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Acid Mine Drainage and Its Characteristics at Kyaukpahto Gold Mine, Influence of Habitat Types on Bird Species of Density, Diversity, and Forest Bird Community Composition in Reserve Forests around Kalaw Town, Eastern Myanmar

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Influence of Habitat Types on Bird Species of Density, Diversity, and Forest Bird Community Composition in Reserve Forests around Kalaw Town, Eastern Myanmar

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Abstract

Different habitat in local scale has been acknowledged as a key factor that influences habitat use by birds, being especially critical for the conservation of important habitats. The previous studies of the research only exhibited bird species identification and recorded a long history in Kalaw region. This study aims to estimate bird species detectability of density, detection probability, and encounter rate in different habitat types, assess bird diversity, community similarity, and its relative abundance to the different habitat types, and finally, identify the influence of habitat types on the relative richness of forest–dependent guilds and relative abundance of avian feeding guilds. Using point count survey with distance sampling established 69 sample plots within three different habitat types. Distance software was conducted to estimate bird species detectability of density, detection probability, and encounter rate in different habitat types. Shannon–Weiner diversity index and Sorenson's Coefficient were calculated for bird diversity and species composition similarity in different habitat types. Non–parametric Kruskal–Wallis H test performed and compared the relative species richness of forest–dependent guilds among habitat types. The relative abundance forest–dependent guilds conducted with one–way analysis of variance (ANOVA) and compared influence of avian feeding guilds with Tukey HSD Post Host tests among habitat types. The highest estimation of the probability of density was found 38.5 individuals/ hectare in natural forest, 28.05 individuals/ hectare in plantation crop and shrubs, and followed 26 individuals/ hectare in plantation respectability. The natural forest revealed the highest species richness, abundance, diversity, and evenness than other habitats. The relative species richness of forest–dependent guilds has significant differences among habitats and specialist forest–dependent species mainly harbor in the structurally complex remnant natural forest. Avian feeding guilds of frugivores, nectarivores, and granivores were significantly different among habitats. This study underscores the importance of remnant natural forests for the persistence and conservation of forest biodiversity and the risks posed by shifting them with plantation and plantation crops.

Keywords: habitat type, forest–dependent, feeding guild, density, diversity

မြန်မာနိုင်ငံအရှေ့ပိုင်း၊ကလောမြို့ဝန်းကျင်ရှိသစ်တောကြိုးဝိုင်းများအတွင်းနေရင်းဒေသများမှငှက်မျိုးစိတ်များ၏ မျိုးစုံမျိုးကွဲ၊ သိပ်သည်းဆနှင့် သစ်တောငှက်များ၏ ဖွဲ့စည်းပုံများတို့ အပေါ် လွှမ်းမိုးသည့်အချက်အလက်များလေ့လာခြင်း

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စာတမ်းအကျဉ်း

ဒေသတွင်းမတူညီသော နေရင်းဒေသများမှ ငှက်မျိုးစိတ်များအပေါ်လွှမ်းမိုးသည့် အချက်အလက်များလေ့လာခြင်းအားဖြင့် ရရှိလာသော အချက်အလက်များအပေါ်မူတည်ပြီး အရေးကြီးသော နေရင်းဒေသများထိန်းသိမ်းရန်အတွက် များစွာအထောက်အကူဖြစ်စေပါသည်။ နှစ်ကာလကြာရှည်ကတည်းက ကလောဒေသတွင် ငှက်စာရင်းကောက်ယူခြင်းနှင့် ငှက်မျိုးစိတ်များ မှတ်တမ်းတင်ခြင်းတို့ကို ဆောင်ရွက်ခဲ့ကြသော်လည်း နေရင်းဒေသများနှင့် ငှက်မျိုးစိတ်များ ဆက်နွှယ်သည့်လေ့လာမှုမျိုးကို ဆောင်ရွက်နိုင်ခဲ့ခြင်း မရှိခဲ့သည်ကို တွေ့ရပါသည်။ ဤစာတမ်း၏ရည်ရွယ်ချက်များသည် မတူညီသော နေရင်းဒေသအတွင်းရှိ ငှက်မျိုးစိတ်များ၏ သိပ်သည်းဆ၊ တွေ့ရှိမှု ဖြစ်တန်စွမ်းနှင့် တွေ့ရှိနှုန်းတို့ကို ခန့်မှန်းရန်၊ မျိုးစိတ်များ တူညီမှု၊ ငှက်များ၏ မျိုးစုံမျိုးကွဲနှင့် ငှက်ကောင်ရေများပြားကြွယ်ဝမှုသည် ကွဲပြားသောနေရင်းဒေသများအပေါ် ဆက်နွှယ်မှုများကို ခန့်မှန်းတွက်ချက်ရန်၊ သစ်တောတွင်း နေထိုင်ကျက်စားသည့် ငှက်အုပ်စုများနှင့် ၎င်းတို့စားသည့်အစာတို့ကိုအခြေခံ၍ ခွဲခြားထားရှိသောငှက်အုပ်စုတို့အပေါ်လွှမ်းမိုးသည့်အချက်များကို လေ့လာရန်တို့ဖြစ်ပါသည်။ ငှက်စာရင်းကောက်ယူရာ၌ Point Count စနစ်ဖြစ်သည့် နမူနာကွက် (၂၃)ခုစီ (နမူနာကွက်တစ်ကွက်လျှင် ၅၀-မီတာအချင်း၊ နမူနာကွက်တစ်ခုနှင့်တစ်ခု (၂၀၀) မီတာ အကွာအဝေးစီအညီချမှတ်ပြီး တစ်ကွက်လျှင် စာရင်းကောက်ယူမှုကြာချိန် (၁၀) မိနစ်ဖြင့် ကလောမြို့နယ်၊ ကလောနှင့်ရေအေး ကြိုးဝိုင်းအတွင်းရှိ နေရင်းဒေသ(၃)မျိုး (သဘာဝတော၊ သစ်တောစိုက်ခင်းနှင့်သီးနှံစိုက်ခင်း/ ခြံပုတ်) တို့တွင်ချမှတ်ပြီး စုစုပေါင်း နမူနာကွက် (၆၉)ကွက်၌ Distance Sampling စနစ် ကိုအသုံးပြု၍ ၂၀၂၀ ခုနှစ်၊ဇန်နဝါရီနှင့် ဖေဖော်ဝါရီလတို့တွင် ဆောင်ရွက်ခဲ့ပါသည်။ Distance Software ကိုအသုံးပြု၍ ကွဲပြားသော နေရင်းဒေသအတွင်းရှိ ငှက်မျိုးစိတ်များ၏သိပ်သည်းဆ၊ တွေ့ရှိမှုဖြစ်တန်စွမ်းနှင့် တွေ့ရှိနှုန်းတို့ကို ခန့်မှန်းခြင်း၊ Shannon-Weiner diversity index and Sorenson's Coefficient ကို အသုံးပြု၍ ငှက်များ၏မျိုးစုံမျိုးကွဲနှင့် မျိုးစိတ်များတူညီမှု များကိုတွက်ချက်ခြင်း၊ Non-parametric Kruskal-Wallis H test ကိုအသုံးပြု၍ နေရင်းဒေသများအလိုက် သစ်တောတွင်းနေထိုင်သည့် ငှက်မျိုးစိတ်အုပ်စုများ၏ကွဲပြားခြားနားမှုကို တွက်ချက်ခြင်းနှင့် One Way ANOVA ကိုအသုံးပြုပြီး အစာကိုအခြေခံ၍ခွဲခြားထားရှိသော ငှက်အုပ်စုတို့၏ နေရင်းဒေသများကြားဆက်နွှယ်မှုနှင့် တွက်ချက်ခြင်းများ ဆောင်ရွက်ခဲ့ပါသည်။ လေ့လာတွေ့ရှိချက်များမှာ ငှက်တွေ့ရှိမှု၊ သိပ်သည်းမှုဖြစ်နိုင်စွမ်းအနေဖြင့် သဘာဝတောတွင် တစ်ဟတ်တာလျှင် (၃၈.၅)ကောင်နှုန်း၊ သစ်တောစိုက်ခင်းတွင် (၂၈.၀၅) ကောင်နှင့် သီးနှံစိုက်ခင်း /ခြံပုတ်များတွင်(၂၆) ကောင်နှုန်း အသီးသီးတွေ့ရှိရပါသည်။ သဘာဝတောတွင် ငှက်များ၏ မျိုးစိတ်ကြွယ်ဝမှု၊ အကောင်အရေအတွက်များပြားမှုတို့သည့် အခြားနေရာများနှင့် နှိုင်းယှဉ်ပါက ကွဲပြားခြားနားမှုရှိသည်ကို တွေ့ရပါသည်။ ထို့အပြင် အသီးစား၊ ဝတ်ရည်စုတ်နှင့်အခွံမာသီးစားသော ငှက်အုပ်စုများ၏ နေထိုင်ကျက်စားမှုသည် မတူညီသော နေရင်းဒေသများကြားတွင် သိသိသာသာ ကွဲပြားခြားနားမှုရှိသည်ကို တွေ့ရှိရပါသည်။ ထို့ကြောင့် ဇီဝ

မျိုးစုံမျိုးကွဲများအတွက် အရေးပါသော သဘာဝတောကျန်များကို အခြားမြေ အသုံးချမှုအဖြစ် ပြောင်းလဲရာတွင် သစ်တောနေငှက်မျိုးစိတ်များအတွက် ထည့်သွင်းစဉ်းစားရန်နှင့် သဘာဝ တောကျန်များကို အစဉ်တစိုက်ကာကွယ်ထိန်းသိမ်းရန် လိုအပ်ကြောင်း တင်ပြအပ်ပါသည်။

Influence of Habitat Types on Bird Species of Density, Diversity, and Forest Bird Community Composition in Reserve Forests around Kalaw Town, Eastern Myanmar

Chapter 1 Introduction

1.1 Background and Problem

Studies on bird diversity are vital to understanding global conservation needs for the avian community. Anthropogenic activities have caused avifauna losses such as deforestation [1] for the reason that some birds are very sensitive to rapid changes in their environment that cause habitat fragmentation [2]. Birds play an important role as a good biological indicator in maintaining the balance of the ecosystem and biodiversity[3, 4], depend on various factors such as habitat structures and anthropogenic activities, birds can diverse and uneven in their distributions, diversity, and density[5]. Hence, bird diversity and its habitat dynamic trend are important reference indexes for regional environmental changes[6]. Furthermore, Avian communities are used as indicators because they are taxonomically well-identified, easy to observe, sensitive to changes in habitat quality, and among the key players in ecosystem functioning[7].

The Republic of the Union of Myanmar is geographically located in Southeast Asia and the topography of Myanmar can roughly be divided into the western hill region, the central valley region, and the eastern hills region[8], and the center of the Indo-Burma Biodiversity Hotspot[9, 10]. Due to the combination and interaction of geography, topography, and climate, Myanmar has a great variety of habitats and ecosystems [11]which provide rich biodiversity with nearly two-thirds of Myanmar still covered in natural ecosystems[12]and also supports the greatest richness of bird species in mainland South-East Asia[13].

Kalaw town is proximity to the Reserve Forest areas and lies at the western edge of the Shan Plateau in Taunggyi District of Shan State, East Myanmar that is a popular tourist destination known for its scenic hilly location and temperate climate and attracted and visited by many birdwatchers, tourist, and tracking[14]. Birdwatching is a significant component of tourism industries for economic benefit in several countries[15, 16]. Kalaw has observed a striking decrease in forest area over the years and therefore, based on the past decade results showing that 7% of forest loss will be taken place in the Kalaw township-wise analysis of future forest loss scenarios during 2016 to 2030[17]and approximately half of the avian species breeding in Kalaw have declined significantly in the last several decades[14].

A study [17] revealed that Myanmar has suffered land cover change due to rapid growth in the urban and peri-urban settlement over the past decade. From 1992 to 2010, its built-up areas have increased by 24% and shifted from forest land to urban and agricultural land. Evidence showed that the species richness of bird communities varied with the process of urban expansion[6]. Almost 60% of the population in Myanmar still rely on the forest for fuelwood needs, exerting pressure on forest resources[17].In Kalaw Township, urban households mainly use wood-related fuels for cooking is 59.7% using firewood, and 14.0 % using charcoal. In rural areas, some 80.0 % of households use firewood, and charcoal using is 9.4 %[18]. These data are not surprising as a study in these areas by [19] mentioned that due to higher fuelwood dependency, the extraction of firewood from nearby forests by local people is also leading to greater deforestation and habitat degradation.

High levels of deforestation and destructive agricultural practices have shown significant wildlife declines and rapid loss of natural habitats in Myanmar[20]. Whereas according to the Kalaw Forest Department record, Kalaw town is adjacent to the reserve forest areas, which has led to the gradual abandonment of forest areas due to human encroachment for agricultural land and housing expansion, and these problems continue to this day. These threats pose a threat to the habitat of birds in the Reserve Forests. As a result, some bird species declined in the Kalaw region[14].

Myanmar has been weakly covered by ornithological surveys[21]. Furthermore, bird species composition, distribution, abundances, detectability, and the threats that affect them are poorly researched in many regions of the country involving the Kalaw region[22]. The current status of most bird species in eastern Myanmar is poorly known and the survey of birds was certainly incomplete in Kalaw region [14]. Due to the lack of proper management systems for understanding the influence of habitat types on bird species of relative abundance, density, diversity, and prefer species is an urgent need for conservation of those locally inhabitants' birds.

The previous studies of the research only showed on bird species identification and recorded a long history in my study area, lacking studies for the relation of bird diversity and habitat types. Here, I conducted this research to provide observation of estimating detectability of bird density, detection probability, and encounter rate using data to evaluate the current status and scrutiny of bird diversity, similarity, and its relative abundance to different habitat types. Additionally, I also identify the influence of habitat types on the relative species richness of forest-dependent guilds and relative abundance of avian feeding guilds focusing mostly on Kalaw and Ye-E Reserve forests. Our research finding information will provide not only fundamental decision making before much transformation of natural forest to other land use but also important as a scientific basis for managing human-altered landscapes for sustainable development of forest biodiversity.

1.2 Objectives

The main goals of this study are to observe and identify the influence of habitat types on bird species of density, diversity, and Forest bird community composition in Kalaw and Ye-E Reserve Forests around Kalaw town. My specific objectives are to:

(i) estimate detectability of bird species density, detection probability, and encounter rate in different habitat types around Kalaw area
(ii) assess bird diversity, community similarity, and its relative abundance to the different habitat types of Kalaw area
(iii) identify the influence of habitat types on the relative richness of forest-dependent guilds and relative abundance of avian feeding guilds

1.3 Research Question and Hypothesis

Research questions are addressed:

(i) Are bird species of density, detection probability, and encounter rate differ in each habitat type?
(ii) Are diversity indices and community similarity of bird species different in the three habitat types of Kalaw area and how are the abundance of bird species related in those different habitat types?
(iii)How influential are bird species of forest-dependent guilds and avian feeding guilds in different habitat types?

I hypothesized that not only estimation of bird species detectability of encounter rate, probability of density but also diversity index and community similarity would be no different in each habitat type. I also hypothesized that different habitat types would be influenced by (1) Forest-dependent guilds including bird groups of Forest Specialist (FF), Forest Generalist(F), and Forest Visitor (f) and (2) Avian feeding guilds including bird groups of frugivores, insectivores, granivores, omnivores, carnivores, and nectarivores.

Chapter 2 Literature Review

2.1 Effect of Land Use Change and habitat degradation on Bird Diversity

As habitat degradation and land cover/land use change has been recognized as a leading factor affecting biodiversity, some composite biodiversity indices regard land use impacts on populations and species richness[23]. Agricultural expansion, logging, overexploitation, and urbanization are all driving bird declines and diminishing the natural world[16]. An estimated 420 million ha of forest has been globally lost through deforestation since 1990 and, the annual rate of deforestation was estimated at 10 million ha in the most recent five-year period 2015 to 2020[24] and its deforestation effect on the survival of forest-dependent birds[25]. Diversity and the extent of natural habitats will continue to decline as human populations increase and alter landscapes for agriculture and development[26]. Land-use change is one of the main drivers of biodiversity loss[27] and it will continue to affect greater species loss in tropical countries [28].

Nearly two-thirds of bird species are mainly found in forests in the tropics[16]. Anthropogenic disturbance can double biodiversity loss from deforestation in tropical forests [29]and these areas are also expected to face even more pressures in the future, largely due to agricultural expansion[30]. Theory shows that a disproportionate loss of woodland depended bird species occurs when total habitat cover decreases to 10–30% of the landscape[31]. Birdlife International (2018) stated that the agricultural expansion affected 1,091 globally threatened birds (74%) and logging impacts 734 species (50%).

Southeast Asia meets with one of the highest rates of deforestation in the tropics due to agricultural expansion, logging, habitat fragmentation, and urbanization, which are expected to result in species declines and extinctions[32]. Bird communities were particularly vulnerable in Southeast Asia as the most threatened regions because of the sensitivity of their bird communities and the increasing rates of native forest replacement[32], thus habitat loss in tropical developing countries will continue to pose an even more direct and immediate threat to a greater number of bird species[28]. In Southeast Asian forest bird species will become extinct between16% and 32% by 2100 using estimates of forest loss and the species-area relationship [33].Habitat loss and degradation in terrestrial ecosystems cover a wide range of alteration of natural and seminatural ecosystems by human activities[34]. The comparing bird communities in forest, agroforest and agricultural ecosystems do not report on the ecologically important changes in the proportions of avian functional group and therefore, the impact of habitat loss for entire bird communities have been few studied in the tropical ecosystem [35].

Conversion of forest to plantations (i.e., oil palm and plantation crop) is one of the major causes of habitat loss in Myanmar[22]. The transformation of natural forests to croplands is associated with expansion in monocultures of plantation forests to obtain demands for timber and wood products. This conversion of natural forests showed that landscapes compose different mosaics of anthropogenically modified habitats such as agroforests, shrubs, farmlands, secondary forests, and plantation crops[36]. Whereas some animal species rely heavily on intact primary forests, others can adapt to secondary forests and forest-agriculture mosaics[2]. Consequently, animals living in degraded forests or forest fragments may face hardships such as reduced food resources and loss of sleeping or hiding places, and in some cases pressure from invasive species. Species must respond to changes in dietary composition and diversity, and population density so habitat change has been revealed to affect many aspects of the ecology and behavior of animals [2].

Although urban lands cover only 2% of the Earth's surface, they host more than half of the world's human population and urbanization may also reduce native species diversity at regional and global scales[37]. Due to increase urban land development which continues the effects of habitat loss and fragmentation on bird biodiversity differed in various bird communities[6] and currently affecting 294 globally threatened bird species in housing and urban area[16]. Due to urbanization in North America, habitat loss induced greater impacts on red-headed woodpeckers and other members of the cavity-nesting guild[38].

Myanmar lost 1,79,318 km^2 of forest from 1950 to 2016 which indicates large-scale deforestation at the country level and the forest cover decline to 34.4% of the total forest area during 1950–2016 with an annual net rate of deforestation of 0.64%. Shan state had the largest net forest loss (5647.7 km^2), and its deforestation rate was 0.93% between 2001 and 2010[39] and scenario model is showing more than a 5% decrease in large core forest from 2016 to 2027[40]. The increase in population, coupled with recent urbanization, infrastructure development, proximity to the sea for trade purposes had led to extensive deforestation[40]. The effect of deforestation has caused not only decreasing the amount of habitat available for plant species [32]but also, the native forest is substituting by plantations or other agricultural uses [36]and increasingly threaten bird diversity[41]. The conversion of forests to agriculture with simplified agricultural systems results in shifts towards less specialized bird communities with altered proportions of functional groups[35].

2.2 Influence of different habitat types on Bird diversity

Examining effects of land use on breeding birds was provided by the relationship between vegetation cover types, habitat structure, and avian communities at both stand and landscape level and should be addressed when assessing habitat quality [42]. The forest cover status of the total country area in Myanmar was 46.96% during the past decade 2000-2010 and 42.19% between 2010-2020[8] which both forest cover and configuration were important predictors of the presence of woodland bird species [43]. Plantation forests are increasingly common worldwide that its cover was about 131 million ha, which is 3 percent of the global forest area and 45 percent of the total area of planted forests [24]. A meta-analysis [44] in tropical regions for bird diversity, plantation forests have negative effects on both richness and abundance but the establishment of native species and mixed arrangements in plantations was found least negative effects for purpose of protective uses. Some studies showed that pine plantations had impoverished avian communities than relative to native forests[45]. Other studies found that similar species richness with important species turnover in both planted and natural forests[46, 47].In contrast, results showed that some local- and landscape-level features can reduce the negative effects of forest plantations on bird diversity and therefore, the effects of exotic and native plantations were also negative on birds species richness, and plantations based on native tree species did not present a negative effect on bird abundance [44].

Forest plantations are structurally simpler than native forests and are dominated by one or a few canopy species, they negatively affect both bird species richness and abundance[44]. As provision of forest resources, especially timber and fuelwood from natural forests alone is insufficient to fulfill demands for forest products, establishment of forest plantation by various objectives and scales was conducted since 1970s in Myanmar[8]. Planted forests constituted about 427090 hectares of the total forested area countrywide in Myanmar during the 2015–

2020 period [8]and according to Kalaw Forest Department data showed that have been establishing 1,265 hectares with native species of *Pinus khasya* plantations on Kalaw Reserve forest for recover degraded land since 1970. Myanmar assumed that planted forests and plantation forests are the same[8]. Both tropical plantations and modified forests can support birds with a variety of taxa including many forest specialists, especially in close to natural forest, and sometimes at higher abundance and richness than in primary habitat[48].

A global analysis [35] stated that bird species of forest specialists involve 53 % of all the bird species found in the tropics, whereas 14 % of tropical species are agroforest species and 3 % are agricultural specialists. He also pointed that forest is the first habitat choice of 897 agroforest species, whereas 150 agroforest species favor woodlands most, 97 species prefer shrub/scrublands, and 16 species favor open agricultural areas respectability. Shrub's habitat provides food, foraging, and nesting sites, and the related complexity of forest structure can also reduce the predation risk of many bird species[49]. In traditional agroforests of tropical China, there were high diversity and richness in bird guilds at different habitat types[50].

There is still needed to understand how bird communities and the proportions of bird functional groups, such as forest specialists, forest generalists, forest visitors, in changing habitats. Furthermore, many study reviews that comparing bird communities in forest, agroforest, and agricultural ecosystems poorly reported on the ecologically important changes in the proportions of avian functional groups [35]. A global synthesis [51] revealed that forestry and agroforestry plantations have negative effects on bird species richness and abundance worldwide, being variable across the plantation types, zoogeographic regions, and latitudes. The influence of both species' habitat use and community structure differ among bird guilds [52]and differences among guilds in terms of their responses to disturbance not only reflect changes in faunal composition but also in the trophic organization[53].

2.3 Historical Birds record in Kalaw

Myanmar has been recorded 1131 bird species [12]involving 10 endemic species and including 58 globally threatened species that was 3.9% of globally threatened species[54], and countrywide surveys are still needed to determine the total number of species in Myanmar[22]. There are 535 bird species recorded for southern Shan State[13]. Kalaw is situated at the eastern edge of the Sino–Himalayan mountain forests, one of the key forest regions for threatened birds in Asia, and historically supported Mrs Hume's Pheasant and Giant Nuthatch for this region[14].

Around the Kalaw's area documented historically 302 bird species abundance [14]involving 25 least concern bird species and 1 endemic species between 1895 and 2008[54] but four species may now be locally extirpated (Mrs Hume's Pheasant *Syrmaticus humiae*, Black Kite Milvus *migrans*, Red-headed Vulture *Sarcogyps calvus*, Giant Nuthatch *Sitta magna*) and at least one other (Large-billed Crow *Corvus macrorhynchos*) may have declined[14]. Wetland habitats are not found at Kalaw but some species were probably a wanderer from wetlands[55] because a large number of these are migratory and come to the Shan States in the cold season[56]. Forest-dwelling and open-country species mainly found in Kalaw but there are few records of wetland species. The primary forest of Ye-E Reserve Forest provides permanent or season resources for a variety of resident or migrate bird species and outside of the forest(i.e. in Kalaw Reserve Forest) is largely cultivated land, numerous small patches of evergreen and pine plantation comprises that is probably an important supporting factor which contributes to the survival of local forest bird communities[14].

2.4 Detectability-based methods of estimating bird density and abundance

Estimating and monitoring bird populations are vital components of conservation and management programs focused on birds as well as for broader ecosystem-focused programs [57]. There are several methods for estimating bird density and abundance and generally can be categorized into two methods which are index (unadjusted) counts or method and detectability-based (adjusted) counts. Unadjusted counts of birds detected during a survey are often used to make inferences about the relative density or abundance of birds [58] and it can only be used to make inference about a population when the ratio of the index to the true population is constant over time [59]. The detectability-based counts of distance sampling have combined the estimation of detection probability which inference in direct estimates of abundance [57]and provided that the basis of robust inferences[58]. The general assumptions of distance sampling are birds are surely detected on the sample sites and initial location [60]and exact measurements of distances. Distance sampling methods need an accurate estimate of the distance between the observer and each bird[57]. Point transect distance sampling is perhaps now the most widely used density estimation method of bird density for multi-species[61, 62].

Chapter 3 Materials and Methods

3.1Selection of potential study areas

3.1.1GIS mapping for Habitat Types

The habitat types were defined based on digital maps of the study areas and field investigation[63]. Data were computed and analyzed with a combination of different techniques. Preliminary image classification was conducted by Myanmar National Land cover map 2000 ,2010, and 2017 with the 30×30-meter resolution to assess the landuse change in three habitat types. These land cover map images were acquired from the SERVIR Services website (https://landcovermapping.org/en/myanmar-national-portal/). All data used WGS 1984, Universal Transverse Mercator (UTM) coordinates in zone 47. Each raster file was also clipped by using the Clipping Tool and layers were also identified and classified for three habitat types in Kalaw and Ye-E Reserve Forests using ArcGIS Version 10.2.2 [64] and Google Earth Pro .We assumed that closed and open forests were natural forest ; crop land and shrub land were plantation crop and shrubs, and adjusting of Kalaw Forest Department's yearly plantations data was showed woody layer as plantation area. The results from image classification showed that natural forest was reduced, and plantation crop and shrubs was increased between the past 20 years interval (Table 1).

Table 1. Land Use and Habitat Types in Kalaw and Ye-E Reserve Forest

Year	Natural Forest	Plantation	Plantation Crop and Shrub	Total (Hectare)
2000	1365	1063	1082	3510
2010	1273	1165	1072	3510
2017	1042	1265	1203	3510

According to Kalaw Forest Department records, the Kalaw Reserve Forest was originally established in 1924 with 32 compartments of 2,795 hectares but was later abandoned in 2013 due to human encroachment, construction buildings, and agricultural land expansion, leaving a total of 2737 hectares of Reserve Forest area today. As the population growth, human encroachment on reserve forest areas continued to this day. Monocultures of native species *Pinus khasya* plantations have been established by the Kalaw Forest Department since 1981 in deforested and degraded land areas, and today, according to Forest Department records, about 1,265 hectares were left.

The Ye-E Reserve Forest was established in 1912 [65]with 3 compartments of 773 hectares to conserve Ye-E Reservoir of the watershed area where no record of forest plantations established, and the entire Reserve Forest was covered by natural forests. It suffers little human encroachment and fuelwood collection occurs frequently inside the reserve forest[65].An analysis with Arc Map version 10.2.2 and Google Engine currently found that the Kalaw and Ye-E reserve forests comprise 1042(30%) hectares of natural forest, 1265(36%) hectares of *Pinus khasya* plantation, and 1203(34%) hectares of plantation crops and shrubs, respectively.

3.2 Study Area

Kalaw town (20°37′60″N 96°34′00″E) is geologically located on the 'Kalaw Red Beds and equivalents' at the western extremity of the Sino–Burman Ranges and borders the Central Zone to the west. Red siltstones, sandstones, and conglomerates give rise to the red clay soils characteristic of the region[14, 66]. The study area is located at around Kalaw town at an altitude of 1,300 m.a.s.l, with surrounding hills ranging from 1,250 m.a.s.l to 1,450 m.a.s.l that has a temperate, sunny climate with three seasons: raining from mid-May to mid-October, winter from mid-October to mid-February, and summer from mid-February to mid-May[14]. According to Kalaw Agricultural Department data, the mean annual rainfall is 1,074 mm and average maximum temperature 29.039°C, and a minimum of 12.464 °C from 2010 to 2019. Kalaw town has 4,508 households and a total population of 19,962[18].

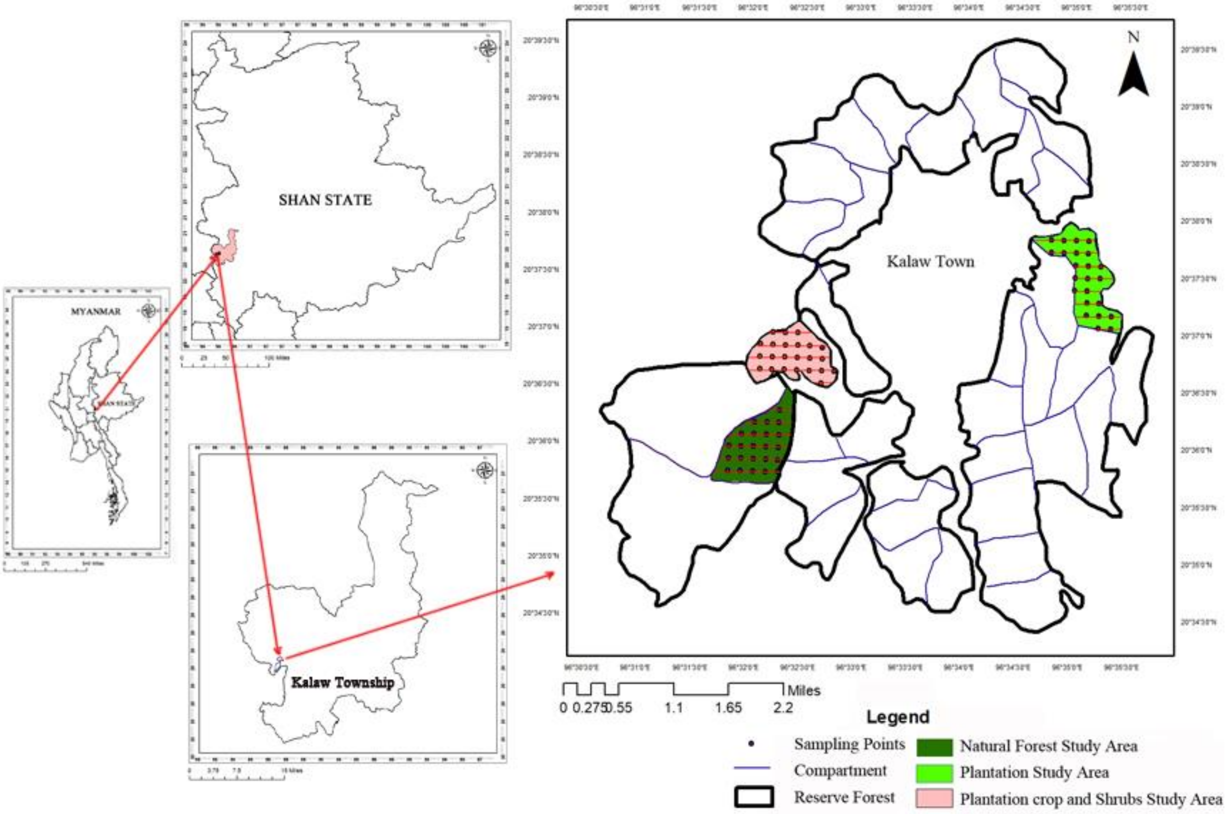

Figure 1. Location of sampling points and study area

3.2.1Site Selection and Stratification of the study area

There are three types of research sites: natural forest (compartment number 2 of Ye-E Reserve Forest), *Pinus khasya* plantation (compartment number 20 of Kalaw Reserve Forest), and plantation crops & Shrubs (compartment number 7 of Kalaw Reserve Forest) as follows based on habitat type, proximate to human settlements and trekking sites (Figure 1).

Natural Forest: It was major found at compartment number 2 northern part of Ye-E Reserve Forest (20˚35.861ˈ N 96˙ 32.058ˈ E) which total area is 121 hectares. It is well-known among bird watchers and trekkers because of its diverse avifauna and suitable conditions for trekking. Hill mature secondary evergreen forest (canopy 20–30 m, with emergent to 40 m) is the dominant forest type and intact understorey and midstorey of trees, shrubs, grasses, and vines[14]. Dominant tree species were characterized by *Quercus serrata Thunb, Schima wallichii, Syzygium thumri, Albizia chinensis, Schleichera oleosa, Ficus comosa Kur, Melanorrhoea usitata,* and *Phyllanthus acidus* and bamboo species are found *Bambusa arundinacea* and *Bambusa tulda*.

Plantation: It was mainly located at compartment number 20 the eastern part of Kalaw Reserve Forest (20˚37.480' N 96˚ 35.166' E) which total area is 100 hectares. This *Pinus khasya* plantation was established in 1981 and is now designated as a Seed Production Area (SPA) and the average height is above 30 meters. In this study, the plantation area includes the area where human planted trees are found monoculture with *Pinus khasya* plant species in Kalaw Reserve Forest.

Plantation Crops and Shrubs: It is mostly located at compartment number 7 the western part of Kalaw Reserve Forest (20˚36.853' N 96˚ 32.420'E) which total area is 111 hectares. Many plantation crops and shrubs areas in the Reserve Forest are interspersed and patchy distribution of land cover types. The hills around Kalaw town found a mosaic of cultivated lands and degraded shrubland. The main form of land use is crop cultivation which locally grown crops planted tea, oranges, chili, ginger, sesame, potato, and maize[14]and much land had been dedicated to the cultivation, particularly for green tea, and orange plantations[67]. The green tea, coffee, plantains, and orange plants with an average plant height of 3 to 6 meters are growing under the shade of avocado pear plantations as patchy. The plantation crops are adjacent to the shrubs and in some places between the shrubs. Shrub species were mainly characterized by *Helianthus annuus*, *Helianthus decapetalus*, *Rotula aquatica, Buddleja macrostachya, Lantana camara, Chromolaena odorata,* and *Vitex trifolia.*Shrubs can be defined as "Refer to vegetation types where the dominant woody elements are shrubs i.e. woody perennial plants, generally of more than 0.5 m and less than 5 m in height on maturity and without a definite crown. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 and 7 meters approximately" [68].

3.3 Survey Design

Distance sampling is a suite of methods for estimating animal abundance [69]. Point transect distance sampling is the most used method for estimating bird density in multispecies surveys[61, 70]. It also provides a rigorous framework for estimating detectability, allowing us to correct counts of detected animals[71]. This method is also termed "point transect sampling" or "variable circular plots" [60]. Point transect sampling, for which the plots are circles, and the observer searches for animals from the center of each circular plot, recording the distance of each detected animal from the center point[69]. A standard point transect survey comprises points spanning the entire study area, and systematically spaced, so that they form a grid[72]. I also conducted systematic point transect sampling and define sample size in each study sites [73].

Making grids in each study area at compartment number 2 of natural forest(121 hectares), compartment number 20 of *Pinus khasya* plantation area(100 hectares), and compartment number 7 of plantation crops and shrubs(111 hectares) and established 23 points in each habitat type using point transect sampling(Figure 6). To avoid the edge effect, a buffer zone around the study areas was performed. Sampling points were set by 200 meters apart from each other and then overlaid a grid (200 × 200 m) on each sample site in GIS to assign survey points at intersects to ensure an even distribution across habitat types and sample areas.

3.4Data Collection

3.4.1Pilot study for preliminary locality surveys

I started a pilot survey for bird species and habitat types on 23 July and 1 August 2020, spending about visiting my study areas. I walked and biked common trails used to each site by two persons of local Ornithologists.

3.4.2 Bird Survey

3.4.2.1 Bird Counts

Birds counted at three sites (23 sampling points in each site) using 10 minutes point counts length because it was suggested that point transects are usually surveyed for a fixed time (10 minutes per sample point) [74]. Birds found within 50 meters radius of the observer collected from the point and their distance of the birds measured by Laser Range Finder. Detection distances should be measured using a laser range finder or estimated in case of shorter distances[60, 75]. To avoid disturbance affected by the observer's arrival, counts started one minute after reaching the survey point. Sample points were systematically set 200 m apart to avoid double counting and each point counted four times (1 day one site) in the breeding season (December to February) where performed at each site in the morning (0600–1200) for three consecutive days each in three study sites. Marking at the center of sample plots set with flats and color-marking stones in the defining GPS points location.

3.4.2.2 Bird Classification

Classification into habitat-preference guilds/bird groups was guided by the forest-dependence classification. "Forest Specialist" (FF) species are true forest birds and detect mostly in unspoiled forests, with few livings in non-forest habitats[35]. "Forest Generalist" (F)species are regularly may occur in undisturbed forests, forest strips, edges, and gaps, and are more common in secondary forest areas than in the interior of an intact forest. However, their breeding is characteristically within the forest. "Forest Visitor" (f) species are often found in the forest but are not dependent upon it, and these species always more common detect and most likely to breed in non-forest habitats[76-78].

Diet classification for bird guilds/bird groups is used to group birds according to their diets and each bird species usually takes up to three "major" and three "minor" diets. Classification of avian feeding guilds performed six major diets such as frugivores, insectivores, granivores, omnivores, carnivores, and nectarivores [26, 53](Table 2).

Table 2. Classification of avian feeding guilds into six mutually exclusive feeding guilds based on predominant diet[53].

Feeding guild	Guild or category	Food source
Carnivore	Carnivore, raptor, piscivore, faunivore, predator	Large arthropods and vertebrate prey
Frugivore	Frugivore, fruit eater	Fleshy fruits
Granivore	Granivore, seed eater	Seeds and nuts
Insectivore	Insectivore, ant follower, bark/foliage gleaner, woodpecker	Small arthropods
Nectarivore	Nectarivore, pollen eaters	Nectar
Omnivore	Omnivore, scavenger, miscellaneous, any species spanning two or more guilds; for example, frugivore–insectivore	Any two or more of the above

3.4.2.3 Associated Person in Bird Survey and Data Collection

During the bird survey and data collection period, Sein Myo Aung@Ko Pan (Ornithologist), Birdlife Myanmar, Biodiversity and Nature Conservation Association (BANCA) Kopanornithologist15@gmail.com, S. Giedan(Ornithologist), and Kalaw Forest Department Services collaborated as a bird survey team.

3.4.2.4 Using Main Equipment

The bird survey measured using equipment such as Camera - Nikon D7500, Binocular-NIKON (PRO STAFF) (8×42), Voice Recorder(J×D), CEER-Super Uni-Directional Electret condenser Microphone, GPS Germin 76, and Laser Range Finder (Class1 Laser) 1× CR2 (3.0VDC).

3.4.2.5 Identification Bird's guild books

To identify and classify birds species used guides books such as Bird of Burma [13]; A Field Guide to the Birds of South-East Asia[78]; The Sibley Guide to Bird life Behavour[79]; Birds of East Asia (Helm Field Guides)[80]; The Birds of the Thai-Malay Peninsula Passerines [81]; Handbook of the Birds of the World and BirdLife International digital checklist of the birds of the world. Version 3[82]; eBird Clements-v2019 integrated checklist [83].

3.5 Data handling and analyses

3.5.1 Estimation of bird species density, detection probability, and encounter rate in different habitats

Data analysis was performed for estimation of bird species density, detection probability, and encounter rate in different habitats using Distance software version 7.3 Release 2[84]and "*DISTANCE*" package [85] in R version 4.0.2 [86]. Conventional Distance Sampling (CDS) models used for bird detectability and density in the study area [58, 71]. Since detectability of birds decreases with the distance from the observer[84], and presumably differs between species [87]and different habitat types[84], the observed numbers were recalculated based on estimated detectability.

Using the software DISTANCE[84], Conventional Distance Sampling (CDS) using global models and models for each study area were fitted by possible combinations of Uniform, Half-Normal ,Hazard-Rate ,and Negative exponential adjustment keys with Cosine, Simple Polynomial and Hermite Polynomial series expansions and no stratification of the global level of resolution of estimate for each habitat type using survey effort four and the size-bias regression method within program DISTANCE to account for, and estimate expected cluster size[88].

Quantile–quantile (Q–Q) plots were used for checking the model fit visually, and statistical evaluation of goodness-of-fit was performed by the Kolmogorov–Smirnov (K–S) test and Cramer–von Mises (C–vM) test. Akaike's Information Criteria (AIC) will be used for selecting between competing models or quantifying the degree of support for each model. AIC is evaluated for each model, and the model with the smallest AIC value is deemed best. For ease of comparison, ΔAIC values are will be used. These are formed by subtracting the AIC value corresponding to the best model (i.e. the one with the smallest AIC) from the AIC value of each model in turn. Thus, the best model has ΔAIC=0[71]. Models with an ΔAIC value of around two or less should be deemed to be well supported by the data, with decreasing support the larger ΔAIC becomes; models with values of ΔAIC above ten should be considered to be very implausible[89]. The best model selected with the lowest AIC and defined detectability of encounter rate, probability of density in the three habitat types in distance software. Cluster densities and individual bird densities were directly obtained using program DISTANCE for each estate as individual birds/hectare.

3.5.2 Bird Species richness, Diversity, Species similarity, and it's Related abundance to different habitats

A bird census was conducted using Shannon-Weiner diversity index (H′) for bird diversity of the study area[90, 91].It can be calculated as follow:

$$\mathbf{H'} = -\sum_{i=1}^{s} \left(\frac{\mathbf{ni}}{\mathbf{N}}\right) \times \mathbf{In}\left(\frac{\mathbf{ni}}{\mathbf{N}}\right)$$

Where H' = index of species diversity, ni is the number of individuals in a species, S is the total number of species, also denoted species richness, N is the total number of individuals.

Evenness index (J') was calculated by following the equation.

$$\mathbf{J'} = \frac{\mathbf{H'}}{\mathbf{InS}}$$

where: H = Shannon Weiner diversity index and S = Number of species

Richness index (D) was calculated by the following equation.

$$\mathbf{D} = \frac{\mathbf{S-1}}{\mathbf{InN}}$$

Where: D = Richness index, S = Total number of species, and N = Total number of individuals

Species composition similarity between different habitat types was defined using Sorenson's Coefficient, which uses quantitative data to estimate species richness (β) diversity. This index looks at the similarity of pairs of sites in term of species abundances [92]using the equation:

$$\mathbf{C_N = 2_{jN} / (aN + bN)}$$

Where *aN* indicates the number of individuals in site A, *bN* the number of individuals in site B, and *jN* the sum of the lower of the two abundances of species that occurs in the two sites. An index value of 1 indicates complete similarity while a value of 0 indicates complete dissimilarity with no species in common.

The presence of relative abundance was categorized for each habitat type as follow:
Relative abundance (%) = (n/N)×100
n= number of a particular species, N= total observations detected for all species

3.5.3 Influence of habitat types on the relative richness of forest-dependent guilds and relative abundance of avian feeding guilds

To determine the influence of habitat types on the relative richness of avian feeding guilds using nonparametric Kruskal-Wallis H test with at 95% confidence level for the difference in means and then compared influence of forest-dependent guilds among habitat types using pairwise comparisons with Kruskal-Wallis Post Host test(Independent Sample test). Based on ranked data, Kruskal–Wallis tests do not require the assumptions of homogeneity of variances within groups and normality of data points, assumptions that are difficult to meet in the case of community data. The relative abundance forest-dependent guilds conducted with one-way analysis of variance (ANOVA) and compared influence of avian feeding guilds with Tukey HSD Post Host tests among habitat types at 95% confidence level using IBM SPSS Statistics for Windows, Version 20.0.

Chapter 4 Result

4.1 Estimation of bird species density, detection probability, and encounter rate in different habitats

The Conventional Distance Sampling (CDS) approach with better fit and smaller ΔAIC (< 2) of Hazard-rate+Hermite polynomial model provided a better detectability for natural forest (p = 0.42) and thus a better CV (13%), resulting in density (D = 38.5 individuals/ hectare, SE = 4.98 ;Encounter rate: ER=5.86) than the Hazard-rate+Hermite polynomial model of plantation crop and shrubs (detectability: p = 0.19; CV = 8%; density: D = 28.05 individuals/ hectare , SE = 2.37;Encounter rate: ER=2.34) and the Half-normal+Cosine model of plantation (detectability: p = 0.24; CV = 30%; density: D = 26 individuals/ hectare , SE = 2.37 Encounter rate: ER=2.19)(Table 3).Diagnostic tests for the top CDS models using Q–Q plot showed no departure from model assumptions. K–S and C–vM test resulted in a better fit for three habitat (natural forest,K–S p = 0.09, C–vM Unif p = 0.30, Cos p = 0.30; plantation, K–S p = 0.04, C–vM Unif p = 0.15, Cos p = 0.15;plantation crop and shrubs, K–S p = 0.00, C–vM Unif p = 0.10, Cos p = 0.05).

Table 3. Results of the most plausible model selection process for models predicting sage estimation of bird species density, detection probability, and encounter rate in different habitats.

Habitat Type	Model	K	Δ AIC	AIC	EDR	D/ hectare	95% CI D LCL	95% CI D UCL	D CV	ER	GOF Chi-p	GOF K-S p	P
Natural Forest													
	HZ+HP	**5**	**0.00**	**3743.63**	**26.55**	**38.50**	**29.88**	**49.59**	**0.13**	**5.86**	**0.00**	**0.09**	**0.42**
	UN+SP	5	0.56	3744.19	27.42	36.22	25.58	51.31	0.18	5.86	0.00	0.10	0.45
	HN+SP	3	1.79	3745.41	26.10	39.74	33.78	46.75	0.08	5.86	0.00	0.13	0.41
	UN+C	5	3.56	3747.19	25.59	41.30	23.16	73.64	0.30	5.86	0.00	0.13	0.39
	NE+SP	5	4.20	3747.82	26.30	39.17	30.12	50.94	0.13	5.86	0.00	0.06	0.41
	HN+C	3	12.00	3755.62	26.96	37.41	23.34	59.94	0.24	5.86	0.00	0.09	0.43
	HZ+C	2	13.24	3756.86	28.44	33.88	30.09	38.16	0.06	5.86	0.00	0.01	0.48
	HZ+SP	2	13.24	3756.86	28.44	33.88	30.09	38.16	0.06	5.86	0.00	0.01	0.48
	NE+C	3	13.32	3756.94	25.11	42.79	29.94	61.15	0.18	5.86	0.00	0.06	0.38
	NE+HP	3	16.15	3759.78	23.14	49.77	44.09	56.19	0.06	5.86	0.00	0.00	0.32
	HN+HP	2	20.48	3764.10	24.98	43.10	32.31	57.49	0.15	5.86	0.00	0.01	0.37
Plantation													
	HN+C	**5**	**0.00**	**2899.31**	**22.64**	**26.00**	**14.55**	**46.46**	**0.30**	**2.34**	**0.00**	**0.04**	**0.24**
	HZ+C	3	3.04	2902.35	23.38	24.74	19.17	31.94	0.13	2.34	0.00	0.03	0.26
	HZ+SP	2	4.37	2903.68	26.16	20.21	17.62	23.18	0.07	2.34	0.00	0.00	0.32

HZ+HP	2	4.37	2903.68	26.16	20.21	17.62	23.18	0.07	2.34	0.00	0.00	0.32
UN+C	3	14.54	2913.85	23.69	23.66	18.30	30.58	0.13	2.34	0.00	0.00	0.27
HN+SP	3	24.31	2923.62	21.23	28.44	23.59	34.29	0.10	2.34	0.00	0.00	0.21
UN+SP	4	33.46	2932.77	22.75	24.98	21.27	29.35	0.08	2.34	0.00	0.00	0.24
HN+HP	2	35.44	2934.75	21.95	27.08	20.04	36.59	0.15	2.34	0.00	0.00	0.23
NE+SP	5	39.12	2938.43	19.19	33.36	19.92	55.89	0.27	2.34	0.00	0.00	0.17
NE+HP	3	40.82	2940.13	19.73	31.57	23.79	41.91	0.14	2.34	0.00	0.00	0.18
UN+HP	3	50.09	2949.40	23.83	22.82	19.09	27.28	0.09	2.34	0.00	0.00	0.27
NE+C	2	71.37	2970.68	18.35	35.46	27.01	46.56	0.14	2.34	0.00	0.00	0.16
Plantation Crop and Shrub												
HZ+HP	**4**	**0.00**	**2835.02**	**21.10**	**28.05**	**23.76**	**33.11**	**0.08**	**2.19**	**0.00**	**0.00**	**0.19**
NE+SP	4	3.23	2838.25	19.65	32.86	25.41	42.50	0.13	2.19	0.00	0.00	0.16
HZ+C	4	7.12	2842.14	22.33	24.63	17.35	34.97	0.18	2.19	0.00	0.00	0.21
UN+C	2	7.47	2842.49	20.20	30.88	26.75	35.65	0.07	2.19	0.00	0.00	0.17
NE+C	3	9.25	2844.27	19.72	32.56	24.44	43.38	0.15	2.19	0.00	0.00	0.16
HN+C	2	12.18	2847.20	21.66	26.31	19.67	35.19	0.15	2.19	0.00	0.00	0.20
HN+HP	2	14.57	2849.59	21.67	26.29	19.31	35.79	0.16	2.19	0.00	0.00	0.20
HZ+SP	2	15.35	2850.37	24.01	20.92	18.10	24.18	0.07	2.19	0.00	0.00	0.24
HN+SP	1	20.21	2855.23	18.82	35.87	30.70	41.90	0.08	2.19	0.00	0.00	0.15
NE+HP	3	36.26	2871.28	16.40	49.93	38.07	65.49	0.14	2.19	0.00	0.00	0.11
UN+HP	4	56.83	2891.85	23.57	22.43	19.20	26.20	0.08	2.19	0.00	0.00	0.23
UN+SP	2	122.12	2957.14	26.52	17.54	15.10	20.37	0.08	2.19	0.00	0.00	0.29

K the number of model parameters, ΔAIC Delta Akaike Information Criteria, EDR the effective detection radius, D/hectare the density estimate, D-CV the coefficient of variation of density, DLCL 95% lower confidence limit of density, DUCL 95% upper confidence limit of density, ER Encounter rate (hectare), GOF Chi-p Goodness-of-fit chi square test,K-S p Kolmogorov–Smirnov test p-value, P the probability of detection, UN Uniform, HN Half-normal,HZ Hazard-rate,NE Negative exponential key detection function, C Cosine, SP Simple polynomial, HP Hermite polynomial series expansion.

The highest abundance of detectability of Black Bulbul(*Hypsipetes leucocephalus concolor*) was detected (detectability: p = 0.48; CV =19.28%; density: D = 10.49 individuals/ hectare ; SE = 2.02)in natural forest, Japanese Tit(*Parus minor nubicolus*) (detectability: p = 0.65; CV = 17.22%; density: D = 3.42 individuals/ hectare ; SE = 0.59) in plantation, and Red-vented Bulbul(*Pycnonotus cafer stanfordi*) was also captured (detectability: p = 0.17; CV = 14.97%; density: D = 4.85 individuals/ hectare ; SE = 0.72) in plantation crop and shrubs.

4.2 Bird Species richness, Diversity, Species similarity, and its related abundance to different habitats

During the present study, a total of 2323 individual birds belonging to 159 species were captured throughout the study area. The highest number of bird species (96) was recorded in the natural forest, followed by plantation crop and shrub (80) and plantation (76). The analysis of data on residential status revealed that out of 159species 133 were residents. The remaining 26 species were winter visitors. Of these, one species of endangered (EN), near threatened (NT), and vulnerable (VU) was recorded and other 155 species were least concern (LC) (Appendix). The natural forest revealed the highest values of species diversity (H′= 3.862) and species richness (D′ = 14. 164) than plantation and plantation crop and shrubs habitats. Evenness index showed slight variation was found between plantation and plantation crop and shrubs habitats, indicating that these two sites have less even distribution as compared with natural forest with the plantation, and natural forest with plantation crop and shrubs habitats (Table 4).

Table 4. Overall diversity, evenness, and species richness indexes birds in different habitats.

Habitat Type	Number of Species	Abundance of birds	Diversity index	Species richness index	Evenness index
Natural Forest	96	818	3.862	14.164	0.846
Plantation	76	796	3.305	11.228	0.773
Plantation Crop and Shrubs	80	709	3.357	12.035	0.766

Table 5. Calculation of Sorenson Coefficient for the complete number of species similarity between habitats.

Habitat Type	Plantation	Plantation Crop and Shrubs
Natural Forest	0.384	0.375
Plantation		0.679

Note: An index value of 1 indicates complete similarity while a value of 0 indicates complete dissimilarity with no species in common.

There are 54 species of natural forest,15 species of the plantation, and 20 species of plantation crop and shrubs that were unique respectively. The computing of the Sorenson Index, the plantation and plantation crop and shrubs found the most similar, and then natural forest habitat had the fewer species similarity to other habitats in the study area (Table 5). A total abundance of 818 birds was recorded from natural forest habitat, 796 and 709 birds from plantation and plantation crop and shrubs habitats respectively. The highest bird abundance was recorded in natural forest, while the lowest was in plantation crop and shrubs. The highest relative abundance found 17.63% of Red-vented Bulbul in plantation crop and shrubs, 10.26% of Black Bulbul in natural forest at 10%, and 14.7% of Japanese Tit in plantation respectively (Appendix).

4.3 Influence of Habitat Types on the relative richness of Forest-dependent guilds and the relative abundance of Avian Feeding guilds

4.3.1 Influence of habitat types on the relative richness of Forest-dependent guilds

A large proportion of birds recorded in this study were forest-dependent species including 84 forest specialists, 39 forest generalists, and 36 forest visitor species. Furthermore, the composition of forest depended guilds captured 72 forest specialists,20 forest generalists and 4 forest visitors from natural forest, 31 forest specialists,22 forest generalists and 23 forest visitors from plantation, and 24 forest specialists,27 forest generalists, and 29 of forest visitors from plantation crop and shrubs (Appendix).

The natural forest indicated the highest species richness followed by plantation and plantation crop and shrubs respectively. The three habitat types found significant differences in species richness of forest-dependent guilds using the nonparametric test Kruskal-Wallis H Test with at 95% confidence level, the results showed Kruskal–Wallis:x^2=7.852, df=2, p<0.020. The computing of pairwise comparisons, the relative species richness of forest-dependent guilds was significantly different among natural forest and plantation habitat(p<0.014) and natural forest and plantation crop and shrubs habitat(p<0.017).

The species richness of forest specialist species was high in natural forest while plantation crop and shrubs habitat had a higher richness forest generalists and forest visitors of dependent guilds (Figure 2). The three habitat types showed significantly different relative species richness of various forest-dependent guilds using nonparametric test Kruskal-Wallis H Test with at 95% confidence level. The results presented that forest specialist species Kruskal–Wallis:x^2=47.055, df=2, p<0.000; forest generalist species x^2=14.527, df=2, p<0.001, and forest visitor species x^2=11.720, df=2, p<0.003 respectively.

Significant differences were further analyzed using pairwise comparisons using Kruskal-Wallis Post Host tests at 95% confidence level, the analysis showed significant differences in relative richness of avian forest dependence guilds among the three habitat types. Pairwise comparisons results showed that relative species richness of forest-dependent guild was most significantly different whereas there was no significant difference among plantation and plantation crop and shrubs (Table 6).

Table 6. Pairwise comparisons using Kruskal-Wallis Post Host test significant results.

Dependent Variable	Habitat Type	Habitat Type	P-value
Forest Specialist	Plantation crop and shrubs	Natural Forest	0.000
	Plantation	Natural Forest	0.000
	Plantation crop and shrubs	Plantation	0.059
Forest Generalist	Natural Forest	Plantation	0.000
	Natural Forest	Plantation crop and shrubs	0.000
	Plantation	Plantation crop and shrubs	0.294
Forest Visitor	Natural Forest	Plantation	0.003
	Natural Forest	Plantation crop and shrubs	0.001
	Plantation	Plantation crop and shrubs	0.414

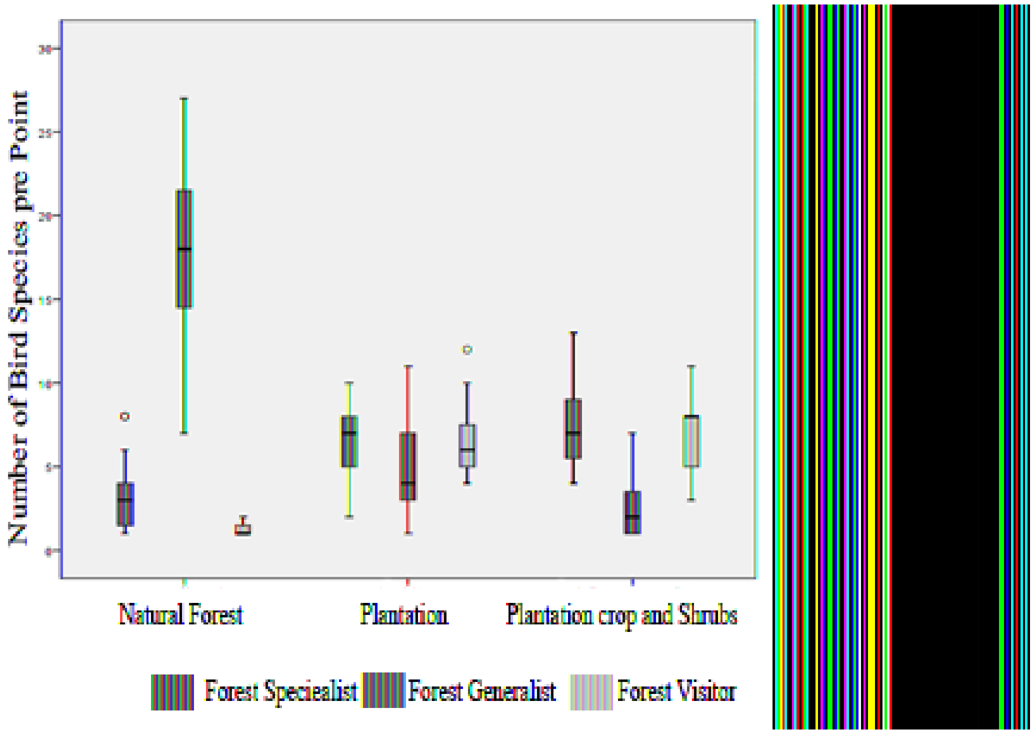

Figure 2. Influence of habitat type on bird species richness of forest-dependent guilds.

4.3.2 Influence of habitat types on the relative abundance of Avian Feeding guilds

There were no significant differences in the relative species richness of Avian Feeding guilds among the habitat types. However, the plantation belonged to the highest abundance of insectivores whereas nectarivores and frugivores were missing and natural forest also found high insectivores, nectarivores, and omnivores (Figure 3).

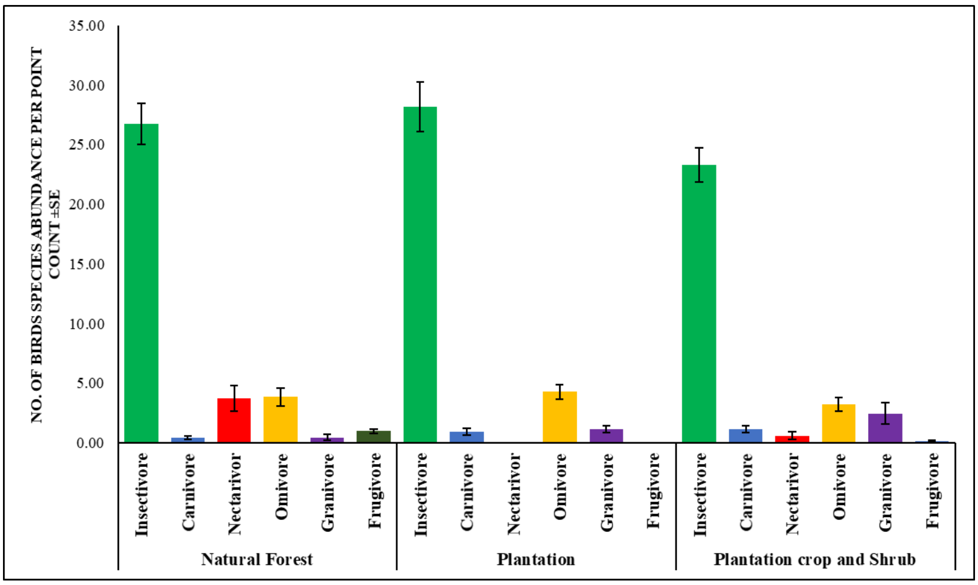

Figure 3. Influence of habitat type on bird species abundance of avian feeding guilds.

There were significant differences in relative abundance of nectarivores (F 2,66=9.333, p<0.000), granivores (F 2,66=3.149, p<0.047), and frugivores (F 2,66=17.332, p<0.000) between the three habitat types at 95% CIs(0.58,2.26),(0.66,2.01),and (0.19,0.54) respectively. The remaining feeding guilds were not significant differences among different habitat types in the relative abundance of insectivores(F 2,66=1.987 p<0.145), omnivores(F 2,66=2.610 p<0.081), and carnivores(F 2,66=0.642, p<0.530) between the three habitat types at 95% CIs(24.0,28.15),(0.53,1.09),and (3.02,4.52) respectively.

Significant differences were further analyzed with pairwise comparisons using Tukey HSD Post Host tests at 95% confidence level, the analysis showed significant differences in the relative abundance of nectarivores (among natural forest and plantation; plantation crop and shrubs and plantation), granivores (among natural forest and plantation; plantation crop and shrubs and plantation). Frugivores indicated higher significant differences among the habitat types (Table 7).

Table 7. Multiple comparisons using Tukey HSD Post Host tests significant results.

Dependent Variable	Habitat Type	Habitat Type	P-value
Nectarivores	Natural Forest	Plantation	0.000
	Natural Forest	Plantation crop and shrubs	0.003
	Plantation crop and shrubs	Plantation	0.813
Granivores	Natural Forest	Plantation	0.664
	Natural Forest	Plantation crop and shrubs	0.040
	Plantation	Plantation crop and shrubs	0.243
Frugivores	Plantation	Plantation crop and shrubs	0.493
	Plantation	Natural Forest	0.000
	Plantation crop and shrubs	Natural Forest	0.000

Chapter 5 Discussion

The results provide updated density estimates for the bird species distributed in the Kalaw and Ye-E Reserve forests around Kalaw town. Previously, there was no recorded data on the long-term sustainability of the forest bird populations and probability of detectability in this study area. This study results showed that natural forest habitat had a higher bird species probability of detectability, density, and encounter rate than another habitat. A recent study[94] concluded that strong differences in bird species of abundance and community composition were found when comparing mature, undisturbed forests to disturbance areas. Other study showed that species richness and density of forest-dependent taxa generally declined in disturbed than mature forests in the South East Asia region[32]. Many studies showed that forest areas are closely related to not only bird distribution and abundance but also between forest composition and bird diversity [31, 43, 95]. Forest composition and structure such as the relationship between plant diversity, density, and bird species can more precisely forecast the richness and distribution of bird species[96].

Our results have demonstrated that bird species richness and abundance were higher in the natural forest habitat than in the other habitats and lowest in plantation crop and shrubs habitat. The effects of anthropogenic habitat disturbance altered bird species richness and abundance[44], and global analysis of [51] revealed that plantations (i.e. monoculture of plantation and plantation crop) showed negative effects on both bird species richness, abundance, and diversity. The alarming result indicated from this study is the poor species richness and diversity detected in plantation and plantation crops and shrubs. It is important, the study [97] found that the human-modified land uses such as plantation and plantation crop significantly reduced bird species richness and diversity than natural forest.

It is clear from this study results that the number of species similarity have most similar in plantation and plantation crop and shrubs habitats. Plantation crops may be higher in bird species than open habitats whereas the species similarity with forests is often very low[32, 98, 99]. This may due to bird species similarity of plantation and plantation crop and shrubs habitat differed from natural forest habitat, although this has contributed to increasing the species richness within the habitat types through sheltering bird species that dwell in plantation and plantation crop and shrubs habitats. The suggestion of [46] stated that the establishment of native species plantations among the area of native forest remnants had a positive effect on the conservation of threatened avifauna, especially in deforestation areas. The strong influence of forest understory features (species diversity, cover, and height) was increased both bird species richness and bird abundance which has to be considered when managing forests[100]. Based on national forest inventory and bird data, the results [101] pointed that natural forest was supported to protect forest birds therefore Protected areas also indicated higher diversity and richness of forest birds which highlight their importance as suitable target areas for the protection of forest birds.

This study results also revealed that areas at three habitats have a species richness of forest-dependent guilds and a higher proportion of forest specialist's species was captured, mostly in natural forest, in all habitats (Appendix). Together results showed that forest generalists were more preferred in shade coffee plantations, and forest specialists had higher capture rates in primary forest[102].The effect of landuse change found that forest specialists were more affected by habitat alteration in comparison to forest visitors and forest generalists[32]. Furthermore, the structure and composition of the bird assemblage of the tree plantations with open vegetation structures and the natural habitats which composed a high shrub density and high proportions of native tree cover were significantly different in abundance and guild structures. In this cause, plantation increases the presence of generalist bird species[47], and some forest plantations, in different ecoregions, serve a poor subset of the native avifauna assemblage and generalist species more found than in natural forests [103, 104].

Forest specialists avoid and sensitive to human-modified habitat types whereas the presence of forest specialist species such as Yellow-browed Warbler, Grey-headed Canary-flycatcher, Ashy Drongo, Black-breasted Thrush, Buff-throated Warbler, Spectacled Barwing (Eastern), Taiga Flycatcher, Dusky Warbler, Olive-backed Pipit, Red-vented Bulbul, and Oriental Turtle-dove, which were common in all habitat types in this study. A study [105]in Indonesia showed that plantation crops were found by 30 % of forest specialist species. Forest generalist and forest visitor most preferred in plantation and plantation crop and shrubs habitats being suitable for only a small number of forest visitor species in natural forest habitat. Therefore, the forest-dependent bird guilds were pointed to be used as an indicator for predicting species sensitivity to habitat type.

Pine-dwelling forest dependent bird species were identified for plantation such as Japanese Tit (*Parus minor nubicolus*), Chestnut-vented Nuthatch (*Sitta nagaensis nagaensis*), Black-headed Greenfinch (*Chloris ambigua ambigua*), and Slender-billed Oriole (*Oriolus tenuirostris tenuirostris*). A study [106] showed that pine-dwelling forest bird species less in planted pine forests than natural pine forests, and the regional bird species richness depends on among pine species, either natural or planted. The study area of mosaic in plantation crop and shrubs area with a dense nonwoody plant cover harbored bird species that all have a preferred foraging height of 2 meters, were common in herbaceous strata such as Rusty-cheeked Scimitar-babbler (*Megapomatorhinus erythrogenys celatus*), White-browed Scimitar-babbler (*Pomatorhinus schisticeps nuchalis*), Chestnut-capped Babbler (*Timalia pileata smithi*),and Scarlet-faced Liocichla (*Liocichla ripponi ripponi*).

In the 1920s, the total designated forest area was approximately '20 square miles' (52 km²) whereas it has declined by 85% over the past 90 years[14], to its current area of 7.9 km² in Kalaw and Ye-E Reserve forests[65]. The reason behind this strong impact on avifauna is to be found in high human pressure. The present study in Reserve forest areas found 159 bird species for all habitat types including historical and provisional records around the Kalaw region, which represented 53% of the 302 species listed in Kalaw and Ye-E Reserve forests. Previous recordings from 1895 to 2008 were annual and seasonal[14], but our study found more bird species over a shorter period in the study area. This is especially concerning as these regions support considerable numbers of forest-dependent bird species, including forest specialists that are entirely reliant on the forest for their survival and the primary forest is necessary to retain many forest specialists[16].In this study, forest specialist species of Burmese Yuhina(*Yuhina humilis clarki*) was refuged only in the natural forest habitat and Dark-backed Sibia(*Heterophasia melanoleuca castanoptera)* was also recorded in the plantation as key bird species in this region which were only found in eastern Myanmar.

The relative species richness and abundance of insectivorous were not statistically significantly different among habitat types and the total record number of insectivore's results showed that plantation had a slight abundance than natural forest whereas less in plantation crop and shrubs. Insectivorous birds have been documented globally as one of the dietary guilds most were most sensitive to habitat degradation and fragmentation[107, 108]. The global finding [109] pointed that there was no difference in the relative abundance of all insectivores between primary forest and shade coffee farm habitats. The estimation of the global annual prey consumption of insectivorous birds was more than 300 million tons per year in the forests, whereas birds in other biomes are less significant contributors more than 100 million tons per year which showed the ecological and economic importance of insectivorous birds in suppressing potentially harmful insect pests in forested areas[110].Insectivore abundances were highly associated with both forest structure and larger forest stands in the undisturbed area and have significant support for ecosystem services for forest[111] because of controlling insect populations, reduced pest outbreaks for tree damage [108, 110] and invertebrate populations and limiting foliage damage in tropical forests and plantation [112].

In this study, seed dispersal of frugivores was found higher in the natural forest whereas nectarivores and frugivores were missing in the plantation. In these senses, greater species abundance of shade trees and forest structure were associated with higher species abundance of insectivores and nectarivores in natural forest and plantation crop and shrubs whereas herbaceous vegetation did not have a strong impact on the avifauna in plantation habitat. Monocultures of pine plantations were unattractive to many seed-dispersing of frugivorous birds because they lack the suitable food resources [113]. The native birds which most suffer from the shifting native forests with pine plantations are frugivores, nectar-feeders, and hole-nest[114]. The genetic linkers of pollinating nectarivores convey genetic material from one plant to another or to a habitat that is suitable for regeneration[7]. A study [115] in NewZealand found that functional extinction of the pollinator birds limited pollination of the shrub, reducing seed production by 84% and reducing the number of juvenile plants produced per adult by 55%. The effects of habitat fragmentation changed both within and between feeding guilds[116] and reduction of seed dispersal in frugivores and pollinator in nectarivores for maintaining plant biodiversity may have a main ecological consequence[117, 118].

Seed dispersal of frugivores Oriental Pied-Hornbill (*Anthracoceros albirostris albirostris*), Yellow-footed Green-pigeon (*Treron phoenicopterus viridifrons)*, Blue-throated Barbet (*Psilopogon asiaticus davisoni*) and Blue-eared Barbet (*Psilopogon duvaucelii cyanotis*) were only registered in natural forest. Coppersmith Barbet (*Psilopogon haemacephalus indicus*) is also found in plantation crop and shrubs. Corlett [119] updated that fruit consumption barbets (Megalaimidae), and some pigeons (Columbidae)species of *Treron* appear to be 100% frugivorous were considered to provide important seed dispersal services in tropical Asia. Comparison of species richness of large frugivorous and insectivorous birds often declines common in the natural forest than in the agroforests and bird guilds of nectarivores, insectivores, omnivores, and sometimes granivores and small frugivores more prefer in the natural forest[26].This study found that the granivores were a higher abundance in plantation crop and shrubs than in other habitats. Sekercioglu et al [102] found that the population of granivorous birds increased in the coffee sites of plantation crops and this guild showed weak negative effects of canopy cover and forest proportion and then tend to be less affected by forest disturbance[99].

Chapter 6 Conclusions and Management Implications

In conclusion, the findings obtained from this study indicated that plantations and plantation crop and shrubs have a limited potential to support forest bird species. Furthermore, the conversion of natural forests to plantation crops and plantation forests leads to a substantial decline in forest birds and especially of the specialized feeding guilds such as insectivores and frugivores. This study suggests that the Reserve Forest areas are large to maintain their full, historic complement of bird species. If anthropogenic disturbances enhanced in this region-wide, eliminating other forest refugia would be unable to maintain the historical avian diversity of the region or to provide source populations for restored forest habitats for many of its present bird species.

The government of Myanmar has a policy target of including 10% of the country's geographical area in its Protected Area network system by 2030 [40]. The area of Kalaw and Ye-E Reserve Forests are not currently located Important Bird Areas in Myanmar [14], relying on the existing reserve forest is not sufficient, and urgently has to upgrade as a protected area under the Myanmar Protection of Biodiversity and Protected Area Law (2018). Greater protection for human encroachment, construction buildings, illegal logging, extractive forest product, and agricultural land expansion to Reserve Forest areas have to manage under Myanmar Forest Law (2018) by the Myanmar Forest Department. Protected areas of primary forest more than 1000 ha were vital for the long-term persistence of all forest-dependent bird species[102] and further efforts are required to halt ongoing and cumulative loss of the remaining natural forest habitat.

Forest Department of Myanmar introduced a very specific plan of 10-year Myanmar Reforestation and Rehabilitation Program (MRRP) from 2017-2018 to 2026-2027 with the establishment of new forest plantations on degraded forests and the restoration of heavily depleted forests through reforestation, enrichment planting, and natural regeneration through silvicultural operations at countrywide[8]. The establishment of mixed-species plantations has no significant effects on bird species of richness and abundance, contrary to what is found at monocultures [44] and human-modified land uses with a complex vegetation structure would potentially sustain high avifaunal diversity[97]. Thus, forest plantations should be established using methods to boost bird diversity by managing with regeneration of a more complex vegetation structure that provides food and shelter resources, benefiting not only generalist bird species but also those more specialized to forest habitats. The traditional shade plantation crops that maintain original canopy species or plant mixed canopies should be encouraged and some natural recruitment allowed for bird diversity[120]. Therefore, plantation crop plantings should be diverse and include native fruiting and flowering plants that produce large fruit crops for long periods.

This study provides important yet preliminary insights into factors that influence different habitat types on bird detectability, diversity, and forest bird community composition in Reserve Forests. This sets the background for further analyses of bird-habitat relationships at multiple spatial scales, particularly of species that are of ecological and conservation importance. Opportunities for future research include comparisons of multiple land uses with protected reserve forests, as well as examining spatial dynamics over time. This requires establishing long-term monitoring studies of bird communities in the region.

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APPENDIX

Bird species observed in Kalaw and Ye-E Reserve Forests around Kalaw Town, with respect to global IUCN Red List Category, seasonal status, Forest-dependent guilds, Avian feeding guilds, and relative abundance (%).

Resident status: R= resident, W=winter visitor, En = Endangered = Least Concern, NT = Near Threatened, VU = Vulnerable, FF = forest specialist, F =forest generalist, f = forest visitor, OMN=Omnivore, CAR=Carnivore, FRU=Frugivore, INS=Insectivore, NEC= Nectarivore, GRA=Granivore,NF=natural forest, P =plantation, PS=plantation crop and shrubs

Common name	Species	Family	Global IUCN Red List Category	Seasonal	Forest Depandent Guilds	Feeding Guilds	Relative Abundance (%)		
							NF	P	PS
Red Junglefowl	*Gallus gallus spadiceus*	Phasianidae	LC	R	F	OMN			0.14
Crested Goshawk	*Accipiter trivirgatus indicus*	Accipitridae	LC	R	FF	CAR	0.12		
Shikra	*Accipiter badius poliopsis*	Accipitridae	LC	R	f	CAR		0.13	
Himalayan Buzzard	*Buteo burmanicus*	Accipitridae	LC	W	f	CAR	0.50		0.28
Steppe Eagle	*Aquila nipalensis nipalensis*	Accipitridae	EN	W	f	CAR			0.14
Crested Serpent-Eagle (Crested)	*Spilornis cheela burmanicus*	Accipitridae	LC	R	FF	CAR	0.12		
Oriental Turtle dove	*Streptopelia orientalis agricola*	Columbidae	LC	R	f	OMN	0.12	0.25	0.28
Spotted Dove	*Streptopelia chinensis tigrina*	Columbidae	LC	R	f	OMN		0.38	1.13
Grey-capped Emerald Dove	*Chalcophaps indica indica*	Columbidae	LC	R	FF	GRA	0.86		
Yellow-footed Green-pigeon	*Treron phoenicopterus viridifrons*	Columbidae	LC	R	FF	FRU	0.12		
Grey-headed Parakeet	*Psittacula finschii*	Psittacidae	NT	R	FF	OMN		0.50	
Banded Bay Cuckoo	*Cacomantis sonneratii sonneratii*	Cuculidae	LC	R	FF	OMN		0.25	
Plaintive Cuckoo	*Cacomantis merulinus querulus*	Cuculidae	LC	R	f	INS			0.14
Red-headed Trogon	*Harpactes erythrocephalus erythrocephalus*	Trogonidae	LC	R	FF	INS	0.49		
White-throated Kingfisher	*Halcyon smyrnensis perpulchra*	Alcedinidae	LC	R	f	CAR		0.13	
Blue-bearded Bee-eater	*Nyctyornis athertoni athertoni*	Meropidae	LC	R	FF	INS	0.37		
Common Hoopoe	*Upupa epops longirostris*	Upupidae	LC	R	f	OMN			0.14

Oriental Pied-Hornbill	*Anthracoceros albirostris albirostris*	Bucerotidae	LC	R	f	OMN	0.12		
Great Barbet	*Psilopogon virens virens*	Megalaimidae	LC	R	FF	FRU	0.24		0.28
Blue-throated Barbet	*Psilopogon asiaticus davisoni*	Megalaimidae	LC	R	FF	FRU	1.10		
Blue-eared Barbet	*Psilopogon duvaucelii cyanotis*	Megalaimidae	LC	R	FF	FRU	1.22		
Coppersmith Barbet	*Psilopogon haemacephalus indicus*	Megalaimidae	LC	R	f	FRU			0.14
Eurasian Wryneck	*Jynx torquilla chinesis*	Picidae	LC	W	f	INS		0.38	0.14
Speckled Piculet	*Picumnus innominatus malayorum*	Picidae	LC	R	FF	INS	0.61		
Grey-capped Woodpecker	*Picoides canicapillus*	Picidae	LC	R	FF	INS	0.12	0.50	
Great Spotted Woodpecker	*Dendrocopos major cabanisi*	Picidae	LC	R	FF	INS		0.25	0.42
Lesser Yellownape	*Picus chlorolophus chlorolophus*	Picidae	LC	R	FF	INS			0.14
Grey-Headed Woodpecker	*Picus canus sordidior*	Picidae	LC	R	FF	INS	0.49	0.13	0.14
Rufous Woodpecker	*Micropternus brachyurus phaioceps*	Picidae	LC	R	FF	INS	0.12		
Greater Flameback	*Chrysocolaptes guttacristatus guttacristatus*	Picidae	LC	R	F	INS	0.24		
Bay Woodpecker	*Blythipicus pyrrhotis pyrrhotis*	Picidae	LC	R	FF	INS	0.49		
Long-tailed Broadbill	*Psarisomus dalhousiae dalhousiae*	Eurylaimidae	LC	R	FF	INS	0.37		
Silver-breasted Broadbill	*Serilophus lunatus elisabethae*	Eurylaimidae	LC	R	FF	INS	0.37		
White-bellied Erpornis	*Erpornis zantholeuca zantholeuca*	Vireonidae	LC	R	FF	INS	0.12		
Large Cuckooshrike (Large)	*Coracina macei rexpineti*	Campephagidae	LC	R	FF	INS		0.25	
Black-winged Cuckooshrike	*Lalage melaschistos avensis*	Campephagidae	LC	R	FF	INS	0.12		
Small Minivet	*Pericrocotus cinnamomeus thai*	Campephagidae	LC	R	f	INS		1.26	
Grey-chinned Minivet	*Pericrocotus solaris rubrolimbatus*	Campephagidae	LC	R	FF	INS	0.12	2.01	0.42
Short-billed Minivet	*Pericrocotus brevirostris neglectus*	Campephagidae	LC	R	FF	INS		0.25	

Long-tailed Minivet	*Pericrocotus ethologus ripponi*	Campephagidae	LC	R	FF	INS	0.12	0.25	0.56
Scarlet Minivet	*Pericrocotus speciosus semiruber*	Campephagidae	LC	R	FF	INS	1.59	1.76	1.97
Slender-billed Oriole	*Oriolus tenuirostris tenuirostris*	Oriolidae	LC	R	FF	INS		1.63	0.14
Black-hooded Oriole	*Oriolus xanthornus xanthornus*	Oriolidae	LC	R	FF	INS		0.13	
Maroon Oriole	*Oriolus traillii traillii*	Oriolidae	LC	R	FF	INS	2.81	0.13	
Common Woodshrike	*Tephrodornis pondicerianus pondicerianus*	Vangidae	LC	R	FF	INS	0.24	1.01	
Bar-winged Flycatcher-shrike	*Hemipus picatus capitalis*	Vangidae	LC	R	FF	INS	0.24		
Common Iora	*Aegithina tiphia philipi*	Aegithinidae	LC	R	f	INS		0.75	0.42
White-throated Fantail	*Rhipidura albicollis celsa*	Rhipiduridae	LC	R	FF	INS	1.47	0.38	0.28
Ashy Drongo	*Dicrurus leucophaeus*	Dicruridae	LC	R	F	INS	1.59	4.27	1.83
Crow-billed Drongo	*Dicrurus annectens*	Dicruridae	LC	R	FF	INS	0.12		
Bronzed Drongo	*Dicrurus aeneus aeneus*	Dicruridae	LC	R	FF	INS	2.69	1.01	0.85
Lesser Racquet-tailed Drongo	*Dicrurus remifer tectirostris*	Dicruridae	LC	R	FF	INS	0.37		
Black-naped Monarch	*Hypothymis azurea styani*	Monarchidae	LC	R	FF	INS	0.49	0.13	0.14
Eastern Jungle Crow	*Corvus macrorhynchos levaillantii*	Corvidae	LC	R	f	CAR		0.50	0.28
Eurasian Jay (White-faced)	*Garrulus glandarius leucotis*	Corvidae	LC	R	F	CAR		0.63	1.27
Common Green Magpie	*Cissa chinensis chinensis*	Corvidae	LC	R	FF	CAR	0.24		
Red-billed Blue Magpie	*Urocissa erythroryncha alticola*	Corvidae	LC	R	F	CAR		0.38	0.42
Grey Treepie	*Dendrocitta formosae himalayana*	Corvidae	LC	R	FF	CAR	0.37		0.14
Long-tailed Shrike	*Lanius schach tricolor*	Laniidae	LC	R	f	CAR		0.25	0.99
Grey-backed Shrike	*Lanius tephronotus tephronotus*	Laniidae	LC	R	f	CAR		0.13	0.14
Black-throated Sunbird	*Aethopyga saturata sanguinipectus*	Nectariniidae	LC	R	FF	NEC	5.38		
Streaked Spiderhunter	*Arachnothera magna musarum*	Nectariniidae	LC	R	FF	OMN	0.49		0.42

Yellow-vented Flowerpecker	*Dicaeum chrysorrheum chrysochlore*	Dicaeidae	LC	R	F	NEC	0.24		
Scarlet-backed Flowerpecker	*Dicaeum cruentatum cruentatum*	Dicaeidae	LC	R	f	NEC	0.12		
Plain Flowerpecker	*Dicaeum minullum olivaceum*	Dicaeidae	LC	R	F	NEC	0.49		
Orange-bellied Leafbird	*Chloropsis hardwickii hardwickii*	Chloropseidae	LC	R	FF	OMN	2.08		
White-rumped Munia	*Lonchura striata acuticauda*	Estrildidae	LC	R	f	GRA			1.41
Scaly-breasted Munia	*Lonchura punctulata yunnanensis*	Estrildidae	LC	R	f	GRA		0.75	0.28
Russet Sparrow	*Passer cinnamomeus rutilans*	Passeridae	LC	R	f	OMN		0.38	
Olive-backed Pipit	*Anthus hodgsoni yunnanensis*	Motacillidae	LC	W	F	GRA	0.37	2.51	6.35
White Wagtail	*Motacilla alba alboides*	Motacillidae	LC	W	f	OMN			0.14
Grey Wagtail	*Motacilla cinerea cinerea*	Motacillidae	LC	W	F	OMN	0.14		
Black-headed Greenfinch	*Chloris ambigua ambigua*	Fringillidae	LC	R	f	OMN		8.42	1.83
Little Bunting	*Emberiza pusilla*	Emberizidae	LC	W	f	OMN			0.14
Chestnut Bunting	*Emberiza rutila*	Emberizidae	LC	W	f	OMN		0.25	
Velvet-fronted Nuthatch	*Sitta frontalis frontalis*	Sittidae	LC	R	FF	INS	0.73	0.50	
Chestnut-vented Nuthatch	*Sitta nagaensis nagaensis*	Sittidae	LC	R	FF	INS		4.15	
Black-collared Starling	*Gracupica nigricollis*	Sturnidae	LC	R	f	OMN			1.41
Chestnut-tailed Starling	*Sturnia malabarica nemoricola*	Sturnidae	LC	R	F	OMN		0.38	
Orange-headed Thrush	*Geokichla citrina innotata*	Turdidae	LC	R	F	OMN	0.12		
Black-breasted Thrush	*Turdus dissimilis*	Turdidae	LC	R	F	OMN	0.61	0.25	0.42
Grey-sided Thrush	*Turdus feae*	Turdidae	UV	W	FF	OMN	0.12		
Eyebrowed Thrush	*Turdus obscurus*	Turdidae	LC	W	F	OMN		0.12	
Lesser Shortwing	*Brachypteryx leucophriscarolinae*	Muscicapidae	LC	R	FF	INS	0.12		
Siberian Rubythroat	*Calliope calliope*	Muscicapidae	LC	W	F	INS		0.75	0.71
White-tailed blue Robin	*Myiomela leucura leucura*	Muscicapidae	LC	R	FF	INS	0.49		
Daurian Redstart	*Phoenicurus auroreusleucopterus*	Muscicapidae	LC	W	F	INS		0.38	0.85
Chestnut-bellied Rock-thrush	*Monticola rufiventris*	Muscicapidae	LC	R	FF	INS		0.25	

Grey Bushchat	*Saxicola ferreus harringtoni*	Muscicapidae	LC	R	f	INS		2.14	2.82
Siberian Stonechat (Stejneger's)	*Saxicola maurus stejnegeri*	Muscicapidae	NR	R	f	INS			0.28
Pied Bushchat	*Saxicola caprata burmanicus*	Muscicapidae	LC	R	f	INS		0.25	1.55
Blue Whistling-Thrush	*Myophomus caeruleus temminckri*	Muscicapidae	LC	W	FF	INS			0.14
Hill Blue Flycatcher	*Cyornis banyumas whitei*	Muscicapidae	LC	R	F	INS	1.22		
Tickell's Blue Flycatcher	*Cyornis tickelliae tickelliae*	Muscicapidae	LC	R	FF	INS	0.37	0.13	
Blue-throated flycatcher	*Cyornis rubeculoides rubeculoides*	Muscicapidae	LC	R	FF	INS	0.24		
Pale-chinned Flycatcher	*Cyornis poliogenys poliogenys*	Muscicapidae	LC	W	FF	INS	0.12		
Vivid Niltava (Large)	*Niltava vivida oatesi*	Muscicapidae	LC	R	FF	INS	0.12		
White-gorgeted Flycatcher	*Anthipes monileger leucops*	Muscicapidae	LC	R	FF	INS	0.49		
Little Pied Flycatcher	*Ficedula westermanni australorientis*	Muscicapidae	LC	R	FF	INS	0.12	0.13	
Taiga Flycatcher	*Ficedula albicilla*	Muscicapidae	LC	W	F	INS	0.12	1.51	4.09
Sapphire Flycatcher	*Ficedula sapphira laotiana*	Muscicapidae	LC	R	FF	INS	0.24		
Oriental Magpie-Robin	*Copsychus saularis erimelas*	Muscicapidae	LC	R	f	INS			1.69
Dark-sided Flycatcher	*Muscicapa sibirica cacabata*	Muscicapidae	LC	R	F	INS		0.13	
Japanese Tit	*Parus minor nubicolus*	Paridae	LC	R	f	INS		14.70	6.35
Yellow-cheeked Tit	*Machlolophus spilonotus subviridis*	Paridae	LC	R	FF	INS	0.24		
Grey-headed Canary-flycatcher	*Culicicapa ceylonensis calochrysea*	Stenostiridae	LC	R	F	INS	3.30	0.75	0.28
Black-crested Bulbul	*Pycnonotus flaviventris vantynei*	Pycnonotidae	LC	R	FF	OMN	3.06	0.25	0.14
Flavescent Bulbul	*Pycnonotus flavescens vividus*	Pycnonotidae	LC	R	FF	OMN	0.73	0.75	1.69
Red-whiskered Bulbul	*Pycnonotus jocosus pattani*	Pycnonotidae	LC	R	f	INS	0.75		0.56
Brown-breasted Bulbul	*Pycnonotus xanthorrhous xanthorrhous*	Pycnonotidae	LC	R	F	INS	0.25		
Red-vented Bulbul	*Pycnonotus cafer stanfordi*	Pycnonotidae	LC	R	f	INS	0.61	6.03	17.63

Ashy Bulbul	*Hemixos flavala flavala*	Pycnonotidae	LC	R	FF	INS	3.79		
Mountain Bulbul	*Ixos mcclellandii tickelli*	Pycnonotidae	LC	R	FF	INS	7.95		
Black Bulbul	*Hypsipetes leucocephalus concolor*	Pycnonotidae	LC	R	FF	INS	10.27	1.51	0.42
Barn Swallow	*Hirundo rustica tytleri*	Hirundinidae	LC	R	f	INS		0.13	0.28
Wire-tailed Swallow	*Hirundo smithii filifera*	Hirundinidae	LC	R	f	INS			0.28
Black-throated Tit	*Aegithalos concinnus pulchellus*	Aegithalidae	LC	R	FF	INS	1.96		-
Martens's Warbler	*Phylloscopus omeiensis*	Phylloscopidae	LC	W	FF	INS	1.47		0.14
Grey-crowned Warbler	*Phylloscopus tephrocephalus*	Phylloscopidae	LC	R	FF	INS	0.86	0.25	
Eastern Crowned Warbler	*Phylloscopus coronatus*	Phylloscopidae	LC	W	FF	INS	0.49		
Davison's Leaf Warbler	*Phylloscopus davisoni*	Phylloscopidae	LC	R	FF	INS	2.20		
Blyth's Leaf Warbler	*Phylloscopus reguloides reguloides*	Phylloscopidae	LC	R	FF	INS	1.22		
Greenish Warbler	*Phylloscopus trochiloides obscuratus*	Phylloscopidae	LC	W	FF	INS	1.10	1.13	0.42
Two-barred Warbler	*Phylloscopus plumbeitarsus*	Phylloscopidae	LC	W	FF	INS	0.86	1.38	1.41
Yellow-browed Warbler	*Phylloscopus inornatus*	Phylloscopidae	LC	W	F	INS	4.03	11.31	8.60
Tickell's Leaf-warbler	*Phylloscopus affinis affinis*	Phylloscopidae	LC	W	F	INS	0.37		0.14
Radde's Warbler	*Phylloscopus schwarzi*	Phylloscopidae	LC	W	F	INS		0.13	0.56
Dusky Warbler	*Phylloscopus fuscatus fuscatus*	Phylloscopidae	LC	W	F	INS	0.12	0.25	0.56
Buff-throated Warbler	*Phylloscopus subaffinis*	Phylloscopidae	LC	W	F	INS	0.37	0.25	0.85
Spot-breasted Parrotbill	*Paradoxornis guttaticollis*	Sylviidae	LC	R	F	INS			0.28
Yellow-eyed Babbler	*Chrysomma sinense sinense*	Sylviidae	LC	R	F	INS		0.63	
Chestnut-flanked White-eye	*Zosterops erythropleurus*	Zosteropidae	LC	W	F	NEC	2.08		0.42
Indian White-eye	*Zosterops palpebrosus palpebrosus*	Zosteropidae	LC	R	F	NEC	2.44		1.41
Japanese White-Eye	*Zosterops japonicus simplex*	Zosteropidae	LC	R	F	NEC			0.12
Burmese Yuhina	*Yuhina humilis clarki*	Zosteropidae	LC	R	FF	INS	1.83		
Grey-throated Babbler	*Stachyris nigriceps yunnanensis*	Timaliidae	LC	R	FF	INS	0.86		

Rusty-cheeked Scimitar-babbler	*Megapomatorhinus erythrogenys celatus*	Timaliidae	LC	R	FF	INS			1.41
White-browed Scimitar-babbler	*Pomatorhinus schisticeps nuchalis*	Timaliidae	LC	R	FF	INS	1.34	1.51	1.27
Golden Babbler	*Cyanoderma chrysaeum auratum*	Timaliidae	LC	R	FF	INS	2.20	0.13	
Rufous-capped Babbler	*Cyanoderma ruficeps bhamoense*	Timaliidae	LC	R	FF	INS	0.24	0.25	
Pin-striped Tit-babbler	*Mixornis gularis lutescens*	Timaliidae	LC	R	F	INS	0.37		
Chestnut-capped Babbler	*Timalia pileata smithi*	Timaliidae	LC	R	F	INS		0.88	0.42
Puff-throated Babbler	*Pellorneum ruficeps shanense*	Pellorneidae	LC	R	FF	INS	0.49		0.14
White-browed Laughingthrush	*Ianthocincla sannio comis*	Leiotrichidae	LC	R	f	INS	3.27	2.68	
Silver-eared Laughingthrush	*Trochalopteron melanostigma melanostigma*	Leiotrichidae	LC	R	FF	INS	0.12		
Scarlet-faced Liocichla	*Liocichla ripponi ripponi*	Leiotrichidae	LC	R	F	INS			0.28
Grey-cheeked Fulvetta	*Alcippe fratercula fratercula*	Leiotrichidae	LC	R	FF	INS	1.71		
Blue Winged Siva	*Siva cyanouroptera sordita*	Leiotrichidae	LC	R	FF	INS	0.37		
Silver-eared Mesia	*Leiothrix argentauris galbana*	Leiotrichidae	LC	R	FF	INS	2.20		
Dark-backed Sibia	*Heterophasia melanoleuca castanoptera*	Leiotrichidae	LC	R	FF	OMN	3.06		1.55
Spectacled Barwing (Eastern)	*Actinodura ramsayi radcliffei*	Leiotrichidae	LC	R	F	INS	0.12	0.50	1.13
Thick-billed Warbler	*Arundinax aedon aedon*	Acrocephalidae	LC	W	F	INS			0.14
Striated Grassbird	*Megalurus palustris toklao*	Locustellidae	LC	R	F	INS			0.28
Common Tailorbird	*Orthotomus sutorius inexpectatus*	Cisticolidae	LC	R	f	OMN		0.25	0.99
Grey-breasted Prinia	*Prinia hodgsonii erro*	Cisticolidae	LC	R	F	INS		6.28	8.60
Burmese Prinia	*Prinia polychroa cooki*	Cisticolidae	LC	R	F	INS		2.26	0.42
Hill Prinia	*Prinia superciliaris erythropleura*	Cisticolidae	LC	R	F	INS		0.50	0.14
Slaty-bellied Tesia	*Tesia olivea*	Scotocercidae	LC	R	FF	INS	0.37		
Chestnut-headed Tesia	*Cettia castaneocoronata castaneocoronata*	Scotocercidae	LC	R	FF	INS	0.12		