from April 2010 to July 2010. Sampling sites were categorized based on the age/growth of palm trees. Line transect method, mist netting and birdwatching were used to gather data on avifauna. Eighty-eight species were recorded. Species richness, abundance, and number of endemic species were also recorded to be higher in mature plantations than in young plantations. A significant difference was noted in bird abundance found in the different age groups of oil palm plantations in Agusan del Sur. Thirty-one endemic species were recorded, one of which is Mindanao endemic. Three vulnerable species, *Gallicolumba criniger* (Mindanao bleeding-heart), *Alcedo argentata* (silvery kingfisher) and *Ficedula basilanica* (little slaty flycatcher) were recorded both in the young and mature plantations. The *Aethopyga primigenius* (grey-hooded sunbird), a near threatened species was recorded in mature plantations only. The presence of these vulnerable species in all study sites indicates the need to protect the degraded secondary residual forest and forest patches along the plantation.
Key Words: birds, diversity, forest, oil palm, species.

Introduction. Oil palm, *Elaeis guineensis* Jacq., is a tropical plant that originally came from the Gulf of Guinea in West Africa and frequently planted on newly-cleared rainforests or peat-swamp forests rather than on already degraded land or disused agricultural land. Its main product is palm oil, which is commonly used as cooking oil, shortening, margarine, soap, detergents, pharmaceutical products, cosmetics and fuel (Basiron 2002; Brown & Jacobson 2005). About 43 countries are presently cultivating this agricultural crop in a total area that is nearly one-tenth of the world's permanent cropland (FAO 2000; Basiron 2007). Indonesia and Malaysia are the world's principal producers for palm oil accounting for 83 percent of production and 89 percent of global exports. Oil palm plantations in Indonesia have grown to 3,107,985.73 ha and in Malaysia, 3,496,483.95 ha (Brown & Jacobson 2005). It is projected that additional land will be developed from 1 to 28 M ha in Indonesia and 0.06 to 5 M ha in Malaysia in order to meet the demand for palm oil production in 2020. This demand can be met to a large extent when only degraded land may be used and if no further deforestation is assumed (Wicke et al 2010).

In the Philippines, 65,000 ha of land situated in CARAGA, and Region 12 in Mindanao and Central Visayas are currently planted with oil palm trees. Production increased from 54,000 T in 2000 to 92,000 in 2010, but the production increase from 2009 to 2010 is very low probably because of the low yield of the aging palm trees. Other plantations in the Philippines are relatively young and they are producing low quality of palm oil. It is to be noted that the domestic demand for oil palm in the country

has increased speedily. To meet this demand, the industry players have to expand their current plantations and farms to 38,934 ha more by 2015 (Southern Philippines Development Authority 2007).

Philippine Palm Oil Development Council (PPODC) has estimated that more than 110,000 hectares of land in the country would be needed and planted with oil palm in order to achieve palm oil self-sufficiency (Palm Oil Truth Foundation 2006). However, the expansion in oil palm cultivation is frequently cited as being a major factor causing deforestation that may consequently result to biodiversity losses in tropical countries (Wakker 2000; Donald 2004; Basiron 2007; Koh & Wilcove 2007; Fitzherbert et al 2008; Koh & Wilcove 2008; Koh et al 2011). This loss in biodiversity includes the Philippines.

Oil-palm establishments would have to support species-poor communities containing few forest species with the majority of individual plants and animals belonging to a small number of generalist species of low conservation concern (Danielsen et al 2008). This would exacerbate species loss by ≈12% (Koh et al 2011) and up to more than 80% of species (Fitzherbert et al 2008) and support few species of conservation importance.

The detrimental effect of oil palm plantation on biodiversity is shown in some recent studies on lizards in Los Haitises region (Glor et al 2001), arthropods (Turner & Foster 2009), ground dwelling forest ants (Bruhl & Eltz 2009), arboreal ants (Pfeiffer et al 2008), butterflies (Koh 2008b; Koh & Wilcove 2008), orangutan *Pongo* spp. (Nantha & Tisdell 2008) and birds (BirdLife International 2008; Koh 2008a; Koh & Wilcove 2008; Edwards et al 2010; Koh et al 2011).

Birds are an important component of biodiversity. They provide a picture of how biodiversity is distributed and serve as valuable indicators of global environmental change, indicators of species richness and endemism patterns. They also play a big role in seed dispersal and pollination (Bibby et al 1992; Bennun & Fanshawe 1997; Donald et al 2001; Burgess et al 2002; Gregory et al 2003; BirdLife International 2010a). The Philippines has 638 species of birds, 206 of which are endemic, five introduced, 52 rare or accidental, 69 species globally threatened (Lepage 2012). Habitat destruction as a result of people's use or development of land has affected 78% of endemic species of birds in the country that inhabit lowland forests, where most deforestation has occurred (Sodhi et al 2004). These fragmented and degraded habitats result to more threatened species (Sajise & Suarez 2010).

Birds such as the European pied flycatcher (*Ficedula hypoleuca)* and the barn owl (*Tyto alba*) play important roles in controlling oil palm pests such as rats and insects (BirdLife 2008; Palm Oil Deforestation Watch 2008; Heru et al 2000). Moreover, Koh (2008a) has found that insectivorous birds in oil palm plantations contribute to the control of leaf-eating oil palm pests. These facts may provide the economic incentive for oil palm producers to make plantations more hospitable for biodiversity. Palm oil industries will, therefore, benefit by keeping the biodiversity within the plantations and by reducing the need for pest management (Butler 2006).

The objectives of this study are: 1) to determine the species composition, abundance, distribution, endemism, species richness, species diversity of birds in oil palm plantations in Agusan del Sur and Compostela Valley, 2) to determine the influence of age/growth of oil palm plantations on the diversity, richness and abundance of avifauna, and, 3) to identify the existing threats on avifauna in oil palm plantation.

Materials and Methods

Sampling sites. Sampling sites (Figure 1) were the oil palm plantations located in Agusan del Sur and Compostela Valley (Table 1).

Sampling site 1 - Filipinas Palm Oil Industry (FPPI), is one of the large-scale oil palm plantations and processing plants in Agusan. This plantation covers about 8,000 hectares of palm trees with an age range of 27-30 years old. The palm trees here generally stand 10-30 meters tall with an average diameter breast height (DBH) of 72-79 inches. The plant community includes basikong (*Ficus sp*.), rattan (*Korthalsea spp*.), giant fern (*Angiopteris evecta* G.), gmelina (*Gmelina arborea*) and avocado (*Persea Americana*

Mill.). Numerous epiphytes such as ferns (pakong parang - *Pteris mutilate* L., pakong lawit - *Goniophlebium percussum* Wagner and Grether), bird's nest (*Asplenicum musaefolium* Melt) and orchids were also recorded while *Mendinilla sp.* was the vine observed to cover 80% of the canopy. The ground cover was 90% ferns. Grass (bugang/talahib - *Saccharum spontaneum* L.) were observed to be very common in all three subsites.

Figure 1. Map of the Philippines showing the sampling sites in San Francisco, Agusan del Sur and Compostela Valley.

Subsite 1 (FPPI30y) - was established in the near forest edge of Barangay Maligaya with the oldest palm trees aged 30 years old. There were also patches of tall trees within the plantation. Canopy epiphytes and ferns were more prevalent than in the other two subsites. Fallen logs were moderately abundant and exposed rocks were common.

Subsite 2 (FPPI29y) - was established near the former residential area of the employees of FPPI plantation in Barangay Cabantao with 29 year-old oil palm trees. Part of it is located near the patch of small forest. Some canopy epiphytes were also present as ferns were common too. Fallen logs are moderately abundant and exposed rocks are common.

Subsite 3 (FPPI27y) - was established along the highway of Barangay Tigbanayan with palm trees aged 27 years old. This subsite was clearly a disturbed area where houses, rice fields, coconut plants (*Cocos nucifera*) and banana plants were found. No small patch of forest was observed. Fallen logs were very rare and no exposed rocks were observed. The nearest anthropogenic clearing is 10-50 m from this subsite.

Table 1

Descriptions of the three sampling areas in Agusan del Sur and Compostela Valley, Philippines (elevation is represented by meters above sea level, temperature is measured in ^{o}C)

Study areas	*Sampling areas*	*Subsites*	*Coordinates*	*Elevation*	*Temp.*
Agusan del Sur	Site 1. Filipinas Oil Palm Inc. (FPPI) Mature 27-30 yrs. (Pitong Gatang, San Franscisco, Agusan del Sur)	1) Barangay Maligaya 30 yrs. (FPPI30y)	08^{0}25.632'N, 126^{0}02.116'E	239-376	26.7-28.2
		2) Barangay Cabantao 29 yrs. (FPPI29y)	08^{0}24.268'N, 126^{0}02.522'E	308-449	29.7-30.0
		3) Barangay Tigbanayan 27 yrs. (FPPI27y)	08^{0}23.959'N, 125^{0}59.622'E	230-276	27.9-29.1
	Site 2. Ladganan Young 5 mos.-6 yrs. (Ladganan, San Franscisco, Agusan del Sur)	1) Ladganan 5 mos. (Lad5m)	08^{0}28.808'N, 125^{0}55.361'E	197-217	29.0-35.3
		2) Ladganan 2 yrs. (Lad2y)	08^{0}28.871'N, 125^{0}55.369'E	197-217	30.0-35.3
		3) Ladganan 3 yrs. (Lad3y)	08^{0}28.923'N, 125^{0}55.427'E	197-217	31.0-35.3
		4) Ladganan 5 yrs. (Lad5y)	08^{0} 8.908'N, 125^{0}55.370'E	197-217	32.0-35.3
		5) Ladganan 6yrs. (Lad6y)	08^{0} 8.895'N, 125^{0}55.567'E	197-217	33.0-35.3
Compostela Valley	Site 3. Compostela Young 2 yrs. (Valma, Ngan, Compostela, Compostela Valley)	1) Compostela 2 yrs. (Com2y)	07^{0}40.122'N, 126^{0}08.563'E	978-1240	30.7-37.8

Sampling site 2 **-** located in Ladganan, San Francisco, Agusan del Sur is a 20-hectare oil palm plantation which is privately owned. Palm trees in this site are categorized as young with ages from five months to six years old. They generally stand 1-5 meter tall, their trunks are not well defined as set. A total of five subsites have been integrated into the Ladganan. Subsite 1 (Lad5m) is a five-month old oil palm plantation while subsite 2 (Lad2y) was in two-year plantation. Subsite 3 (Lad3y) is a three-year old plantation. Subsites 4 (Lad5m), 2 (Lad2y) and 3 (Lad3y) are located near the edge of a small patch of trees, contained grasses, fallen logs and rocks. Subsites 4 (Lad5y) and 5 (Lad6y) are in five-year old and six-year old palm trees plantation, respectively. They are adjacent to FPPI plantation with very rarely observed grasses, fallen logs and rocks. They are 5-10 meters away from any residential area.

Sampling site 3 - is a 20-hectare plantation surrounded with degraded secondary residual forest. Each palm tree in this plantation has an average height of 3.5 meters aged two years old (Com2y). DBH was not measured since its trunk is not yet well defined. Sampling in this area was carried out before the first harvest to capture or record the presence of fruit-eating birds. The plant community includes akasya (*Samanea saman* Jacq.), balete (*Ficus balete* Merr.), dita (*Alstonia scholaris* L.), fireworks (*Clerodenrum quadriloculare*), Ipil-ipil (*Leucaena leococephala* Lam.) and bamboo (*Bambusa sp.*). A falcata (*Paraserianthes falcataria* L.) plantation can be seen from the plantation. Small patches of garden plants such as eggplants (*Solanum melongena*), corn (*Zea mays*), papaya (*Carica papaya* L.), bananas (*Musa sp.*) and fruiting trees such as mango

(*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), guava (*Psidium guajava* L.), cacao (*Theobroma cacao* L.), marang (*Artocarpus odoratissimus*), antipolo (*Artocarpus altilis*), kaong (*Arean pinnata*), lomboy (*Syzygium cumini* L.) and wild rambutan (*Nephelium lappaceum* L.) are also found within the plantation. Mixtures of herbs, shrubs, ferns (pakong-parang - *Pteris mutilate* L. and tree fern) and grass (cogon grass - Poaceae, para grass - *Brachiaria mutica* F. and pig grass - *Poa annua* L.) were also found within the plantation and in the plantation edge. Fallen logs and minimally exposed rocks at the edge of the plantation were present. No human settlements were noted in this area other than the caretaker's small hut.

Bird sampling. The assessment of birds in oil palm plantations was done from April to June 2010 using the line transect, bird watching and mist netting methods. Binoculars (8x40) were used to observe birds from 500 hours to 1030 hours when the weather was fine and resumed from 1600 hours to 1830 hours. Bird identification was confirmed by using the book of Kennedy et al (2000). A special survey was made from 2000 hours to 2200 hours in order to record nocturnal birds like owls. To sample birds occurring in the undergrowth of oil palm plantation, mist nets with mesh size of 36mm, each having 3 shelves and with the dimensions of 12m x2.8m, were used. They were placed randomly with respect to topography, location of fruiting plants, tree fall gaps, and positioned to adjacent forests or other factors that might influence capture. A 1-meter gap from the ground was also observed when installing the nets. The nets were left open by night to capture nocturnal birds (Blake & Loiselle 2000; Pangcatan 2006; Tibule 2006). Mist netting was only employed in the young oil palm plantations where bamboo poles could be used (substituting the young palm trunks which were not yet defined) to tie up the nets.

Avian sampling was carried out before and after the application of pesticides and before and after harvest in oil palm plantations. Wakker (2000) reported that in Malaysia and Indonesia, species of fauna that survive in oil palm plantations tend to become pests and begin to eat young palm plants for food. This in turn requires the application of pest "control" methods which include the use of chemical pesticides.

In the Compostela Valley where oil palm tree are still young (2 years old), bird sampling was done before the harvest. Based on our conversations with the growers and farmers, the first harvest of oil palm can be done after two years, but the first harvest cannot be sold yet because of low oil quality. It is only after the second and subsequent harvests when the oil produced can be sold.

This was also what was done in the young plantations in Agusan del Sur. In FPPI, sampling was done during harvest to capture or observe fruit-eating birds. Forest species are defined as those with 'forest', 'forest edge' or 'woodland' habitats (Kennedy et al 2000). Other threats such as road establishments within the plantations, small scale mining, application of herbicides and pesticides were also recorded.

One-two voucher specimens were prepared and deposited at the MSU-IIT Natural Science Museum. Biodive Program Software was used in analyzing biodiversity indices. It is a statistical package program for Windows PC enabling many measures of diversity to be calculated for a dataset of taxa by samples. Statistical analysis employed One-way Analysis of Variance (ANOVA) and Multiple comparison methods.

Results and Discussion

Species composition, endemism, species richness and bird diversity. Eighty-eight avian species in 12 orders and 38 families were recorded in all study sites comprising 66 species in site 1, 49 species in site 2 and 59 species in site 3. Eleven species (13%) were found to be restricted to site 1, 10 (11%) in site 2 and nine species (10%) in site 1 (see Table 2). Order Passeriformes was the dominant order comprising 59% of the total number of species and 58% of the total number of individuals. The total number of species includes 53 forest species and 35 non-forest species. Thirty species were present in all sampling sites of which 15 (50%) are known as forest species. The forest species include nine (60%) endemic species of which Philippine bulbul (*Ixos philippinus*) was the

most dominant. Pygmy swiftlet (*Collocalia troglodytes*) and Philippine coucal (*Centropus viridis*) were also endemic species but are also known as non-forest species. Yellow-vented bulbul (*Pycnonotus goiavier*) (Figure 2), a non-endemic and non-forest species, was found to be the most dominant species in all sampling sites, comprising 11%. This species was also the most abundant species in young and mature oil palm plantations in Agusan and the second abundant species in Compostela Valley. The overall relative abundance of this species was higher in mature plantations (57%) than in young oil palm plantations (43%).

Thirty-one endemic species were recorded from all sampling sites where 30 are Philippine endemic and one Mindanao endemic. The number of endemic species was higher in mature plantations (FPPI, 27-30 years old) than in young oil palm plantations (5 months-6 years old). When the number of endemic species in the two young oil palm plantations was considered, that of Compostela Valley contained the higher number of endemic species compared to that of Agusan del Sur. However, there is no considerable variation between the number of endemic species in the mature oil palm plantations in Agusan del Sur and the young oil palm plantations in Compostela Valley. The total number of endemic species also included four globally threatened species, three of which were categorized by IUCN (2011) as vulnerable species. Silvery kingfisher (*Alcedo argentata*) was recorded only in site 1, bleeding-heart (*Gallicolumba criniger*) in site 2 and little slaty flycatcher (*Ficedula basilanica*) (Figure 3) in site 3. One vulnerable species and one near threatened species were observed in the mature oil palm plantation. Young plantations in Agusan del Sur and Compostela Valley had the same number (1) of vulnerable species recorded.

Figure 2. *Pycnonotus goiavier* (Yellow-vented bulbul).

Figure 3. *Ficedula basilanica* (little slaty flycatcher) found in the two-year old oil palm plantation in Compostela Valley.

Table 2

Summary of bird species found in Agusan del Sur and Compostela Valley, Philippines

Order	*Family*	*Species*	*Common name*	*Distribution*	*Conservation status*	*FPPI 27-30yrs*	*Ladganan 5mo.-6 yrs*	*Compostela 2 yrs*
Apodiformes	Apodidae	*Collocalia esculenta*	glossy swiftlet		Least concern	64(4.40)	34(5.45)	46(10.04)
		Collocalia troglodytes	pygmy swiftlet	Philippine endemic	Least concern	39(2.68)	2(0.32)	**96(20.96)**
	Cuculidae	*Eudynamys scolopacea*	Asian koel		Least concern	12(0.83)	25(4.006)	0
	Hemiprocnidae	*Hemiprocne comata*	whiskered treeswift		Least concern	1(0.07)	0	0
Caprimulgiformes	Caprimulgidae	*Caprimulgus affinis*	savanna nightjar		Least concern	0	4(0.64)	0
Ciconiiformes	Ardeidae	*Ardea purpurea*	purple heron		Least concern	0	1(0.16)	0
		Ardea sumatrana	great-billed heron		Least concern	0	2(0.32)	0
		Nycticorax caledonicus	rufous night-heron		Least concern	0	1(0.16)	0
Columbiformes	Columbidae	*Chalcophaps indica*	emerald dove		Least concern	12 (0.83)	16(2.564	1(0.23)
		Gallicolumba criniger	Mindanao bleeding-heart	Philippine endemic	Vulnerable	0	1(0.16)	0
		Geopelia striata	zebra dove		Least concern	4 (0.28)	2(0.32)	6(1.13)
		Phapitreron leucotis	white-eared brown-dove	Philippine endemic	Least concern	45 (3.10)	18(2.56)	5(1.09)
		Ptilinopus occipitalis	yellow-breasted fruit-dove	Philippine endemic	Least concern	1(0.07)	5(0.80)	5(1.09)
Coraciiformes	Alcedinidae	*Alcedo argentata*	silvery kingfisher	Philippine endemic	Vulnerable	3(0.21)	0	0

	Coraciidae	*Eurystomus orientalis*	asian dollarbird		Least concern	0	1(0.16)	0
		Halcyon chloris	white-collared kingfisher		Least concern	104(7.15)	33(5.29)	7(1.53)
		Halcyon smyrnensis	white-throated kingfisher		Least concern	10(0.69)	2(0.32)	1(0.23)
	Meropidae	*Merops viridis*	blue-throated bee-eater		Least concern	0	0	3(0.66)
Cuculiformes	Cuculidae	*Cacomantis variolosus*	brush cuckoo		Least concern	18(1.24)	0	5(1.09)
		Centropus bengalensis	lesser coucal		Least concern	6(0.41)	10(1.60)	8(1.75)
		Centropus melanops	black-faced coucal	Philippine endemic	Least concern	1(0.07)	9(1.44)	4(0.87)
	Columbidae	*Centropus viridis*	Philippine coucal	Philippine endemic	Least concern	48(3.30)	23(3.69)	12(2.62)
		Macropygia phasianella	reddish cuckoo-dove	Philippine endemic	Not indicated	0	0	1(0.23)
Falconiformes	Accipitridae	*Accipiter virgatus*	besra		Least concern	1(0.069)	0	3(0.66)
		Spilornis cheela	crested serpent-eagle		Least concern	4(0.28)	0	3(0.66)
		Spilornis holospilus	Philippine serpent eagle	Philippine endemic	Least concern			
Galliformes	Phasianidae	*Coturnix chinensis*	blue quail; king quail		Least concern	0	0	1(0.23)
Gruiformes	Rallidae	*Amaurornis phoenicurus*	white-breasted waterhen		Least concern	6(0.41)	10(1.60)	0
		Gallirallus torquatus	barred rail		Least concern	4(0.28)	2(0.32)	3(0.66)

		Porphyrio porphyrio	purple swamphen		Least concern	0	4(0.64)	0
		Rallina eurizonoides	slaty-legged crake		Least concern	14(0.96)	0	10(2.18)
		Stigmatopelia chinensis	spotted dove		Least concern	109(7.50)	17(2.72)	0
		Treron pompadora	pompadour green-pigeon		Least concern	0	46(7.37)	0
Passeriformes	Nectariniidae	*Aethopyga primigenius*	grey-hooded sunbird	Mindanao endemic	Near threatened	3(0.21)	0	0
		Aethopyga pulcherrima	metallic-winged sunbird	Philippine endemic	Least concern	1(0.07)	0	0
		Aethopyga shelleyi	lovely sunbird	Philippine endemic	Least concern	2(0.14)	0	3(0.66)
		Arachnothera clarae	naked-faced spiderhunter	Philippine endemic	Least concern	7(0.48)	0	2(0.44)
		Arachnothera longirostra	little spiderhunter		Least concern	0	0	1(0.23)
		Nectarinia jugularis	olive-backed sunbird		Least concern	58(3.99)	16(2.569)	9(1.97)
		Nectarinia sperata	purple-throated sunbird		Least concern	29(1.99)	7(1.12)	7(1.53)
	Rhabdornithidae	*Rhabdornis mystacalis*	stripe-sided rhabdornis	Philippine endemic	Least concern	0	0	2(0.44)
	Rhipiduridae	*Rhipidura javanica*	pied fantail		Least concern	26(1.79)	4(0.64)	0
	Sturnidae	*Sarcops calvus*	coleto	Philippine endemic	Least concern	1(0.07)	0	3(0.66)
		Aplonis panayensis	Asian glossy starling		Least concern	18(1.24)	30(4.81)	0
	Sittidae	*Sitta frontalis*	velvet-fronted nuthatch		Least concern	4(0.28)	0	0

Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		Least concern	45(3.10)	0	2(0.44)
Cisticolidae	*Cisticola exilis*	golden-headed cisticola		Least concern	0	0	5(1.09)
Muscicapidae	*Copsychus saularis*	Oriental magpie-robin		Least concern	102(7.02)	29(4.65)	0
	Cyornis rufigastra	mangrove blue-flycatcher		Least concern	8(0.55)	4(0.64)	1(0.23)
	Eumyias panayensis	Island flycatcher		Least concern	4(0.28)	0	2(0.44)
	Ficedula basilanica	little slaty flycatcher	Philippine endemic	Vulnerable	0	0	1(0.23)
	Muscicapa griseisticta	grey-streaked flycatcher		Least concern	2(0.14)	0	0
Corvidae	*Corvus enca*	slender-billed crow		Least concern	17(1.17)	6(0.96)	6(1.13)
Dicaeidae	*Dicaeum australe*	red-striped flowerpecker	Philippine endemic	Least concern	50(3.44)	21(3.37)	8(1.75)
	Dicaeum bicolor	bicoloured flowerpecker	Philippine endemic	Least concern	9(0.62)	0	7(1.53)
	Dicaeum nigrilore	olive-capped flowerpecker	Philippine endemic	Least concern	1(0.07)	0	0
	Dicaeum trigonostigma	orange-bellied flowerpecker		Least concern	15(1.03)	0	5(1.09)
	Prionochilus olivaceus	olive-backed flowerpecker	Philippine endemic	Least concern	3(0.21)	0	2(0.44)
	Dicaeum pygmaeum	pygmy flowerpecker	Philippine endemic	Least concern	14(0.96)	3(0.49)	6(1.13)
Monarchidae	*Hypothymis azurea*	black-naped monarch		Least concern	10(0.69)	12(1.92)	4(0.87)

Pycnonotidae	*Ixos philippinus*	Philippine bulbul	Philippine endemic	Least concern	76(5.23)	30(4.81)	20(4.37)
Campephagidae	*Lalage nigra*	pied triller		Least concern	22(1.51)	2(0.32)	4(0.87)
Estrildidae	*Lonchura malacca*	tricoloured munia		Least concern	2(0.14)	14(2.24)	10(2.18)
	Lonchura leucogastra	white-bellied munia		Least concern	0	0	2(0.44)
Timaliidae	*Macronous striaticeps*	brown tit-babbler	Philippine endemic	Least concern	82(5.64)	24(3.85)	2(0.44)
Sylviidae	*Megalurus palustris*	striated grassbird		Least concern	2(0.14)	4(0.64)	11(2.40)
	Megalurus timoriensis	tawny grassbird		Least concern	3(0.21)	8(1.29)	4(0.87)
	Orthotomus castaneiceps	Philippine tailorbird	Philippine endemic	Least concern	10(0.69)	0	0
	Orthotomus cuculatus	mountain tailorbird		Least concern	17(1.17)	0	3(0.66)
	Orthotomus nigriceps	black-headed tailorbird	Philippine endemic	Least concern	7(0.48)	0	1(0.23)
	Phylloscopus coronatus	Eastern crowned leaf warbler		Least concern	0	0	3(0.66)
	Phylloscopus olivaceus	Philippine leaf-warbler	Philippine endemic	Least concern	0	0	3(0.66)
	Phylloscopus trivirgatus	mountain leaf-warbler		Least concern	24(1.65)	2(0.32)	2(0.44)
Pachycephalidae	*Pachycephala philippinensis*	yellow-bellied whistler	Philippine endemic	Least concern	1(0.07)	0	0
Paridae	*Parus elegans*	elegant tit	Philippine endemic	Least concern	1(0.07)	10(1.60)	7(1.53)
Passeridae	*Passer montanus*	Eurasian tree sparrow		Least concern	35(2.40)	0	1(0.23)
Motacillidae	*Motacilla cinerea*	grey wagtail		Least concern	6(0.41)	0	2(0.44)

	Oriolidae	*Oriolus chinensis*	black-naped oriole		Least concern	22(1.51)	30(4.81)	0
	Pittidae	*Pitta erythrogaster*	red-bellied pitta		Least concern	1(0.07)	0	0
		Pitta sordida	hooded pitta		Least concern	0	3(0.48)	0
	Timaliidae	*Ptilocichla mindanensis*	striated wren-babbler	Philippine endemic	Least concern	4(0.28)	0	4(0.87)
	Pycnonotidae	*Pycnonotus goiavier*	yellow-vented bulbul		Least concern	**174(12.00)**	**57(9.14)**	**55(12.01)**
		Pycnonotus urostictus	yellow-wattled bulbul	Philippine endemic	Least concern	6(0.41)	12(1.92)	
	Zosteropidae	*Zosterops montanus*	mountain white-eye		Least concern	5(0.34)	0	11(2.40)
	Hirundinidae	*Hirundo tahitica*	Pacific swallow		Least concern	0	0	3(0.66)
Piciformes	Ramphastidae	*Megalaima haemacephala*	coppersmith barbet		Least concern	15(1.03)	11(1.76)	5(1.09)
Psittaciformes	Psittacidae	*Bolbopsittacus lunulatus*	guaiabero	Philippine endemic	Least concern	4(0.28)	13(2.08)	9(1.97)
		Loriculus philippensis	Philippine hanging-parrot	Philippine endemic	Least concern	0	3(0.48)	0
		Total of species: 88				66	49	59
		Total of individuals: 2536				1454(57.33)	624(24.61)	458(18.05)
		Total of endemic species: 31				25	14	24
		Total of threatened species						
		Vulnerable species: 3				1	1	1
		Near-Threatened species: 1				1	0	0

Note: The first number corresponds to the number of individuals recorded while the number in parentheses represents the relative abundance of that species. Distribution and Conservation status is based on IUCN 2011. Dominant species are bold in number.

Table 3 shows that species richness and the number of individuals of birds are higher in mature plantations (FPPI) than in young plantations. Between the two young plantations, Compostela Valley has greater species richness but lesser number of individuals than in Agusan del Sur. Species diversity was recorded to be high in the three sampling sites. But when the species diversity across subsites is considered, subsite 3 (FPPI27y) in FPPI and subsites 1 (Lad5m), 2 (Lad2y) and 4 (Lad5y) in Ladganan plantation have moderate diversity value. The oil palm plantation in Compostela Valley has greater dominance index than the plantations in Agusan del Sur. The high index value implies that dominant bird species exist in the oil palm plantations in this site. The pygmy swiftlet (*Collocalia troglodytes*) was found to be the dominant species (20.96 percent) in the Compostela oil palm plantation. The Evenness value obtained in the three sampling sites shows that the number of individuals within each species was moderately even in Ladganan while not evenly distributed in FPPI and Compostela.

The number of individuals of birds differ significantly according to the age of the oil palm plantation (Table 4). However, there is no significant difference in the number of individuals according to the sampling sites. For example, there is no significant difference in the number of individual of birds between the young oil palm plantation in Agusan (5 months-6 years old) and the young oil palm plantation in Compostela (2 years old) ($p = 0.069 > 0.05$) as well as the number of individuals between the young (5 months-6 years old) and mature oil palm plantations (27-30 years old) within Agusan ($p = 0.062 > 0.05$).

The highest number of species, endemic species, high species diversity as well as number of individuals were probably recorded in Site 1 (FPPI, Agusan del Sur), due to the edge effects. Edge effects refer to the influence of the proximity and number of nearby forest edges, edge age, weather events, structure and composition of the adjoining matrix vegetation on the number of animal species present in the direct vicinity. This term is commonly used in conjunction with the boundary between natural habitats, especially forests, and disturbed or developed land (Laurence et al 2007). The nearby forest may act as a source habitat and result in a steady influx of forest birds to the agricultural system. In other words, the occurrence of a moderate fraction of the forest avifauna in agricultural habitats does not necessarily imply that these degraded habitats are suitable for forest species over longer periods but these few forest bird species and individuals may tend to utilize food resources that are located further away from their forest habitats (Luck & Daily 2003). The natural shade of trees in agroforestry systems can provide food resources, allowing long-lived species to persist for longer periods (Marsden & Pilgrim 2003) but artificial plantations with exotic shade trees far from natural forest usually do not support large numbers of resident forest species (Greenberg et al 2000).

Tree cover in tropical land use systems is important in maintaining the resident forest bird population (Waltert et al 2005). This kind of structure provides canopy stratum to various arboreal species. Avocado (*Persea americana*), marang (*Artocarpus odoratissimus*), which have more or less the same height as that of mature palm trees (more or less 30 meters), banana and guava are among the trees which can possibly provide food to some bird species in this site. These factors are supported by Styring et al (2011), who pointed out that increased in species richness and diversity of bird community is due to the contributing factors like canopy height and secondary canopy development.

Table 3

Biodiversity Indices in Oil palm plantations in Compostela Valley and Agusan del Sur, Philippines

Study areas	Sampling areas	Subsites	Number of individuals	Species richness (S)	Dominance	Shannon Index (H')	Evenness
Agusan del Sur	Site 1. Filipinas Oil Palm Inc. (FPPI) Mature plantation 27-30 yrs. old	1) Barangay Maligaya 30 yrs. old (FPPI30y)	389	35	0.05375	3.166	0.6774
		2) Barangay Cabantao 29 yrs. old (FPPI29y)	1004	61	0.05054	3.383	0.4831
		3) Barangay Tigbanayan 27 yrs. old (FPPI27y)	61	18	0.08627	2.613	0.7577
			1454	**66**	**0.04789**	**3.432**	**0.4686**
	Site 2. Ladganan Young plantation 5 mos. - 6 yrs. old	1) Ladganan 5 mos. (Lad5m)	79	21	0.06874	2.835	0.811
		2) Ladganan 2 yrs. (Lad2y)	98	19	0.09059	2.63	0.7301
		3) Ladganan 3 yrs. (Lad3y)	253	35	0.05082	3.183	0.6891
		4) Ladganan 5 yrs. (Lad5y)	48	16	0.08594	2.582	0.8264
		5) Ladganan 6 yrs. (Lad6y)	146	31	0.06099	3.107	0.7207
			624	**49**	**0.04088**	**3.441**	**0.6372**
Compostela Valley	Site 3. Compostela Young plantation 2 yrs. old	1) Compostela 2 yrs. (Com2y)	**458**	**59**	**0.07789**	**3.266**	**0.452**

Table 4

Least significant difference for multiple comparisons of the number of individuals of birds according to age/growth (dependent variable)

Sites	*Age/growth*	*Mean difference*	*P*
Filipinas Oil Palm Inc. (FPPI) (Mature 27-30yrs. old)	30 years vs. 29 years	0.000	$p<0.05$*
	30 years vs. 27 years	0.000	$p<0.05$*
	29 years vs. 27 years	0.063	$p>0.05$
Badong's Plantation (Young 5months-6yrs. old)	6 years vs. 5 years	0.015	$p<0.05$*
	6 years vs. 3 years	0.008	$p<0.05$*
	6 years vs. 2 years	0.233	$p>0.05$
	6 years vs. 5 months	0.096	$p>0.05$
	5 years vs. 3 years	0.000	$p<0.05$*
	5 years vs. 2 years	0.214	$p>0.05$
	5 years vs. 5 months	0.440	$p>0.05$
	3 years vs. 2 years	0.000	$p<0.05$*
	3 years vs. 5 months	0.000	$p<0.05$*
	2 years vs. 5 months	0.636	$p>0.05$

* The mean difference is significant at the 0.05 level.

Hughes et al (2002) predicted that if tall trees were removed from the landscape, bird richness would decline by approximately 40%. It has been found that the straight and tall trunks of mature palm trees provide light and space for the development of understory and shrub layers. These, in turn, attract a variety of bird species that utilize the different vegetational strata. Also, shrubs as a preferred stratum by forest birds in oil palm plantations underline the importance of conserving and recolonizing native flora in degraded habitats. Thus, the continuous application of herbicides as observed in the sampling sites 1 and 3, and probably in site 2 because of the almost clear ground with few grasses are seen to threaten the plant community as well as the existence of birds in the plantations. The use of herbicides can alter bird population due to toxicity (Blus & Henny 1997). Even when herbicides which are used have low toxicity to birds, the herbicides would still decrease the abundance of many types of vegetation which the birds rely on (MacKinnon & Freedman 1993). Herbicide use in agriculture in Britain has been linked to a decline in seed-eating bird species which rely on the weeds killed by the herbicides (Newton 2004).

Najera & Simonetti (2010) reported that independent of the type of plantation, bird richness and abundance were greater in structurally complex plantations. A structurally complex plantation has abundant food resources, differences in surrounding habitats (like patches of second growth and distance to primary forest) and differences in local vegetation characteristic within plantations (density of large trees/group of trees and diverse shade tree assemblage density of dead trees, canopy cover density and shrub volume) which influence the bird diversity and composition in agricultural landscapes in the wet tropics (Najera & Simonetti 2010; Foster et al 2009; Clough et al 2007; Peh et al 2005; Hughes et al 2002; Peh et al 2006; Greenberg et al 2000).

The variations in species composition and species diversity of the subsites are due to the differences in local vegetation characteristics within the plantation (Clough et al 2007). For example, subsite 1 (FPPI30y) in Agusan which has a high diversity has dense growth of trees, high underground cover of ferns, lower degree of threats/disturbance and lower occurrence of anthropogenic clearing. This supports previous studies by Davis & Philips (2005) and Hassall et al (2006), who found higher abundance of birds in oil palm plantations, although these are probably species which were previously

characteristic of open habitats or agricultural areas (Chey 2006; Davis & Philips 2005). Another factor that might contribute to the high species richness is the prevalence of canopy epiphytes and ferns as ground cover. It was observed during the sampling that most of the trunks of mature palm trees had epiphytic plants such as capa-capa (*Medinilla sp.*), pakong parang (*Pteris mutilate* L.), pakong lawit (*Goniophlebium percussum* Wagner and Grether), bird's nest (*Asplenicum musaefolium* Melt) attached to them. These epiphytes are known to house a high density as well as species richness of arthropods and are therefore important components of the tropical ecosystem, thus providing more food for insect-eating birds. The abundance of epiphytes is related to the abundance of species that primarily forage in epiphytes (Ellwood & Foster 2004). Also, approximately 90% of ferns were present in the area. This observation is similar to the findings of Turner & Foster (2009) that ferns establish quite quickly in young oil palm (an average of 45 ha−1 in 7-year old oil palm) and increase in abundance as plantations mature (an average of 971 ha−1 in 26-y-old oil palm). Bobo & Waltert (2011) found that arthropod richness and density attract many understorey forest birds in agricultural areas. The abundance of ferns in this area means that more Arthropods serve as food for insectivorous bird species.

The occurrence of globally threatened species particularly in mature plantations is supported by Turner et al (2008), and Brown & Jacobson (2005) who pointed out that higher levels of oil palm production are also generally associated with a higher number of endangered species such as the case in Malaysia which has by far the highest levels of palm oil production per unit area and the highest relative number of endangered species. Old grown plantation palm trees grow to about 30 meters high and have some epiphytes attached to their trunk, and exhibit enough undergrowth present and slightly undisturbed forests encircling the half side of the plantation. These factors could help birds including endemic species to find refuge in monoculture plantations. The presence of approximately half of forest bird species in the plantations of Agusan del Sur and Compostela Valley, including a few globally threatened species, indicate the importance of forests or forest fragments in the vicinity of the oil palm plantations. Hughes et al (2002) stated that the availability of forest growth near the plantation, ground vegetation, mixed crops planted inside the plantation and presence of epiphytic plants have no doubt contributed to the high species richness in this degraded habitat. This factor is further supported by Peh et al (2006), who pointed out that the neighboring fragments of primary forest in southern Peninsular Malaysia undoubtedly contributed to the relatively high forest species richness observed in oil palm plantations and rubber tree plantations, too.

The conservation value of degraded habitats in agricultural landscapes is thus likely to depend on factors such as the type of crops planted, distance to nearest primary forest, intensity of farming, hunting pressure, amount of remaining native vegetation, and landscape disturbance history. This factor explains why the young oil palm plantation in Compostela Valley (2 years old) recorded more number of species and endemic species compared to the young plantation in Agusan del Sur (5months-6years old) but did not differ a lot from the mature oil palm plantations (27-30 years old) in Agusan del Sur. The young plantation in Compostela Valley was planted with mixed crops such as eggplants (*Solanum melongena*), bananas (*Musa sp.*), papaya (*Carica papaya* L.), mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), wild rambutan (*Nephelium lappaceum* L.) and corn (*Zea mays*), coconut (Cocos nucifera), guava (*Psidium guajava*), cacao (*Theobroma cacao* L.) and surrounded by degraded secondary residual forest. There were also mixtures of herbs, ferns, cogon (Poaceae) and grasses that can be found within the plantation and in the plantation edge. This finding is further supported by Blake & Loiselle (2000) who stated that in Costa Rica, 46% of regional avifauna can still utilize the agricultural landscape because of the presence of agricultural crops such as maize fields, eggplant, papaya and banana and was surrounded by groups of trees and patches of secondary forest. Bobo & Waltert (2011) reported that higher food availability found in agricultural habitats attracts many forest birds.

In addition, based on personal communication with the private owner of the plantation, the area was a secondary forest before it was converted to agricultural land.

Secondary forests play an important role in the conservation, for example, of many Sulawesi bird species in Sulawesi (Waltert et al 2004). BirdLife (2010b) also added that vulnerable species are diminishing for the reason that its population is experiencing a rapid decline as a result of the loss and decline in quality of lowland stream habitats. The three sites in this study were categorized as lowlands. These kinds of areas are more likely suitable for monoculture oil palm plantations and can be habitable by some vulnerable species like the silvery kingfisher and the flycatcher. The occurrence of near threatened and endemic vulnerable species in all study sites illustrate the need to protect forests fragments along the oil palm plantation.

Inside the plantations, roads are established to provide easy access especially during harvest where tons of palm fruits are harvested. The roads also provide access to people who want to settle in the area which further disrupt an already delicate natural balance. Clearing for roads further break the remaining rainforest into fragments and open up the surroundings. The private grower in Compostela Valley wanted to expand the 20-hectare plantation. In fact, during the sampling period, bulldozers were working to clear patches of forests. This would put the forest at risk as well as the fauna including the birds. Another threat observed was the mining activity which is one of the livelihood activities inside plantations particularly in the mature plantation in Agusan del Sur. The milling building was also located inside the plantation. Every now and then, harvesters from different regions come over to bring their fruits for further processing. Human settlements are also present. Mature plantations also cover a huge area of about 8,000 hectares. These large areas of plantation can hinder the migration patterns and block travel routes of the animals in the area. This may therefore add to the difficulty of large forest animals from moving over large distances under the forest to find something to eat. This could also mean that the animals could be killed if they move around the plantation in search for food. The burning of understory plants was also noted. Growers in FPPI and Compostela were observed using herbicides during roundup spraying. Roundup spray is a non-selective herbicide, meaning it will only affect any leaves the spray touches. However, its continuous application can further pose a threat to the undergrowth vegetation within the plantation which is helpful to a few birds. Application of fertilizers, herbicides and pesticides would also contribute to the destruction of soil thus affecting plant diversity (Wakker 2000).

Conclusions. Edge effects (availability and number of nearby forest fragments and the structure and composition of the adjoining vegetation) and the structural complexity of the plantation (presence of ground cover plants, canopy epiphytes and patches of natural trees within the plantation) influence the presence of birds in oil palm plantations. The relatively young oil palm plantation in Compostela, which is surrounded by forests fragments, had high number of endemic species and globally threatened species. It is recommended that fragments be given top priority in conservation in order to maintain the species richness in the surrounding habitats. The occurrence of near threatened and vulnerable species in all study sites illustrate the need to protect the forests along the plantation. Additional research and monitoring is needed to show whether a species colonizing plantation forests can maintain viable populations. Despite the fact that relatively high species richness can be found in modernized agroforestry systems, conservation of global and regional biodiversity strongly depends on adequate areas of forest. Furthermore, the presence of some insectivorous birds within the plantation benefits the oil palm companies and local growers because they control the leaf-eating palm pests. These results illustrate the need for palm oil industries to make the plantations more hospitable by keeping and maintaining the plant community such as the ground cover and epiphytic plants within plantations. Also, the management of oil palm plantation should consider conserving some aspects of natural habitats nearby plantations to avoid biodiversity loss.

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