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RESEARCH PAPER

Genetic heat index based avifaunistic data on four landscapes in West Pasaman Regency, West Sumatra, Indonesia

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ABSTRACT

West Pasaman Regency in West Sumatra Province has been thriving in most sectors since established as a new administrative area on 2003. The importance of environmental value needs to be integrated into development process in this regency, in order to create an eco-friendly development. The Genetic Heat Index (GHI) concept highlights the importance of an area by considering conservation status of organisms reside within, something which previously often neglected for the decision-making process. This paper intends to calculate and compare the GHI value of four prominent landscapes in West Pasaman Regency based on their avifauna inventory; Mount Talamau and Laut Tinggal Lake (mountainous area), Tongar River (lowland-to-hilly riparian agricultural area) and Panjang Island (an offshore island). The study recorded 118 bird species collectively from all sites, each of them was coded according to their conservation status. Laut Tinggal Lake had the highest GHI value 4.26, followed by Panjang Island 4.20, Mt. Talamau 4.14 and Tongar River 4.03. Although the priority should be given to site with the highest GHI value, the consideration on species uniqueness, species diversity and comparable GHI value across sites, however, illustrating the need to afford protection on them all.

Keywords: Bird; Conservation status; Diversity; Laut Tinggal Lake; Mount Talamau; Tongar River

INTRODUCTION

Indonesian archipelago, with its very unique and strategic position in between two continents and two oceans, has remarkable natural biodiversity, including 10% of vascular plants, 12% of mammals, 16% of reptiles, 25% of fishes and 15% of insects from all known global species (Sujatnika *et al*., 1995). Whereas for birds, Indonesia is habitat for around 1598 species or 17% of total global bird species; of which 372 species (23.8%) are Indonesian endemics (Sukmantoro *et al*., 2007; Abdullah *et al*., 2016). It has brought Indonesia as the fourth richest country for bird species and bird endemism as well.

Sumatra is an island with low bird endemism among others in the archipelago. It is assessed that around 583 bird species occupy the mainland of Sumatra, with 438 species (approximately 75%) are local inhabitants (MacKinnon *et al*., 2000). This number can increase into 602 species (of which 450 are local dwellers) if the inhabitants in some offshore islands and inaccessible mountainous spots surveyed thoroughly. This total number counts in 22 Sumatran endemics, 37 Indonesian endemics and 36 species with limited distribution (Novarino *et al*., 2008). This assumption reflects the necessity to include offshore islands into the scheme of avian survey, as Sumatran species record is possible to increase as more information on species distribution added.

West Pasaman Regency was expanded as a new municipality based on Law No. 38 year 2003, along with two other new regencies in West Sumatra Province, Solok Selatan and Dharmasraya. As a new administrative area, the main regional income relies on agricultural sector, where the oil-palm plantation become the frontier on agricultural products. Oil-palm plantation covers more than 150 thousand hectares, along with overall area used to grow other agricultural products, embrace approximately 69.58% of total land area in this regency. Meanwhile, total area allotted for

conservation purpose reach less than 22% (Pemda Kabupaten Pasaman Barat, 2018). This ratio is quite worrisome for the sustainability of wildlife, considering some localities in this regency had been recorded in some old bibliographies regarding the historical finding of important tropical wildlife species (such as infamous Mount Ophir which was frequently mentioned in the two volumes of Wallace's The Malay Archipelago and some other later publications). Moreover, the optimum extent of the biodiversity and wildlife in this area may have been unexplored.

Genetic Heat Index (hereinafter GHI) is a rating system used, initially, to know the conservation value of plant species based on their global distributions or endemism (Hawthorne, 1996). Later on, this methodology was found suitable to be applied on other organisms and adequately fond for adaptation to specific conditions in certain area; it generates such biodiversity measures for various individual sites, that determined which site should be prioritized for various land use (or in this case for conservation priority) (Vermeulen and Koziell, 2002). As West Pasaman Regency has various landscapes which spans from sea level up to close to 3,000 meters of mountainous peak, as well as it has been sufficiently surveyed for its biodiversity for quiet of period, we perceived that the GHI concept is suitable to describe the conservation value across the landscapes without being necessarily complicated by their physical and differences. This study aims to address the avifauna diversity in four different landscapes in West Pasaman Regency, which become the basis to calculate sites' GHI value using the conservation status of their avifauna diversity.

MATERIAL AND METHODS

Study Sites and Times

The study was conducted in 4 locations within West Pasaman Regency, Western Sumatra, namely: Mt. Talamau, at GPS coordinate of 0º6'30.97"N 99º56'39.93"E and 850-2600 m elevation, this location was visited for seven days between 27 December 2015 to 2 January 2016; 2Lake Laut Tinggal at GPS coordinate of 00º28.556'N, 99º40.193'E and 1612 m elevation, it was surveyed within the last week of January 2016 for seven days; Tongar River, at 0º 9'12.41"N, 99º54'13.46"E, 100-300 m elevation, it was inspected for its bird diversity in two separate occasion of two days in March 2016 and two days on June 2016; and Panjang Island, at 00º11'7.41""N and 99º18'31.44"E, 0-30 m above sea level, in where the data collection was conducted for four days between 19-22 May 2017.

The first and second sites both represented high elevational landscapes, which due to its accessibility, Mt. Talamau receives more visitors than Laut Tinggal Lake. As consequence, the later site impacted less by human interferences. Laut Tinggal Lake was formed from crater of ancient volcano, which later filled with water and now become the upstream for some important rivers in West Pasaman Regency. The third site is a mixed riparian-agricultural area (oil-palm, rubber and other horticulture plantations) with slash-burn land processing becomes the preceding trait for starting a plantation; human disturbance in this site, therefore, is profound. The last site is a small populated offshore island, one kilometer from Air Bangis beach which also serves as the sanctuary for coral reefs and marine biotas, including sea turtles (Ermayanti, 2010; Oktarina *et al.*, 2013). Most of the sites have lack information about their avifauna, except probably for Mount Talamau.

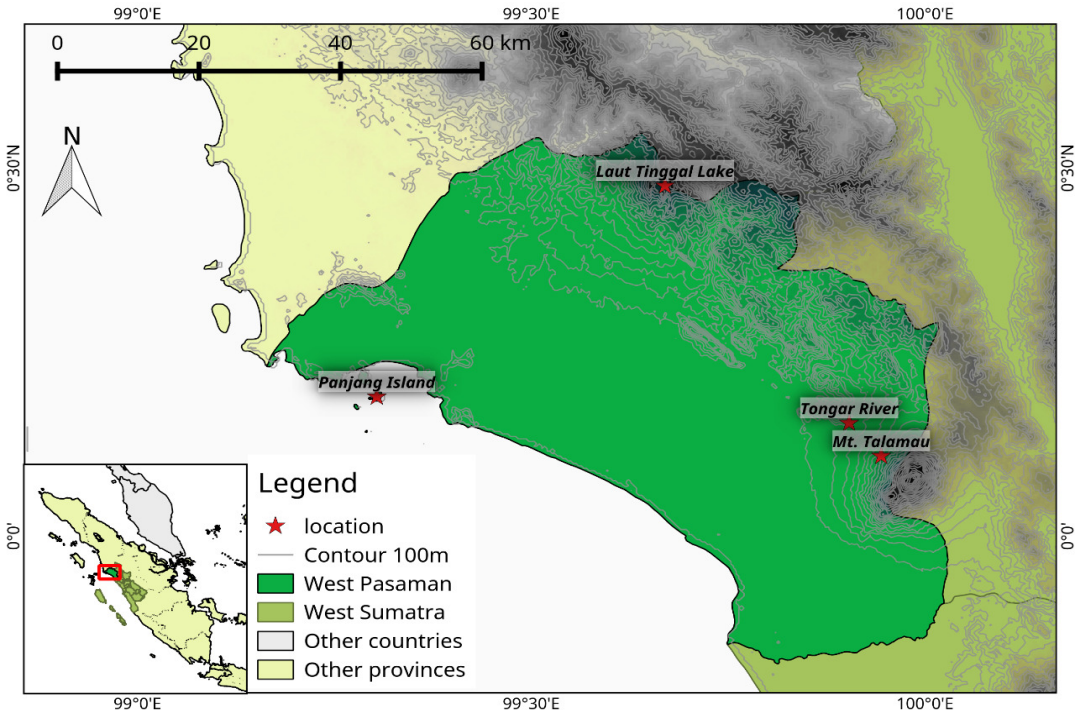

Figure 1. The map of the study site in the coastline of West Sumatra Province

Data Collection

The field survey method was used in this study by deploying two data collection techniques which were carried out simultaneously in each site. MacKinnon Lists (MacKinnon and Phillips, 1993) was in use to get the primary data of species inventory through audio-visual identification on bird species. The number of target species was reduced in each list into ten species to adjust with the birding skill of survey participants and their visual prowess. Observations were conducted in early morning between 7-9 am and in the afternoon between 3-5 pm during good weather, where birds could be clearly spotted with 42x10 Bushnell and Nikon binoculars. A 2-3 km pathway in each site (i.e. island coastline in Panjang Island, hiking trails in the other sites) served as the trajectory for conducting the MacKinnon Lists technique, exhaustively surveyed or until it reached less than 10% increment of new species added into the subsequent list. In addition, mist-netting technique, with six nets of total 72 m length (due to the size and condition of terrain, we were only able to set up four nets in Panjang Island) were used to supplement the audio-visual data by capturing cryptic and secretive species; the technique was conducted following established protocol (Bibby *et al.*, 1998; Novarino *et al.*, 2008). Species identification was guided with MacKinnon *et al.* (2000) and Eaton *et al.* (2016), while taxonomic orders consulted to Sukmantoro *et al.* (2008)

Data Analysis

The bird inventory was then sorted out using national and international conservation status, that are: 1) legislation of Republic of Indonesia, 2) categories set by the IUCN Red List of Threatened Species (see www.iucnredlist.org), 3) trading status according to the Convention on International Trade in Endangered Species – CITES (see www.cites.org) and 4) distributional status of species (i.e. migrant or endemic) using information provided by aforementioned guide books. Bird inventory of each locality was then compared to highlight the similarity and diversity of bird

species across sites using Jaccard Index (Chao et al. 2005) by employing the following formula:

$$Jaccard\ Index\ (JI) = \frac{Sc}{Sa + Sb + Sc}$$

Where; Sa = Samples that are unique in Site a, Sb = Samples that are unique in Site b, Sc = Samples that are common in both sites. Finally, Genetic Heat Index (GHI) was calculated based on the formula proposed by Vermeulen and Koziell (2002) as follow:

$$\text{Genetic Heat Index (GHI)} = \frac{27\ \text{Black} + 9\ \text{Gold} + 3\ \text{Blue}}{\text{Black} + \text{Gold} + \text{Blue} + \text{Green}}$$

Where;

- Black category signifies all bird species with IUCN Red List's Extinct in the Wild (EW), Critically Endangered (CE), Endangered (EN); or those that enlisted as Appendix I by CITES; island or country endemics or birds with limited distribution.
- Gold category include all birds protected by Indonesian national law (Law No. 5 Year 1990 and Governmental Regulation No. 7&8 Year 1999), all regional endemic species (distributed across two or more countries); IUCN Red List's Vulnerable (Vu), Near Threatened (NT); birds with Appendix II by CITES.
- Blue category covers all migrant/vagrant species or species with Conservation Dependent (CD) status according to IUCN Red List.
- Green category is for all species that not included in above criteria, such as Data Deficient (DD) and Least Concern (LC) by IUCN Red List.

In case a species has more than one conservation status, the highest one will be used in the calculation. This equation determines the actual conservation value of certain site or locality, independently to the total number of individuals observed per species or total species inventory. The formula concerns more on species with the conservation status and the typical distributional range of each species, rather than depend on site's species richness, the effort given in each survey conducted or skill level of surveyor. As this equation solely depend on the conservation status of the species, the locality of the regarded species is neglectable and therefore, the comparison among different sites can be made in order to answer the research question. Species inventory, similarity, diversity and GHI value from each site are then compared and discussed.

RESULTS

Total Bird Species and Similarity between Sites

In overall, we recorded 118 bird species across the four research sites. These species belong to 40 families and 12 orders, where Passeriformes becomes the order with the most species recorded. No species is commonly observed in all sites, as previously presumed due to the differences of landscapes' conditions. The two higher sites, Laut Tinggal Lake and Mt. Talamau, were characterized with bird species from higher altitude as well as the dwellers of primary forest, such as some hornbill species. In Panjang Island, we observed 30 bird species, while in Laut Tinggal Lake, Mt. Talamau and Tongar River respectively 57, 29 and 58 species (Appendix 1). The size of site may affect the resulted species inventory, in addition to its accessibility, type of habitat and surveyor's birding skill dedicated in each site. As all bird surveys were carried out and led directly by the author, who

deployed similar methodology, hence the result from each site were supposed to be comparable to answer the research question.

The bird inventory in Panjang Island was possibly and temporally representing the actual species number, as the survey coverage encompassed more than 90% of island area. However, we still hold an assumption that Panjang Island may have some migrant bird species that were absence during our observation effort there, as it was conducted around their breeding season. The same assumption, for different reason, is retained for the other three sites which spacious grounds were not completely covered during their respective survey and plenty of bird species became overlooked. Suppose more time and effort given in the future surveys, we believe that complete inventory birds will be yielded, which in turn reveal the actual GHI value of the sites. Below, we present the total account of birds recorded in the four landscape sites, followed by the similarity index among study sites.

Panjang Island and Mount Talamau may have less species number than the other two sites, however, Panjang Island retained specific water birds from order Ciconiiformes and Charadriiformes. Two raptors, Brahminy Kite and White-bellied Sea-eagle, were only observed in this island. The species number in Mount Talamau did not necessary reflect the actual species number existing there. Unpredictable mountainous weather (including gale, fog and frequent downpour) had caused somewhat visual limitation during survey days in this site. Despite efforts paid in this site, survey resulted in less species visually identified; nevertheless, a notable observation was made on Graceful Pitta *Pitta venusta*, a Sumatran endemic that among of its described type specimens were collected from the nearby Mount Ophir or Mount Pasaman (MacKinnon *et al.*, 2000). The situation was fairly different during the surveys in Laut Tinggal Lake and Tongar River, as most of field days were marked with bright-sunny weather. This weather condition favored the activity of avifauna which in turn improve the feasibility for bird-sighting (Bibby *et al.*, 1998; MacKinnon *et al.*, 2000). Some species, such as Olive-winged Bulbul was only observed in Panjang Island, albeit that bulbul group was considered as common inhabitants in all type of habitats. This species seems to prefer mixed vegetation in lower altitude more than the other bulbuls recorded in this study (MacKinnon *et al.*, 2000; Eaton *et al.*, 2016); in adversely, the Asian Red-eyed Bulbul was observed existing almost in all sites. Copper-throated Sunbird was also found only in Panjang Island, reckoning that this species has certain affinity with mangrove vegetation. In the other hand, several families in Passeriformes which are typical in old secondary or primary forest such as Turdidae, Timaliidae and Muscicapidae were absent in the island. This may indicate that the island has no primary coverage, where these groups usually prefer.

Table 1. Similarity on bird community between the pairs of localities

	Tlm	LTL	Tngr
Ppan #common species	0(59)	6(77)	19(71)
Community similarity	0.00	0.07	0.27
Tlm #common species	-	15(65)	7(80)
Community similarity		0.23	0.09
LTL#common species	-	-	17(74)
Community similarity			0.23

Note: Tlm (Mt. Talamau), LTL (Laut Tinggal Lake), Tngr (Tongar River), Ppan (Panjang Island). Figure in brackets indicates total number of species in a site pair

The pair of Panjang Island-Tongar River has the biggest Jaccard Index (0.27), followed by Mount Talamau-Laut Tinggal Lake and Laut Tinggal Lake-Tongar River pairs (each 0.23). The rest of site pairs have similarity indices less than 0.10; Mount Talamau-Tongar River pair 0.09, Laut Tinggal Lake-Panjang Island pair 0.07 and Mount Talamau-Panjang Island pair 0.00 (Table 1). The Panjang Island-Tongar River are both having the most similar features, such as connection to aquatic body (sea or river), high daily temperature, human modified habitat and gapped vegetation coverage as land fragmented by plantations or settlements. Black Eagle, Zebra Dove, two species of Coucal, Collared Kingfisher, bulbuls, tailorbirds were among the common species between the two localities. Mount Talamau-Laut Tinggal Lake pair is understandably to similarly possess highland bird species, as both are located in high altitude (above 1500 m) and with typical habitat of high tropical rainforest; Barred Cuckoo-dove, Indian Cuckoo, Red-bearded Bee-eater, Scarlet Minivet, Siberian Blue-robin, Chestnut-naped Forktail, Grey-throated Babbler were some of the highland bird species found in both sites. The interesting similarity was seen on Laut Tinggal Lake-Tongar River pair, with similarity index 0.23, equivalent to the Mount Talamau-Laut Tinggal Lake pair. Both sites in this pair resembles each other in the term of being riparian area, albeit Laut Tinggal Lake is slightly higher in altitude and less affected by human activity. In both sites, we observed the Vulnerabele Short-toed Coucal, some bulbuls and tailorbirds. Mount Talamau-Tongar River pair still retain 0.09 similarity, as both sites are in adjacency; some species like Crested Serpent-eagle, Barred Cuckoo-dove, Spectacled Bulbul, Tiger Shrike and others are still able to move between site. Meanwhile, Laut Tinggal Lake retained 0.07 similarity index with Panjang Island, as three species of Bulbul and three species of Tailorbird were observed as common in both sites. The mountainous habitat of Mt. Talamau was presumably different in large than the offshore habitat of Panjang Island, thus significantly reduced the possibility to have common species between the two sites, resulting in two distinct bird communities (similarity index 0.00).

Genetic Heat Index

We determined the conservation status of each bird species (see the column with heading 'Status' in Appendix 1) before categorizing it into Black, Gold, Blue and Green according to the degree of their conservation status, as stated in the research methodology section above. We then calculated GHI value for every site using the given formula. Table 2 summarizes the total number of each color category for Mount Talamau, Laut Tinggal Lake, Tongar River and Panjang Island, followed respectively by its calculated GHI value.

Table 2. Total species weighted into categories based on their conservation status (Black, Gold, Blue and Green) and GHI for each locality

Category	Mt. Talamau	Laut Tinggal Lake	Tongar River	Panjang Island
Black	2	6	3	1
Gold	6	7	16	11
Blue	4	6	3	0
Green	17	38	36	18
GHI value	4.14	4.26	4.03	4.20

Tongar River showed the lowest index among all sites, despite it had the most birds with gold category. Birds with this category in this site were mostly from protected-by-law raptor and sunbird species, yet they have wide distribution and not typical in habitat preference since they seem adaptable to various habitats. Although species with black, gold and green categories have the most influence as nominator within the formula and determine the ultimate GHI value of a site, the number of species with green category still plays important role as denominator. It is indeed that the "green" species defined to have no conservation concern attached, relieving the comparison to be made across sites with striking difference number of "green" species (Vermeulen and Koziell, 2002); in such way that Panjang Island, which is less in size and more constrained with surrounding sea than other sites, have comparable GHI value with other sites with more species inventory, i.e. Laut Tinggal Lake and Mt. Talamau. Furthermore, the high GHI score should not only be looked as the indicator or importance of certain site or area, in fact, it becomes a warning about the imminent precarious situation regarding the protected species, as there is a handful of these high value species use the same habitat. This situation will potentially lead to the critical situation for the whole wildlife community, as they tend to compete for relatively similar, and even limited, resources (e.g. space, food and others.

DISCUSSION

Birds' diversity, as well as their community composition changes following the increase of elevational gradient of the habitats (Blake & Loiselle, 2000). As the number of species tend to decrease while the altitude increases, those inhabiting the high altitude of mountain area show some adaptation to the harsh environment conditions; it is reflected from, among other things, the size of clutch (Boyce et al. 2015). Beside harboring the typical high elevational resident species, the mountain sites also play important role as the stop-over for various migrant birds in tropical region, as these tropical sites enriched with additional food resources such as fruits, nectars, epiphytic vegetations and bamboo thicket, to sustain the incoming migrants (Wilson & Martin, 2005; Boyle & Martin, 2015). The records of a handful of migrant species and forest interior dwellers from the families Turdidae, Timaliidae, Muscicapidae and Bucerotidae in Mt. Talamau and Laut Tinggal Lake were in line with these findings, as they were not observed from other lower elevations.

Tongar River has the richest bird species for at least two reasons; 1) its intermediate elevational position which according to the observation from Acharya et al. (2011) at the intermediate elevation of Himalaya mountainous region found it as the site with the most bird diversity; and 2) being a suitable habitat for birds through the existence of mixed-plant agricultural area with various plant commodities such as palm-oil, rubber, mahogany, candle nut and other fruit trees, interspersed with annual or biannual crops. Imai et al. (2017) addressed that such mixed-vegetation habitat preferable to accommodate various frugivorous, insectivorous birds, as well as become the alternate habitat for forest birds (the Great Argus, *Argusianus argus*, which recorded only in this area was a forest dweller bird). The in-between plantation area in Tongar River site, which usually used as paddy or corn field instead of being barren land, was also favorable by some raptors (Crested Serpent-eagle and Black Eagle) for their hunting area. As the intermediate elevation site, Tongar River hold similar bird diversity with either the higher or lower site. It may signify another important role of this site to buffer the animals (in this regard birds) from the higher or the lower area, although some sensitive species may refrain from this area due to intensive human interference (Graham *et al.*, 2014).

The lowest site in this study, Panjang Island, represented the coastal and marine ecosystem where the bird community herein distinguished by the sizeable bird families; Ciconiiformes and Charadriiformes. As part of distinct group called as "shorebirds" or "waders", these groups have been used as environmental indicators (Becker, 1989). As the shorebirds have been experiencing tremendous population loss elsewhere (BirdLife International, 2008), it is urgent to pay attention on this bird group in order to monitor the quality of marine ecosystem in west coastline of Sumatra. Unfortunately, the shorebirds in this side of coastline receive lack of attention compared to the east coast of Sumatra, despite some migrant species use it as wintering ground or migration stop-over (Janra in prep.).

GHI index is a recent concept in determining conservation priority over several alternative area, landscapes or region (Vermeulan & Koziell, 2002). It works indiscriminately over variety of habitat types, counting only on the conservation status of the species recorded in each habitat and neglecting the requirement for an "apple to apple" comparison. Beyond calculating the site's GHI to see how "hot" it is, no less important to treat each individual site as careful as possible when analyzing the species that contribute to the total index value. The composition of black, gold and blue species indeed determines the GHI value, however, the lower color coding should not be treated any less than the higher one. An area with dozens blue species may have higher GHI value than another area with several gold or black species. The species with green category, which serves as denominator in GHI formula, still retains a meaningful function for interpreting the overall condition of a concerned area. An area with many green category species and low blue, gold or black species may have small GHI number, but it is actually a healthy environment as many species still retain viable population. In contrary, an area with significant number of blue, gold or black species possess more threats to those species or to their environment.

Determining the GHI value is a mean to prioritize conservation action over various alternate areas, especially when the resources to conduct the efforts are limited. Consequently, the efficient allocation of resources for conservation should be impacting the maximum number of species in such regard, as well as addressing the threats which possibly hamper the success of the conservation effort (Wilson *et al.*, 2006). In this study, Laut Tinggal Lake is the site with the most "black" species, which should make it as "the hottest" pick for conservation priority in West Pasaman Regency. What have to be borne in mind when picking the GHI-recommended Laut Tinggal Lake that this site was not independently detach from other area to maintain its biodiversity. In fact, the protection on all elevational site should be recommended from this study, recall the interconnected between elevational sites, the similarity of bird species and comparable GHI value. Having only four landscapes known for its GHI value is indeed insufficient to maximize the assimilation of conservation aspect into regency developmental plan. Eventually, we still remarkably know little the actual bird diversity in all major landscapes of West Pasaman Regency which is needed to completely understand the overall conservation importance. It may call for more systematic survey, monitoring and research in various unstudied parts of the regency to provide a thorough picture of its avifauna diversity.

CONCLUSIONS

This research has recorded 118 bird species within some important sites in West Pasaman Regency. Despite the difference on its bird species, diversity and typicality in each site, the Genetic Heat Index value for each site is almost similar in number, which are 4.14 for Mount Talamau, 4.26

for Laut Tinggal Lake, 4.03 for Tongar River and 4.20 for Panjang Island. While the figure of GHI may signal the conservation priority on one site over others, it is needed to further analyze each individual site by looking at its composition of color ranked species that contribute for the GHI value, as it will help delivering an effective conservation action. The ecological and GHI value across sites may signal the needs to extend the protection effort to all sites.

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REFERENCES

Abdullah, A. I. Zahara, G. Wilson. 2016. The preliminary study on feeding behavior of male and female little egret (*Egretta garzetta*) in mangrove and rice field habitats based on peck frequency. Aceh Journal of Animal Science, 1(1): 39-44.

Acharya, B.K., N.J. Sanders, L. Vijayan, B. Chettri. 2011. Elevational gradients in bird diversity in the eastern Himalaya: An evaluation of distribution patters and their underlying mechanism. PLos ONE 6(12): 1-14.

Becker, P.H. 1989. Seabirds as monitor organisms of contaminants along the German North Sea coast. Helgoländer Meeresuntersuchungen, 43(3-4): 395-403.

Bennett, D.P., D.A. Humphries. 1974. Introduction to Field Biology. Second Edition. Edward Arnold, London.

Bibby, C., M. Jones, S. Marsden. 1998. Expedition field techniques – bird surveys. Royal Geographical Society, London.

BirdLife International. 2008. State of the world's birds: indicators for our changing world. BirdLife International, Cambridge.

Blake, J.G., B.T. Loiselle. 2000. Diversity of birds along an elevational gradient in the Cordillera Central, Costa Rica. The Auk, 117(3): 663-686.

Boyce, A.J., B.G. Freeman, A.E. Mitchell, T.E. Martin. 2015. Clutch size declines with elevation in tropical birds. The Auk, 132: 424-432.

Boyle, W.A., K. Martin. 2015. The conservation value of high elevation habitats to North American migrant birds. Biological Conservation, 192: 461-476.

Chao, A., R.L. Chazdon, R.K. Colwell, T-J. Shen. 2005. A new statistical approach for assessing similarity of species composition with incidence and abundance data. Ecology Letter, 8: 148-159.

Eaton, J.A., S. van Balen, N.W. Brickle, F.E. Rheindt. 2016. Birds of the Indonesian Archipelago. Greater Sundas and Wallacea. Lynx Edicions, Barcelona.

Ermayanti. 2010. Adaptation Strategy of Elder Fishermen and Its Relationship with Social Defense. Case Study in Air Bangis Villages, Sungai Beremas Subdistrict, West Pasaman Regency. Report on DIPA Project, Andalas University, Padang.

Graham, C.T., M.W. Wilson, T. Gittings, T.C. Kelly, S. Irwin, O.F.M. Sweeney, J. O'halloran. 2014. Factors affecting the bird diversity of planted and semi-natural oak forests in Ireland. Bird Study, 61: 309-320.

Hawthorne, W.D. 1996. Holes and the sums of parts in Ghanaian forest: regeneration scale and sustainable use. Proceeding of the Royal Society of Edinburgh, 10B: 75-176.

Howes, J., D. Bakewell, Y.R. Noor. 2003. Shorebirds studies manual. Wetlands International – Indonesia Programme, Bogor.

Imai, H., T. Nakashizuka, M. Oguro. 2017. Environmental factors affecting the composition and diversity of the avian community in igune, a traditional agricultural landscape in northern Japan. Journal of Ecology and Environment, 41: 1-12.

IUCN. 2017. The IUCN Red List of Threatened Species. Version 2017-3. <http://www.iucnredlist.org>. Downloaded on 27 February 2018.

MacKinnon, J., K. Phillips. 1993. A Field guide to the birds of Sumatra, Java and Bali. Oxford University Press, London.

MacKinnon, J., K. Phillips, S. van Balen. 2000. A Field guide to the birds of Sumatra, Kalimantan, Java and Bali. Birdlife International – Indonesia Programme, Jakarta.

Novarino, W., H. Kobayashi, A. Salsabila, Jarulis, M.N. Janra. 2008. Panduan lapangan pencincinan burung di Sumatera. Nagao Natural Environment Foundation. PILI-NGO, Bogor.

Oktarina, A., E. Kamal, Suparno. 2014. Studies on coral reefs condition and their management strategies in Panjang Island, Air Bangis, West Pasaman Regency. Jurnal Natur Indonesia, 16(1): 23-31.

Pemda Kabupaten Pasaman Barat. 2018. Potensi daerah. Website Resmi Pemerintah Kabupaten Pasaman Barat, http://pasamanbaratkab.go.id/potensi/ Accessed on 1 March 2018.

Sujatnika, P. Jepson, T.R. Soehartono, M.J. Crosby, A. Mardiastuti. 1995. Melestarikan keanekaragaman hayati Indonesia: Pendekatan Daerah Burung Endemik. PHPA/Birdlife International - Indonesia Programme, Jakarta.

Sukmantoro, W., M. Irham, W. Novarino, F. Hasudungan, N. Kemp, M. Muchtar. 2007. Daftar burung Indonesia no. 2. Indonesian Ornithologists' Union, Bogor.

van Tyne, J., A.J. Berger. 1976. Fundamental of Ornithology. John Wiley and Sons, New York.

Vermeulen, S., I. Koziell. 2002. Integrating Global and Local Values: A Review of Biodiversity Assessment. International Institute for Environment and Development, London.

Wilson, K.A., M.F. McBride, M. Bode, H.P. Possingham. 2006. Prioritizing global conservation efforts. Letter. Nature, 440: 337-340.

Wilson, S., K. Martin. 2005. Songbird use of high-elevation habitat during the fall post-breeding and migratory periods. Ecoscience, 12(4): 561-568.

Appendix 1: Tabulation of species observed from four sites and their conservation status (Order in bolded capital letter, family in bold, species in regular font)

Classification (Order, Family, Species)	English Name	Cons. Status	Location			
			TLM	LTL	TNGR	PPAN
CICONIIFORMES						
Ardeidae						
Ardea alba	Great Egret	AB				x
Egretta sacra	Pacific Reef Egret	AB				x
FALCONIFORMES						
Accipitridae						
Haliastur indus	Brahminy Kite	II, AB				x
Haliaeetus leucogaster	White-bellied Sea-eagle	II, AB				x
Spilornis cheela	Crested Serpent Eagle	II, AB	x	x	x	
Ictinaetus malayensis	Black Eagle	II, AB			x	x
GALLIFORMES						
Phasianidae						
Argusianus argus	Great Argus	NT, II, AB			x	
GRUIFORMES						
Turnicidae						
Turnix suscitator	Barret Buttonquail				x	
CHARADRIIFORMES						
Laridae						
Sterna sumatrana	Black-naped Tern	AB				x
COLUMBIFORMES						
Columbidae						
Treron vernans	Pink-necked Green Pigeon					x
Macropygia unchall	Barred Cuckoo Dove		x	x	x	
Streptopelia chinensis	Spotted Dove				x	
Geopelia striata	Zebra Dove				x	x
CUCULIFORMES						
Cuculidae						
Cuculus micropterus	Indian Cuckoo	M	x	x		
Cacomantis merulinus	Plaintive Cuckoo			x	x	
Eudynamys scolopaceus	Asian Koel					x
Rhinortha chlorophaeus	Raffles' Malkoha		x			
Centropus rectunguis	Short-toed Coucal	Vu		x	x	
Centropus sinensis	Greater Coucal				x	x
Centropus bengalensis	Lesser Coucal				x	x
STRIGIFORMES						
Strigidae						
Bubo sumatranus	Barred Eagle-owl	II			x	
APODIFORMES						
Apodidae						
Hydrochous gigas	Giant Swiftlet	NT			x	
Collocalia esculenta	Glossy Swiftlet				x	
Hemiprocnidae						
Hemiprocne comata	Whiskered Treeswift				x	
CORACIIFORMES						
Alcedinidae						
Halcyon smyrnensis	White-throated Kingfisher	AB			x	
Halcyon chloris	Collared Kingfisher	AB			x	x
Actenoides concretus	Rufous-collared Kingfisher	NT, AB	x			
Meropidae						

Classification (Order, Family, Species)	English Name	Cons. Status	Location			
			TLM	LTL	TNGR	PPAN
Merops viridis	Blue-throated Bee-eater				x	
Nyctyornis amictus	Red-bearded Bee-eater		x	x		
Bucerotidae						
Rhyticeros undulatus	Wreathed Hornbill	II, AB	x	x		
Buceros rhinoceros	Rhinoceros Hornbill	NT, II, AB	x			
PICIFORMES						
Capitonidae						
Psilopogon pyrolophus	Fire-tufted Barbet			x		
Megalaima australis	Blue-eared Barbet					x
Picidae						
Sasia abnormis	Rufous Piculet		x			
Picus flavinucha	Greater Yellownape			x		
Picus miniaceus	Banded Woodpecker		x			
Meiglyptes tukki	Buff-necked Woodpecker	NT				x
Blythipicus rubiginosus	Maroon Woodpecker			x		
PASSERIFORMES						
Eurylaimidae						
Eurylaimus ochromalus	Black-and-yellow Broadbill	NT	x	x		
Psarisomus dalhausie	Long-tailed Broadbill			x		
Pittidae						
Pitta venusta	Graceful Pitta	E, VU, B	x			
Hirundinidae						
Hirundo tahitica	Pacific Swallow				x	x
Motacillidae						
Motacilla cinerea	Grey Wagtail	M		x		
Campephagidae						
Coracina larvata	Sunda Cuckooshrike			x		
Pericrocotus igneus	Fiery Minivet	NT			x	
Pericrocotus flammeus	Scarlet Minivet		x	x		
Hemipus hirundinaceus	Black-winged Flycatcher-shrike				x	
Aegithinidae						
Aegithina tiphia	Common Iora				x	
Aegithina viridissima	Green Iora	NT		x	x	
Chloropseidae						
Chloropsis spp.	Leafbird				x	
Pycnonotidae						
Pycnonotus atriceps	Black-headed Bulbul			x	x	
Pycnonotus melanicterus	Black-crested Bulbul		x		x	
Pycnonotus aurigaster	Sooty-headed Bulbul			x	x	x
Pycnonotus goaiver	Yellow-vented Bulbul			x	x	x
Pycnonotus plumosus	Olive-winged Bulbul					x
Pycnonotus brunneus	Asian Red-eyed Bulbul			x	x	x
Pycnonotus erythropthalmos	Spectacled Bulbul		x	x	x	
Criniger bres	Grey-cheeked Bulbul				x	
Tricholester criniger	Hairy-backed Bulbul			x		
Ixos virescens	Sunda Bulbul	E, NT		x		
Laniidae						
Lanius tigrinus	Tiger Shrike	M	x	x	x	
Turdidae						
Luscinia cyane	Siberian Blue Robin	M	x	x		
Enicurus velatus	Sunda Forktail	E		x		
Enicurus ruficapillus	Chestnut-naped Forktail	NT	x	x		
Myophoneus melanurus	Shiny Whistling Thrush	E		x		

Classification (Order, Family, Species)	English Name	Cons. Status	Location			
			TLM	LTL	TNGR	PPAN
Timaliidae						
Pellorneum capistratum	Black-capped Babbler				x	
Pellorneum buettikoferi	Sumatran Babbler	E, NT		x		
Malacocincla malaccense	Short-tailed Babbler				x	
Malacocincla sepiarum	Hosrfield's Babbler	E			x	
Pomatorhinus montanus	Chestnut-backed Schimitar-babbler			x	x	
Pnoepyga pusilla	Pygmy Wren-babbler			x		
Stachyris chrysaea	Golden Babbler			x		
Stachyris nigriceps	Grey-throated Babbler		x	x		
Macronous gularis	Striped Tit-babbler				x	
Macronous ptilosus	Fluffy-backed Tit-babbler	NT		x		
Garrulax mitratus	Chestnut-caped Laughingthrush				x	
Pteruthius flaviscapis	White-browed Shrike-babbler				x	
Heterophasia picaoides	Long-tailed Sibia			x		
Sylviidae						
Prinia familiaris	Bar-winged Prinia	E		x	x	x
Prinia flaviventris	Yellow-bellied Prinia			x	x	x
Orthotomus cuculatus	Mountain Tailorbird			x		
Orthotomus sutorius	Common Tailorbird				x	
Orthotomus ruficeps	Ashy Tailorbird			x	x	x
Phylloscopus borealis	Arctic Warbler	M	x	x	x	
Phylloscopus trivirgatus	Mountain Leaf Warbler			x		
Muscicapidae						
Muscicapa dauurica	Asian Brown Flycatcher	M			x	
Ficedula mugimaki	Mugimaki Flycatcher	M		x		
Ficedula westermanni	Little Pied Flycatcher		x			
Niltava grandis	Large Niltava	E	x			
Culicicapa ceylonensis	Grey-headed Canary-flycatcher			x		
Monarchidae						
Hypothimis azurea	Black-naped Monarch		x			
Rhipiduridae						
Rhipidura albicollis	White-throated Fantail		x	x		
Paridae						
Parus major	Great Tit			x		
Sittidae						
Sitta frontalis	Velvet-fronted Nuthatch			x		
Dicaeidae						
Prionochilus maculatus	Yellow-breasted Flowerpecker				x	
Dicaeum trigonostigma	Orange-bellied Flowerpecker		x		x	
Dicaeum cruentatum	Scarlet-backed Flowerpecker				x	
Nectariniidae						
Anthreptes malacensis	Brown-throated Sunbird	AB			x	x
Anthreptes singalensis	Ruby-cheeked Sunbird	AB			x	x
Hypogramma hypogrammicum	Purple-naped Sunbird	AB		x	x	
Leptocoma calcostetha	Copper-throated Sunbird	AB				x

Classification (Order, Family, Species)	English Name	Cons. Status	Location			
			TLM	LTL	TNGR	PPAN
Cinnyris jugularis	Olive-backed Sunbird	AB			x	x
Aetophyga siparaja	Crimson Sunbird	AB			x	
Arachnothera longirostra	Little Spiderhunter	AB		x	x	
Arachnothera chrysogenys	Yellow-eared Spiderhunter	AB		x	x	
Zosteropidae						
Zosterops palpebrosus	Oriental White-eye			x		
Estrildidae						
Lonchura striata	White-rumped Munia	E			x	
Lonchura punctulata	Scaly-breasted Munia				x	x
Lonchura maja	White-headed Munia				x	x
Ploceidae						
Passer montanus	House Sparrow				x	x
Ploceus philippinus	Baya Weaver				x	x
Dicruridae						
Dicrurus macrocercus	Black Drongo		x			
Dicrurus leucophaeus	Ashy Drongo		x	x		
Dicrurus annectans	Crow-billed Drongo			x		
Dicrurus paradiceus	Greater Racquet-tailed Drongo				x	
Artamidae						
Artamus leucorhynchos	White-breasted Woodswallow				x	
Corvidae						
Dendrocitta occipitalis	Sumatran Treepie	E		x		
Corvus enca	Slender-billed Crow			x	x	
Total			29	57	58	30

Remarks: Tlm (Mt. Talamau), LTL (Laut Tinggal Lake), Tngr (Tongar River), Ppan (Panjang Island). Conservation status: 1) IUCN Red List Category: NT (Near Threatened), VU (Vulnerable). 2) CITES status: Appendix (II). 3) Distribution status: E (Endemic), M (Migrant). 4) Indonesian Regulation: A (Indonesian Law No. 5 Year 1990), B (Government Regulation No. 7 & 8 Year 1999)

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