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Research Article

Birds Species on Vertical Stratification of Mangrove Vegetation Nusa Lembongan, Bali Indonesia

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ABSTRACT
This study aims to determine the use of vertical stratification of mangrove vegetation by bird species in the mangrove ecosystem of Nusa Lembongan. The study was conducted at seven mangrove ecosystem sites, in April-July 2021. Observation of the number of birds in each vegetation strata was carried out using the point count method. The association of the use of vegetation strata by bird species was carried out by *Detrended correspondence analysis* (DCA) statistical test. The results showed that total of 32 species are found in the mangrove ecosystem of Nusa Lembongan which belong to 26 families. There is a strong association between bird species and the vertical strata of vegetation. The species of birds associated with pure mangrove vegetation are; strata I, namely *Amaurornis phoenicurus* (Pennant,1769), *Ardea purpurea* Linnaeus, 1766, *Sterna bergii* M.H.K.Lichtenstein, 1823, *Passer domesticus* (Linnaeus, 1758), and *Pycnonotus aurigaster* (Vieillot, 1818); strata II are *Todiramphus chloris* (Boddaert,1783), *Todirhamphus sanctus* (Vigors and Horsfield,1827), *Alcedo coerulescens* Vieillot,1818 and *Butorides striata* (Linnaeus,1758); strata III are *Hypothymis azurea* (Boddaert, 1783), *Lanius schach* Linnaeus,1758, *Merops philippinus* Linnaeus,1767, *Nectarinia jugularis* Linnaeus,1766 and *Gerygone sulphurea* Wallace, 1864; strata IV are *Collocalia linchi* Horsfield & F.Moore,1854, *Oriolus chinensis* Linnaeus, 1766, *Hirundo tahitica* Gmelin,1789 and *Pycnonotus goiaver* (Scopoli, 1786). The bird species associated with mixed mangrove and dryland vegetation are strata I, namely species *Turnix suscitator* (J.F.Gmelin,1789), *Acridotheres javanicus* Cabanis,1851, *Anthreptes malacensis* (Scopoli, 1786), *Passer domesticus* (Linnaeus,1758), *Pycnonotus aurigaster* (Vieillot,1818), *Spilopelia chinensis* (Scopoli,1786)and *Geopelia striata* (Linnaeus,1766); strata II, namely *Alcedo coerulescens* Vieillot,1818, *Zosterops chloris* Bonaparte, 1850, *Todirhamphus sanctus* (Vigors and Horsfield,1827) and *Todiramphus chloris* (Boddaert,1783); strata III, namely *Anthreptes malacensis* (Scopoli,1786), *Cacomantis merulinus* (Scopoli,1786), *Hypothymis azurea* (Boddaert,1783), *Copsychus saularis* (Linnaeus,1758), *Nectarinia jugularis* Linnaeus,1766, *Gerygone sulphurea* Wallace,1864 and *Merops philippinus* Linnaeus,1767; strata IV, namely *Collocalia linchi* Horsfield & F.Moore,1854, *Hirundo tahitica* Gmelin,1789 and *Corvus* sp. Factors influencing strata preference by birds are resources, both food and space, as well as the bioecological characteristics of the birds themselves.

INTRODUCTION
Mangrove forest on the coast of Nusa Lembongan, which covers an area of 202 ha, has an important role physically, biologically, ecologically, and

economically. Physical roles include maintaining a stable coastline from abrasion, controlling seawater intrusion into groundwater, protecting the area behind the mangroves from waves. Economic functions include the development of mangrove ecotourism and source of livelihood for fishermen. Biological/ecological functions include a feeding ground, a spawning ground and a nursery ground for various types of fish, crustaceans, mollusks, and birds. It is even stated that mangroves are habitat for about 13% of Indonesian avivauna and mangroves play an important role for migratory waterbirds. Bird diversity is also an indicator of the health condition of mangroves (Negelkerken et al. 2008; Setiawan et al. 2012; Salahuddin et al. 2021; Wetland International 2022).

Birds use mangrove vegetation for foraging, nesting, perching, attracting mates, playing, breeding, and sheltering. Bird species that utilise mangrove habitats are generally from groups of water birds, but also terrestrial birds. The use of vegetation by birds is closely related to the vertical stratification of mangrove vegetation. Certain types make use of the bottom layer/mud flat, mangrove root layer, canopy layer or the top of the vegetation. Bibby et al. (2000) stated that the selection of strata by birds is determined because birds also have micro-habitat needs. Many species of birds live in the upper canopy layer, so it is difficult to find the birds (especially because they move quickly). However, there are also bird species that do not occupy canopy in the vegetation, but prefer shrub habitats which are usually under stands. The choice of bush habitat is also due to the fact that the habitat is suitable and able to meet their needs.

Several studies related to bird associations in the vertical stratification of mangrove forests found that each layer of habitat/vegetation found variations in bird richness. For example, in the *Avicennia alba* strata vegetation the most widely used by birds is the top layer of vegetation and in the *Rhizophora mucronata* strata vegetation the most common bird is the middle layer of vegetation (Pradana et al. 2022). Hernowo (2016) found that the middle vegetation strata of mangrove vegetation in Batu Ampar, Kubu Raya District, West Kalimantan Province, were mostly used by birds. The Nusa Lembongan mangroves also show vertical stratification related to the use of bird diversity. There are birds that use the bottom layer/mud/water level, root layer, canopy layer and top layer of mangrove vegetation in Nusa Lembongan. Thus, the purpose of this study was to determine the use of vertical stratification of mangrove vegetation by bird species in the mangrove ecosystem of Nusa Lembongan.

MATERIAL AND METHODS

Study Site

The study was conducted in 7 locations of the Nusa Lembongan mangrove forest (Figure 1). The geographical position of the mangrove ecosystem of Nusa Lembongan is at 8° 40'00,22" S and 115° 28'02,99" E. The research was conducted on two vegetation groups, namely pure mangrove vegetation and mixed mangrove vegetation with dry vegetation. Pure mangrove vegetation is vegetation composed of true mangrove species and associated species, while mixed vegetation is vegetation consisting of mangrove plant species and dry vegetation around the mangroves. The research was carried out for 4 months from April to July 2021.

Research Procedure

Identification of bird species is done directly from field observations with the help of binoculars. The birds found were photographed with a digital camera. Identification of bird species based on morphological characters

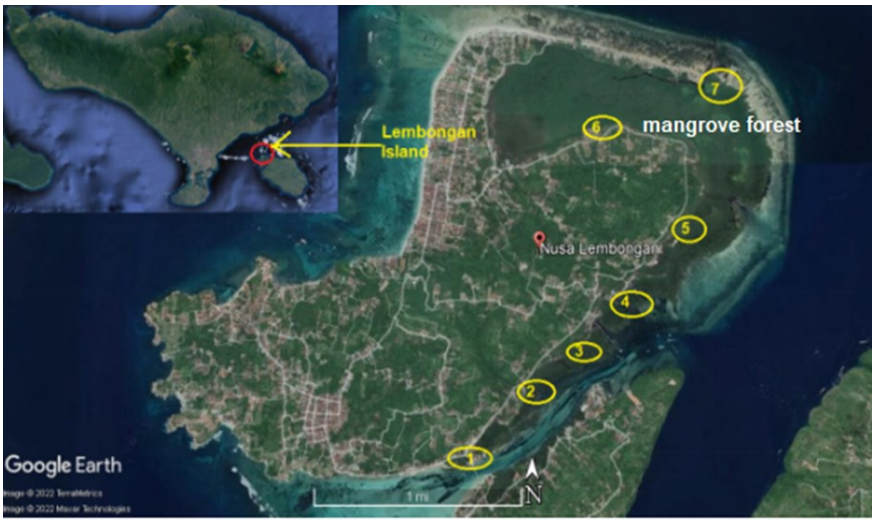

Figure 1. Maps of Research Locations.

(including the shape of the legs, feathers, feather colour, wings, wing colour, beak). Identification refers to the Java, Bali, and Sumatra bird field guide series (MacKinnon et al. 2010).

Observation of bird abundance were carried out by using the point count method (Bibby et al. 2000). Counting points were done at 7 sites of the mangrove ecosystem, at each site 3 counting points were carried out. At each point, observations were carried out for 15 minutes with a distance of 150 meters between points. Surveys for the presence of bird species were conducted based on the vertical stratification of mangrove habitats. The parameters observed at each point of count were the species and the number of individual birds.

Based on the results of observations on the use of pure mangrove vegetation and mixed mangrove with dry vegetation by bird species in the field, the stratification of mangrove habitat is divided into 4 strata. The four strata are stratum I which is the vegetation floor (mud/sand/water average); strata II is mangrove root layer; strata III is the canopy layer and strata IV is the top surface layer of the canopy to the top of the vegetation (up to a distance of 5 meters above the surface of the vegetation canopy) (Figure 2).

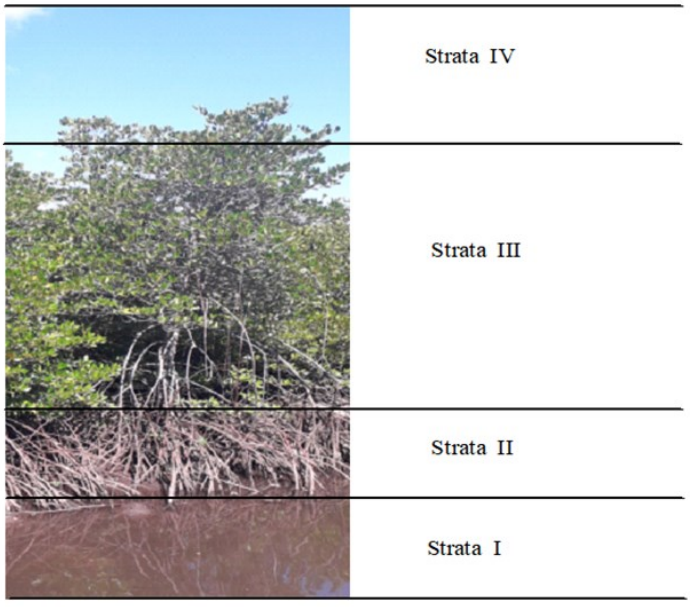

Figure 2. Strata category of the use of vegetation by birds in the mangroves of Nusa Lembongan.

Data Analysis

Data on the species and number of individuals of each bird were analysed in descriptive quantitative method by describing the analysis of the list of species and the number of birds in each category of vertical mangrove strata. Association of vegetation strata utilisation by bird species was tested for DCA correspondence (Detrended Correspondence Analysis) using SPSS version 24.

RESULTS AND DISCUSSION

Mangrove Vegetation Vertical Strata

The vertical stratification of mangroves related to the use of birds is divided into four strata. Strata I is part of the forest floor; in this strata, it can be flat mud, rocky sand, water, or sandy soil with undergrowth; strata II is the root part of mangrove vegetation (support roots, knee roots, breath roots); strata III is the main part of the vegetation canopy; strata IV is the part of the canopy surface above the vegetation to a height of 5 meters. Several researchers determined the vertical structure of mangroves based on the height from the ground to the top of the mangrove canopy (Hernowo 2016; Kusmana & Azizah 2022; Pradana et al. 2022).

At the seven observation sites, there were variations in each strata (especially in strata I, II and III) based on the main species of mangrove constituents, the presence of coastal vegetation or species of mangrove associations and the zoning of mangrove areas. Mangrove vegetation in Nusa Lembongan related to its use by birds, is divided into two groups, namely pure mangrove vegetation and mixed mangrove vegetation and dryland vegetation.

Pure mangrove vegetation

Pure mangrove vegetation was represented by site 1, site 3, site 5 and site 7. The plant species in pure mangrove vegetation consisted of *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, *Sonneratia alba*, as well as several species of *Excoecaria agalloca*, *Lumnitzera racemosa* and *Bruguiera gymnorhiza*. Some associated plants including *Pandanus tectorius*, *Hibiscus sinensis*, *Thespesia populnea*, *Terminalia cattapa*, and *Guettarda speciose*. Strata I is part of the mangrove forest floor, which can be rocky sand, sand, mud flats, sea water when high tides and only some parts have mangrove plants association. Strata II is dominated by the mangrove root system (stilt roots and pneumatophore). Strata III is the main layer of the mangrove canopy and stratum IV is the canopy surface up to 5 meters above the canopy (Figure 3).

Mixed vegetation of mangrove and dry land vegetation

Mixed mangrove vegetation was represented by site 2, site 4 and site 6. The plant species in mixed mangrove vegetation were dominated by *Sonneratia alba*, *Avicenia marina*, *Avicennia alba*, *Lumnitzera racemosa*, some *Rhizophora stylosa*, *Rhizophora apiculate*, and several associated plant species mangroves, namely *Opuntia* sp., *Salicornia* sp., *Pandanus tectorius*. Strata I is the ground floor of the mangrove forest and the ground floor of dry land, can be sandy soil, flat mud and dry soil with some undergrowth (grass). Strata II is dominated by the mangrove root system. This site is bordered by several land plant trees including *Acacia auriculiformis*, *Acacia leucophloea*, *Borrasus flabelifer*, *Leucaena leucocephala*, *Cocos nucifera* and *Terminalia cattapa*, as well as dry vegetation including *Manihot utilissima*, *Gliricedia sepium*, *Ficus glabela*, *Cassia fistula*, *Ziziphus mauritiana*, *Antidesma bunius*, *Hibiscus sinensis*, *Tectona grandis*, *Lannnea grandis*, *Azadirachta indica*, *Manilkara kauki*, *Schleichera oleosa*, as well as lower

Figure 3. Pure mangrove vegetation structure in the Nusa Lembongan mangrove ecosystem.

vegetation including grass *Adropogon aciculatus*, *Cyperus barbatus*, Eragrostis sp., and *Imperata cylindric*a. Strata III in this site is composed of a canopy layer of mangrove vegetation and tree vegetation of land plants. Strata IV of mixed mangrove vegetation is the surface layer to the top of the mangrove canopy and land plant canopy.

Figure 4. Mixed mangrove vegetation structure in the Nusa Lembongan mangrove ecosystem.

Birds in the vegetation strata

In the mangrove ecosystem of Nusa Lembongan, 32 species of birds that were found belong to 26 families. The number of bird species found in pure mangrove vegetation was 20 species and in mixed mangrove vegetation (mangrove and dry land vegetation) as many as 28 species. In pure mangrove vegetation, 20 species of birds were found, 13 species of the birds are terrestrial bird groups and 7 species are water birds. Terrestrial bird species found in mangrove vegetation are nectar-eating birds (nectarivore), fruit-eating (frugivore) and grain-eating (granivore) and insectivorous or small reptiles (Table 1). Flowers from many types of mangrove plants produce nectar, which can be used by nectarivore birds.

Insects and small reptiles associated with mangrove plants serve as food for insectivorous birds. Kartijono et al. (2010) and Pradana et al. (2022) also found that many nectar-eating and insectivorous birds used mangrove vegetation on Mosquito Island and Wonorejo mangroves. Water bird species that were found are fish-eating birds, crustaceans, sea worms and mollusks. This faunal fauna is common in mangrove habitats.

The number of water birds found in the mangroves of Nusa Lembongan is relatively lesser than water birds in other mangrove ecosystems. Among them are the number of water birds in the mangroves of the Bali Island of Serangan as many as 24 species (Sumardika et al. 2017), 15 species of water birds in the Pejarakan mangroves (Ginantra et al. 2020) and the number of water birds in the mangrove area of the south

Table 1. Bird species in pure mangrove vegetation.

No	Scientific name	Common name	Number individual in vegetation strata				Main feeding guilds (birds group)
			I	II	III	IV	
1	*Amaurornis phoenicurus* (Pennant,1769)	white breasted waterhen	4				Carnivore (Water bird)
2	*Alcedo coerulescens* Vieillot,1818	Small blue kingfisher		5	5		Carnivore (Water bird)
3	*Ardea purpurea* Linnaeus, 1766	Purple heron	3		5	4	Carnivore (Water bird)
4	*Butorides striata* (Linnaeus,1758)	Striated heron	3	5			Carnivore (Water bird)
5	*Collocalia linchi* Horsfield & F. Moore,1854	Cave swiftlet				20	Insectivore (Terestrial bird)
6	*Gerygone sulphurea* Wallace, 1864	Golden-bellied gerygone			6	3	Insectivore (Terestrial bird)
7	*Hirundo tahitica* Gmelin,1789	Pacific Swallow			6	7	Insectivore (Terestrial bird)
8	*Hypothymis azurea* (Boddaert,1783)	Black-naped monarch			3		Insectivore (Terestrial bird)
9	*Lanius schach* Linnaeus,1758	Long-tailed Shrike			3		Insectivore (Terestrial bird)
10	*Merops philippinus* Linnaeus,1767	Blue-tailed bee-eater			3		Insectivore (Terestrial bird)
11	*Nectarinia jugularis* Linnaeus,1767	Olive-backed sunbird			18	3	Nectarivore (Terestrial bird)
12	*Oriolus chinensis* Linnaeus,1767	Back naped oriale			4	3	Frugivora (Terestrial bird)
13	*Pachycephala grisola* (Blyth, 1843)	Mangrove whistler		2	2		Insectivore (Terestrial bird)
14	*Passer domesticus* (Linnaeus,1758)	House sparrow	7			2	Granivore (Terestrial bird)
15	*Pycnonotus aurigaster* (Vieillot,1818)	Sooty-headed Bulbul	12		28		Frugivora (Terestrial bird)
16	*Pycnonotus goiaver* (Scopoli, 1786)	Yellow vented bulbul				4	Frugivora (Terestrial bird)
17	*Sterna bergii* M.H.K.Lichtenstein,1823	Greater Crested Tern	5			2	Carnivore (Water bird)
18	*Spilopelia chinensis* (Scopoli, 1786)	Spotted dove	5		21	7	Frugivora (Terestrial bird)
19	*Todiramphus chloris* (Boddaert,1783)	Collared kingfisher		8	9		Carnivore (Water bird)
20	*Todirhamphus sanctus* (Vigors and Horsfield,1827)	Sacred kingfisher		3	3		Carnivore (Water bird)

coast of Bangkalan, Madura Island as many as 15 species (Ramadhani et al. 2022).

Utilization of birds in mangrove vegetation strata is divided into 4 strata. The division of these strata is slightly different from what were found by Hernowo (2016) who divides 3 strata on the utilization of mangrove vegetation in Batu Ampar. In the Batu Ampar mangrove, the mud average and the mangrove root system become one strata, namely strata C. While the Nusa Lembongan mangroves, the lowest stratum is divided into two, namely the average mud, water or substrate is strata I and strata II are the root part of the mangrove. Birds use stratum 3 (the main part of the mangrove canopy) which is 48.7% and stratum IV (the surface to the top of the mangrove canopy) which is 25.0% compared to stratum I which is 17.1% and stratum II is 9.2%. Hernowo (2016), Kartijono et al. (2010), and Pradana et al. (2022) also found that the main stratum of the mangrove canopy was mostly used by birds. The association of the use of bird species in pure mangrove vegetation strata is presented through a biplot correspondence analysis (Figure 5).

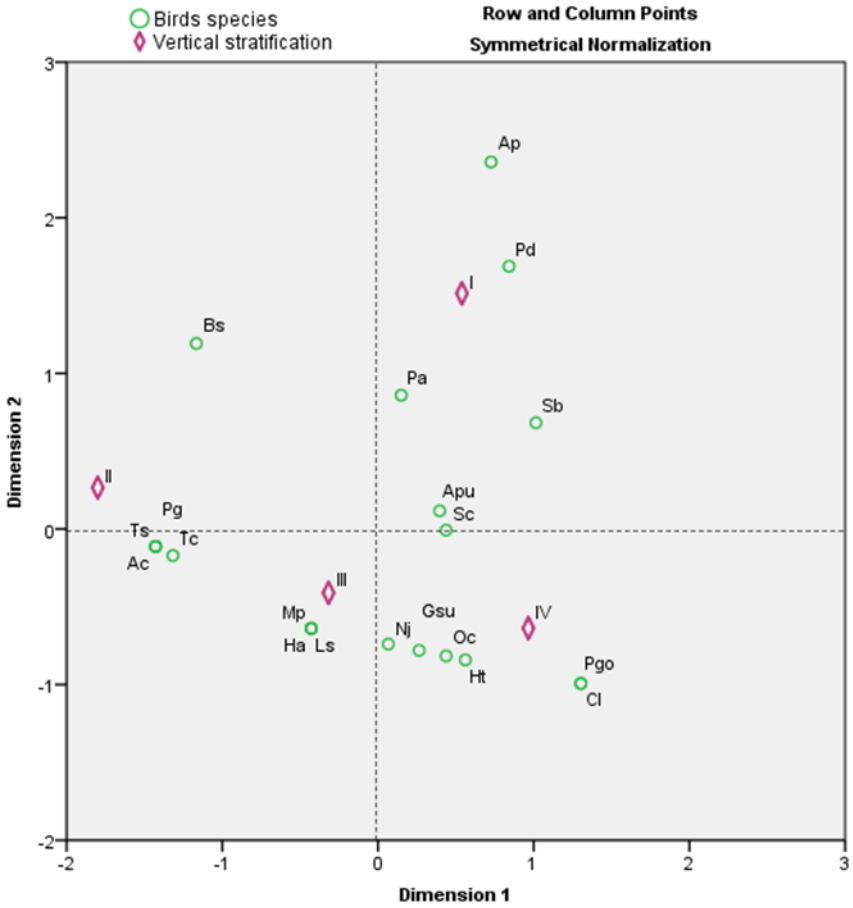

Figure 5. Biplot correspondence analysis of birds on pure vegetation of mangroves. (Birds species code; **Ap**:*Amaurornis phoenicurus;* **Apu**: *Ardea purpurea;* **Bs**:*Butorides striatus;* **Pd**: *Passer domesticus;* **Pa**: *Pycnonotus aurigaster;* **Sc**: *Spilopelia chinensis;* **Sb**:*Sterna bergii;* **Ac**:*Alcedo caerulescens;* **Pg**: *Pachycephala grisola;* **Tc**:*Todiramphus chloris;* **Ts**:*Todirhamphus sanctus;* **Gsu**:*Gerygone sulphurea;* **Ht**:*Hirundo tahitica;* **Ha**:*Hypothymis azurea;* **Ls**:*Lanius shcach;* **Mp**:*Merops philippinus;* **Nj**:*Nectarinia jugularis;* **Oc**:*Oriolus chinensis;* **Cl**:*Collocalia linchi;* **Pgo**:*Pycnonotus goiaver*)

Common bird species associated in strata I and strata II include collared kingfisher (*Todiramphus chloris*), purple heron (*Ardea purpurea*), sacred kingfisher (*Todirhamphus sanctus*), mangrove whistler (*Pachycephala grisola*), white breasted waterhen (*Amaurornis phoenicurus*), small blue

kingfisher (*Alcedo caerulescens*), greater Crested Tern (*Sterna bergii*), and striated heron (*Butorides striatus*). The species of birds that use strata I and II are fish-eating birds, crustaceans and mollusks associated with mangrove habitats. In feeding activities, these birds are generally silent and perched first on the mangrove roots to wait for their prey in the water or in the mud. As soon as the prey is seen in the water or in the mud, it immediately flies into the water or mud to catch the prey. There were also birds observed, namely striated heron and purple heron pecking mollusks in the mangrove roots. White breasted waterhen and purple heron were observed walking along the mangrove mud mudflat while pecking on crustaceans and mollusks. Sutopo et al. (2017), Hernowo, (2016) and MacKinnon et al. (2010), stated that in terms of bird bioecology, the presence of birds in strata I and strata II is related to the habits of these birds in foraging for food.

In strata III, associated birds include blue-tailed bee-eater (*Merops philippinus*), black-naped monarch (*Hypothymis azurea*), golden-bellied gerygone (*Gerygone sulphurea*), long-tailed shrike (*Lanius shcach*), back-naped oriale (*Oriolus chinensis*), sooty-headed bulbul (*Pycnonotus aurigaste*), spotted dove (*Spilopelia chinensis*), and olive-backed sunbird (*Nectarinia jugularis*). The types of birds in strata III are seed/fruit-eating, insect-eating and nectar-eating birds. Mangrove stratum III is more utilized by bird species, this is because this strata provides more resources for bird life, both as a food source, perch, resting place, mating and nesting activities. Pradana et al. (2022), Cita and Budiman. (2019), Mancini et al. (2018), and Hernowo, (2016) stated that the complexity, structural heterogeneity and productivity of mangrove vegetation are important factors for the diversity of bird species.

Species of birds in strata IV include cave swiftlet (*Collocalia linchi*), yellow vented bulbul (*Pycnonotus goiaver*), and pacific swallow (*Hirundo tahitica*), is a type of bird that is able to eat insects that fly above the canopy or insects that perch on the surface of the mangrove canopy. Cave swiftlets is generally observed to catch insects while flying over vegetation. Kopij (2000) has previously observed *Collocalia linchi* and *Apus pacificus* to be flying in large numbers around mangrove forests, both of which flying round and round to hunt down insects. Cave swiftlet (*Collocalia linchi*) is quite high in population in the mangrove ecosystem of Nusa Lembongan. MacKinnon et al. (2010) stated that *Collocalia linchi* and *Apus pacificus* are species of birds that have a wide distribution and are very common worldwide from the lowlands to the highlands. They show flocking behaviour.

The choice of stratification of mangrove vegetation is more related to the bird's preference for the necessities of life provided by each vegetation stratum, whether food, resting place, perching while making sounds, playing, or taking shelter. During our research, we did not find any birds using mangrove vegetation for nesting. Some bird researchers also state that the presence of birds in vegetation stratification is more closely related to vegetation productivity, fulfilment of micro habitat needs, these habitats are suitable and able to meet the needs of certain bird species (Bibby et al. 2000; Nagelkerken et al. 2008; Wisnubudi 2009; Cita & Budiman 2019).

Table 2 shows the species of birds that use mixed vegetation of mangroves and dry vegetation. 28 bird species were found utilizing mixed mangrove and dry vegetation. In this type of vegetation, there are also more groups of terrestrial birds, which are 24 species, compared to water birds, which are 4 species.

Table 2. Bird species in mixed mangrove and dry vegetation.

No	Scientific name	Common name	Number individual in vegetation strata				Feeding guilds (birds group)
			I	II	III	IV	
1	*Acridotheres javanicus* Cabanis, 1851	Javan myna	4			2	Insectivore (Terestrial bird)
2	*Alcedo coerulescens* Vieillot,1818	Small blue kingfisher	2	5	2		Carnivore (Water bird)
3	*Amaurornis phoenicurus* (Pennant,1769)	white breasted water-hen	4				Carnivore (Water bird)
4	*Anthreptes malacensis* (Scopoli,1786)	Brown-throated sun-bird			5		Nectarivore (Terestrial bird)
5	*Cacomantis merulinus* (Scopoli,1786)	Plaintive cuckoo			4		Insectivore (Terestrial bird)
6	*Collocalia linchi* Horsfield & F.Moore,1854	Cave swiftlet				13	Insectivore (Terestrial bird)
7	*Copsychus saularis* (Linnaeus, 1758)	Oriental magpie-robin			4		Insectivore (Terestrial bird)
8	*Corvus* sp.	Crow			3	3	Carnivore (Terrestrial bird)
9	*Geopelia striata* (Linnaeus,1766)	Zebra dove	5		9	4	Granivore (Terestrial bird)
10	*Gerygone sulphurea* Wallace,1864	Golden-bellied gery-gone			6	3	Insectivore (Terestrial bird)
11	*Hirundo tahitica* Gmelin,1789	Pacific Swallow			6	7	Insectivore (Terestrial bird)
12	*Hypothymis azurea* (Boddaert,1783)	Black-naped monarch			6		Insectivore (Terestrial bird)
13	*Lalage sueurii* (Vieillot, 1818)	White shouldered triller			3		Insectivore (Terestrial bird)
14	*Lanius schach* Linnaeus,1758	Long-tailed Shrike			5		Insectivore (Terestrial bird)
15	*Lonchura molucca* (Linnaeus, 1766)	Black faced munia			3		Granivore (Terestrial bird)
16	*Merops philippinus* Linnaeus,1767	Blue-tailed bee-eater			5	4	Insectivore (Terestrial bird)
17	*Nectarinia jugularis* Linnaeus,1766	Olive-backed sunbird			11	3	Nectarivore (Terestrial bird)
18	*Oriolus chinensis* Linnaeus, 1766	Back naped oriale			2	3	Frugivora (Terestrial bird)
19	*Passer domesticus* (Linnaeus, 1758)	House sparrow	6		3		Granivore (Terestrial bird)
20	*Psilopogon haemacephalus* (P.L.S.Müller, 1776)	Coppersmith Barbet			3		Frugivora (Terestrial bird)
21	*Pycnonotus aurigaster* (Vieillot, 1818)	Sooty-headed Bulbul	9	4	24		Frugivora (Terestrial bird)
22	*Pycnonotus goiaver* (Scopoli, 1786)	Yellow vented bulbul			3	3	Frugivora (Terestrial bird)
23	*Spilopelia chinensis* (Scopoli,1786)	Spotted dove	12		4	3	Frugivora (Terestrial bird)
24	*Todiramphus chloris* Boddaert,1783)	Collared kingfisher	5	6	3	3	Carnivore (Water bird)
25	*Todirhamphus sanctus* (Vigors and Horsfield,1827)	Sacred kingfisher		4	2		Carnivore (Water bird)
26	*Treron vernans* (Linnaeus, 1771)	Pink-necked green pi-geon			5		Frugivora (Terestrial bird)
27	*Turnix suscitator* (J.F. Gmelin,1789)	Barred buttonquail	4				Granivore (Terestrial bird)
28	*Turnix suscitator* (J.F. Gmelin,1789)	Lemon-bellied white-eye		3	5		Insectivore (Terestrial bird)

In strata III (main part of the vegetation canopy) the richest bird species are 55.9%, strata IV is 17.3%, strata I is 18.9% and strata II is 7.9%. The species of birds associated in strata I and strata II were actually more terrestrial birds, compared to water bird species. Terrestrial bird species include barred buttonquail (*Turnix suscitator*), javan myna (*Acridotheres javanicus*), brown-throated sunbird (*Anthreptes malacensis*), house sparrow (*Passer domesticus*), spotted dove (*Spilopelia chinensis*), sooty -headed bulbul (*Pycnonotus aurigaste*r). Barred buttonquail, spotted dove, sooty-headed bulbul are typical birds whose activities are mostly in bushes, soil, around grass on the beach or in fields (Mackinon 2010). Types of water birds in strata I and II include Small blue kingfisher (*Alcedo caerulescens*) and collared kingfisher (*Todiramphus chloris*). In strata III, the species richness is higher in mixed mangrove and dry vegetation types than in pure mangrove vegetation types, especially terrestrial bird species.

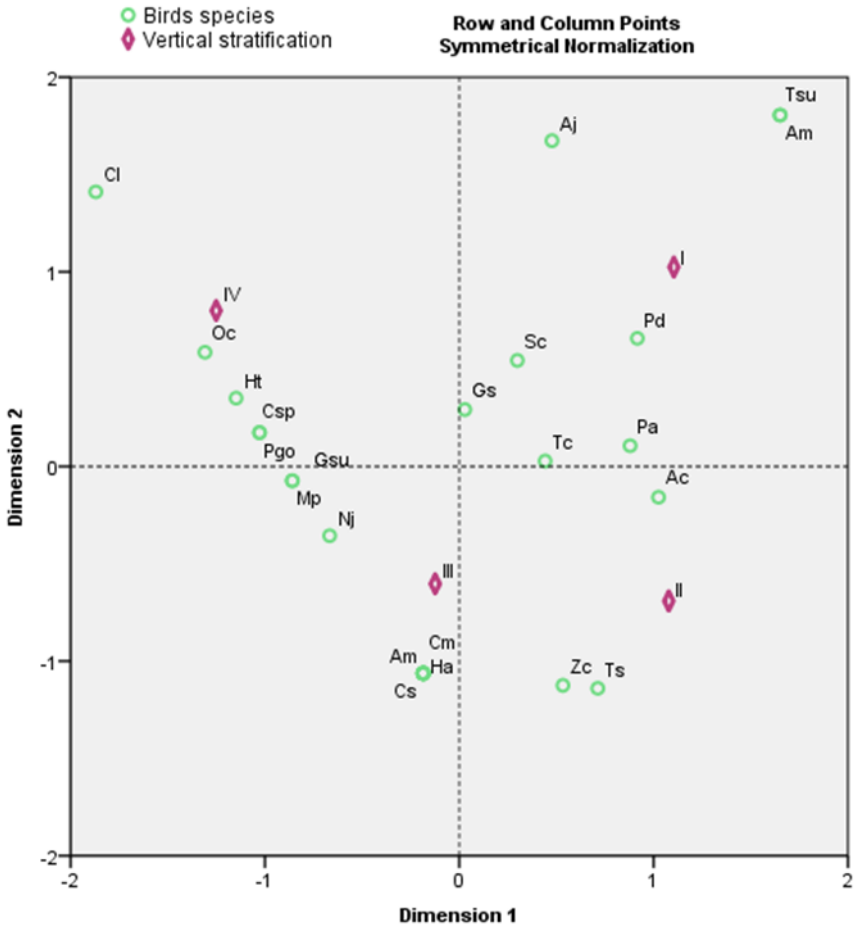

Figure 6. Biplot correspondence analysis of birds on mixed vegetation of mangroves and dry land. (Birds species code: **Aj**:*Acridotheres javanicus;* **Ac**:*Alcedo caerulescens;* **Ap**:*Amaurornis phoenicurus;* **Gs**: *Geopelia striata;* **Pd**: *Passer domesticus;* **Pa**: *Pycnonotus aurigaster;* **Sc**: *Spilopelia chinensis;* **Tc**:*Todiramphus chloris;* **Tsu**:*Turnix suscitator;* **Ts**:*Todirhamphus sanctus;* **Zc**:*Zosterops chloris;* **Am**:*Anthreptes malacensis;* **Cm**:*Cacomantis merulinus;* **Cs**:*Copsychus saularis;* **Csp**:*Corvus* sp..; **Gsu**:*Gerygone sulphurea;* **Ht**:*Hirundo tahitica;* **Ha**:*Hypothymis azurea;* **Lsu**:*Lalage sueurii;* **Ls**:*Lanius shcach;* **Lm**:*Lonchura molucca;* **Mp**:*Merops philippinus;* **Nj**:*Nectarinia jugularis;* **Oc**:*Oriolus chinensis;* **Ph**:*Psilopogon haemacephala;* **Pgo**:*Pycnonotus goiaver;* **Tv**:*Treron vernans;* **Cl**:*Collocalia linchi)*

Bird species associated with strata IV include cave swiftlet (*Collocalia linchi*), back naped oriale (*Oriolus chinensis*), pacific swallow (*Hirundo tahitic*a), and yellow vented bulbul (*Pycnonotus goiaver*). These

types of birds carry out the activity of catching insects while flying, some are perched on the top of the canopy while catching insects or small reptiles, some are perched while making sounds and some are flying over the canopy. Association for the use of bird species in mixed vegetation strata of mangroves and dry land, presented through biplot correspondence analysis (Figure 6).

In general, the factors that influence strata preference by birds are resources, both food and space to rest, perches, mating activities, nesting places, shelter from heat, shelter from predators, play, and the bioecological characteristics of the birds themselves. (Mackinon, 2010; Mohd-Azlan et al. 2015; Iswandaru et al. 2020; Safe'i et al. 2021; Pradana et al. 2022). For example, striated heron and purple heron are commonly found in strata I and II, namely the mangrove roots, mud flats or in water. This is related to the bird's habit of foraging for food, such as fish eaters or aquatic vertebrates. So, they will perch in areas close to the water to be able to keep an eye on their prey.

CONCLUSION

The use of mangrove vegetation strata by birds in the Nusa Lembongan mangrove ecosystem is divided into 4 vertical strata. There is a strong association between bird species and the vertical strata of vegetation. In pure mangrove vegetation, the number of bird species that are strongly associated with strata I is 5 species; strata II as many as 4 species; strata III is 5 species, and stratum IV is 4 species. In the mixed vegetation of mangroves and dry vegetation, there were 7 species of birds that had a strong association in strata I; strata II is 4 species; strata III as many as 7 species and strata IV is 3 species.

AUTHOR CONTRIBUTION

I.K.G. is the main author who design research, browse related literature, analyze data and write articles. I.K.M is responsible for collecting data in the field, tabulating data, and checking draft articles. M.J. assisting in data collection in the field, data tabulation, checking the English language of the manuscript.

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CONFLICT OF INTEREST

We certify that there is no conflict of interest in the research or funding of this manuscript

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