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NATURAL HABITAT OF BALI STARLING (*Leucopsar rothschildi*) IN BALI BARAT NATIONAL PARK, INDONESIA

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ABSTRACT

The Indonesian tropical savannas and dry forests provide habitats to various endemic wildlife. Unfortunately, a few of these endemic species are now seriously threatened and are red listed in the conservation status of International Union for Conservation of Nature (IUCN). Among these species, the Bali starling or Bali mynah *Leucopsar rotschildi*, locally known as Jalak Bali, is now mostly restricted to the Bali Barat National Park. Given the high extinction risk faced by such species, conservation programs require multidisciplinary approaches that would address both the biological attributes of the species itself and their habitat requirements. Regrettably, for many species, their habitat ecology remains inadequately understood. Hence, this study aimed to: 1. characterize the Bali starling habitat in terms of structure and floristic composition; and 2. document evidences of vegetation cover changes in the Bali Barat National Park. Analysis of remote sensing imagery and field sampling for vegetation attributes were conducted to address these objectives. Normalized Difference Vegetation Index (NDVI) was calculated from Landsat imageries using red and near infrared bands. Tree cover percentage data were downloaded from Vegetation Continuous Fields (VCF) of the University of Maryland's website. Results showed that forest and savanna are the dominant land cover types in the Bali Barat National Park. However, their distribution is somewhat dynamic with changes in vegetation cover and greenness found across the years which increase the cover of woody plants is the general trend. The Bali starling in the Bali Barat National Park is mostly found at or near distinct vegetation boundaries, such as the borders between savanna and forest, savanna and cropland, savanna and shrubland, settlement and cropland and, between forest and shrubland. Although Cekik in Jembrana, Bali and Brumbun Bay in West Bali, as the conservation sites for Bali starling, are both planted with tree species providing shelter and food for Bali starling, the bird has not been seen in the two areas since the 1990s. These results further confirm the importance of examining the habitat patterns of endemic birds within a landscape that are influenced by multiple factors interacting in space and time. Addressing data inadequacy in habitat patterns of endemic species distribution is crucial in developing conservation management strategies. Hence, evaluating the habitat remnants of the Bali starling is vital for its conservation and needed reintroduction and eventual release to its natural habitat.

Keywords: Bali starling, habitat suitability, savanna

INTRODUCTION

Tropical savannas and dry forests are important ecosystems which comprise those habitats supporting various endemic wildlife of Indonesia. A few of these species are now under serious threat of extinction and, consequently, have high conservation status according to the IUCN (IUCN 2014), including Banteng (*Bos javanicus*) that is now mostly confined to the savanna in the Baluran National Park of East Java Province, the Komodo Dragon (*Varanus komodoensis*) which is endemic to the Komodo Islands of East Nusa Tenggara Province, and the endemic Bali starling bird (*Leucopsar rotschildi*) which is now mainly found in the savanna of Bali Barat National Park (BBNP) on the northwest tip of Bali Province. Unfortunately, the rapid and widespread habitat loss and variable management capacities in natural reserves had posed considerable risk to biodiversity (Purwandana *et al.* 2014).

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The critically endangered Bali starling (*Leucopsar rothschildi*) is the only endemic bird found in Bali. The first Bali starling known to science was collected near Bubunan, Bali and was described by Stresemann (1912). The Bali starling is an attractive aviary bird being largely white, with black wings, tail tips and bare skin of a turquoise-blue color on the lores and behind the eye. On account of its restricted range, extremely small numbers growing in the wild and persistent pressures on the last free ranging birds, the Bali starling is considered critically endangered according to the latest International Union for Conservation of Nature (IUCN) threat categories (IUCN 2014). Habitat destruction and bird capture for the pet trade brought the species to the verge of extinction (van Balen *et al.* 2000). In 1998, estimates showed that less than 20 birds remained in the wild within a small area on the northwest tip of Bali Island within the boundaries of Bali Barat National Park (BBNP) (Collins *et al.* 1998). Although the wild population is near extinction, Bali starlings have been successfully bred in captivity (Collins *et al.* 1998).

The species' original habitat in Bali was described as 'dry savanna and shrub woodlands' and 'tall and dense forest' in the 1920s (van der Paardt 1926), and until this time it was believed to be historically restricted to a narrow belt of dry monsoon climate in Northern Bali and East Java (van Balen *et al.* 2000). From 1920-1960, its range had shrunk to the fire-induced open shrub and savanna woodland, found below an elevation of 150 - 175 masl in the northeast part of the Prapat Agung Peninsular within the BBNP (van Balen *et al.* 2000). Bird distribution and abundance patterns within a landscape are influenced by multiple factors interacting spatially and temporally (Orians & Wittenberger 1991). Habitat structure and floristic composition, such as percentage of canopy cover, tree species diversity and the distribution of specific plant taxa, are known to have significant roles in defining the spatial occurrence of bird species (James & Wamer 1982; Rice *et al.* 1984; Wiens & Rotenberry 1981).

With the high extinction risk faced by such species, intended conservation programs are likely to require multidisciplinary approaches that would address both the biological attributes and resource requirements of the species, such as their habitat requirements and conditions (Estoque *et al.* 2012). Therefore, habitat evaluation is important in the conservation of Bali starling and its reintroduction and eventual release back to their natural habitat. Moreover, knowledge and better understanding on the potential distribution and habitat suitability of the Bali starling is important in selecting potential sites for future *ex-situ* conservation and breeding programs designed to save this endemic bird from its extinction. Several studies on the Bali starling have focused on the bird itself; ranging from its behavior, reproduction, breeding, genetics, taxonomy, demography and reintroduction, among others (Collins & Smith 1994; Collins *et al.* 1998; De Iongh *et al.* 1982; Dirgayusa *et al.* 2000; Seibels *et al.* 1997; Williams & Feistner 2006). However, studies on the habitat of Bali starling are scarce (Widodo 2014), considering that these habitats are vital to the ongoing maintenance of its viable populations, and yet are also very prone to conversion, disturbances and degradation. Therefore, this study aimed to: 1. describe the current distribution of Bali starling and characterize its habitat structure at the Bali Barat National Park in terms of its plant community structure and composition, and 2. assess the cover and greenness index (NDVI) to quantify the dynamics of vegetation cover in these habitat areas; and 3), assess the degree of recent habitat changes broadly affecting the Bali starling species at Bali Barat National Park (BBNP).

MATERIALS AND METHODS

The Bali Barat National Park (BBNP), located on the northwestern side of Bali, Indonesia, covers around 19,000 ha (~ 5% of Bali's total land area) comprising 15,588 ha of terrestrial areas and 3,415 ha of marine habitats. A seaport at Gilimanuk is situated on the west of the park. BBNP is also bordered with several villages and can be reached by roads from Gilimanuk and Singaraja, or by using ferries from Ketapang, East Java. Several major habitat types are found in the national park; savanna, mangroves, montane and mixed-monsoon forests, and, coral islands. Bali Barat was designated as a National Park in 1984 based on the Ministry of Forestry decree (No. 096/Kpts-II/1984). The area is predominanly of the latosol soil type, reddish in color, weakly crumbed and sticky when wet although hardened and cracked when dry. The park is topographically varied, ranging from plains near the coast to steep hills and mountains. It has four mountains, namely Prapat Agung, Banyuwedang, Klatakan and Sangiang *(*the highest peak at 1,414 m). Off the coast, four islands are also under the BBNP jurisdiction, namely Menjangan, Burung, Gadung and Kalong Islands. BBNP has a moderate climate seasoned with monthly rains, but higher rainfall occurs during the wet season in December to February. The average annual rainfall ranges from 900 - 1,500 mm and average temperature is at 33°C (Masy'ud *et al.* 2008; Masy'ud *et al.* 2007; Whitten *et al.* 1996).

Reports on the Bali starling population, distribution and their habitat were obtained through the published literature and also via personal communications with BBNP rangers and managers. Data on its local distribution were obtained from De Longh *et al.,* (1982), Whitten *et al.,* (1996), van Balen *et al.*, (2000) and BBNP manager, Wiryawan, (2014, pers.comm.). Based on these studies, the Bali starling occurrence data were divided into three eras of distribution, namely 1984, 1994 and 2010, considering the only 3 years of reliable and accurate surveys done on these years. An overlay analysis of these Bali starling location data was done using Indonesia's topographical/ earth surface map (Rupa Bumi Indonesia/RBI) for the year 2001 (scale 1 : 80,000) obtained from the Indonesian Geospatial Agency (BIG/BAKOSURTANAL). The 2001 land use data was the most recently available. To avoid misalignment, all the data used the same datum and the same map projection within the GIS (WGS 1984-UTM, Zone_50).

The Vegetation Continuous Fields (VCF) collection contains proportional estimates for vegetative cover types: woody vegetation, herbaceous vegetation, and bare ground. The product is derived from all seven bands of the MODerate resolution Imaging Spectroradio-meter (MODIS) sensor onboard NASA's Terra satellite. This continuous classification scheme of the VCF product may depict areas of heterogeneous land cover better than traditional discrete classification schemes. While traditional classification schemes indicate where land cover types are concentrated, this VCF product is best for showing how much of a land cover such as "forest" or "grassland" exists anywhere on a land surface (DiMiceli *et al.* 2011).

NDVI is an index derived from remotely sensed imagery which can differentiate between vegetation types by showing the difference between near infrared (which is strongly reflected by vegetation) and red light (which is absorbed by vegetation). NDVI is correlated to vegetation biomass, vigour and photosynthetic activity. This index exploits the reflectance patterns of ground elements in the red (R) and near-infrared (NIR) bands of the electromagnetic spectrum to distinguish green vegetation from its background soil brightness, and is calculated as (NIR - R)/ (NIR + R). NDVI values range from -1 to 1, with positive values representing vegetated areas and negative values representing non-vegetated regions (Sankaran 2001). The NDVI ratio approach usually adopted for land cover change estimation is used here in preference to the more commonly employed post-classification pixel-by-pixel comparison method (Lillesand *et al.* 2008) since it also permits identification of areas where changes in vegetative cover have been significant, but insufficient to cause change in class membership (Sankaran 2001).

In order to generate normalized difference vegetation index (NDVI), a number of Landsat images were used. Landsat images were downloaded from http://earthexplorer.usgs.gov/path 117, row 066. The chosen downloaded images are those with minimal cloud cover percentage by selected scenes with at least image quality level 9 (no errors detected, perfect scene) (Table 1).

Table 1 Details of downloaded images for NDVI analysis

Images	Source	Date acquired	Spatial Resolution	Image quality	Cloud cover
1	Landsat 4	21/03/1989	30 x 30 m	9	20
2	Landsat 7	12/11/1999	30 x 30 m	9	8.63
3	Landsat 7	31/05/2003	30 x 30 m	9	7.53
4	Landsat 8	11/06/2016	30 x 30 m	9	24.99

NDVI was generated using the NDVI feature in ArcMAP (ArcGIS 10.1) image analysis toolbar. Band 1, 2, 3, and 4 were chosen for Landsat 4 and 7, whereas band 2, 3, 4, and 5 were chosen for Landsat 8 as input images in ArcMAP which represent the blue, green, red and near infrared (NIR) bands. By choosing the image analysis tab, all the bands layers were merged into one composite layer and then the RGB (Red-Green-Blue) channels were adjusted to show just the NIR, red and green bands to extract the NDVI values. Once NDVI images were generated, different levels of a green color scheme was applied for easier interpretation. These NDVI values must be used carefully as they represent only one time in the chosen years (due to the limited availability of good images for the chosen years) and as these will mainly reflect recent rainfall, especially in terms of groundcover. Then the data points for the 1984, 1994 and 2010 Bali starling locations were overlaid on the NDVI images from different years (1989, 1999, 2003 and 2016). These years were chosen because these years were the closest years to the years of Bali Starling location (as clear image of the exact years of Bali Starling location cannot be found). The mean and SD from nine pixel values surrounding the exact coordinate locations of the Bali starling was then calculated from the NDVI images. Changes in mean NDVI of starling locations between different years were tested for significance using ANOVA in SPSS and, when significant differences were detected, a post-hoc test was performed.

From 1979 to 1994, the Bali starling was regularly observed in Brumbun Bay, West Bali. From 1995 to 2009, no survey was done in the area, therefore no Bali starling data were obtained from these locations. In 2010, the surveys conducted by BBNP has recorded Bali starling population in this location again. At another site, Cekik in Jembrana, West Bali, the Bali starling was also observed during the period 1979-1994, but in the 2010 survey, BBNP did not find the starling in the area. Fieldwork was again conducted in November 2014 in these two locations, namely Cekik and Brumbun, and these areas were cross-checked with a fire map based on MODIS burned areas produced from year 2000 to 2013 to obtain information on fire history. However, no fire occurred at these localities. The Landsat imagery during this period also confirmed that no major fires occurred at BBNP.

During the dry season in September to November 2014, ten sampling plots of 50 x 50 m were established randomly in each savanna sites (Cekik and Brumbun). In each of the 50 x 50 m plots, smaller plots of 5 x 5 m were nested randomly. Inside the 50 x 50 m plot, all the tree species ≥ 10 cm diameter at 1.3.m height (dbh) were identified, measured and recorded. In the smaller-nested plots, all the groundcovers species were noted (grasses, herbaceous and ferns) and their coverages were estimated. Species in each site were identified in the field where possible and a field herbarium was created for easier identification at the species level during subsequent field works. The identification was assisted by personnel from herbarium Bogoriense and herbarium Baliensis of the Indonesian Institute of Sciences (LIPI) who used flora books such as the "Flora of Java" (Backer & van den Brink 1963), "Mountain Flora of Java" (van Steenis 1972), "Weeds of Rice in Indonesia" (Soerjani *et al.* 1986), " Ecology of Java and Bali" (Whitten *et al.* 1996) and "Ecology of Nusa Tenggara and Maluku" (Monk *et al.* 2000) and names were standardized based on the Plant List (www.theplantlist.org).

The Importance Value Index or IVI (Kent 2011; Kent & Coker 1992) was calculated for each species in each plot to understand the structure and plant community composition of each savanna. IVI was used to describe the quantitative structure of the community (Curtis & McIntosh 1950; Kent & Coker 1992). This value represents the contribution of a species to the community in terms of the number of plants within the quadrats (density), its contribution to the community through its distribution (frequency), and its influence on the other species through its dominance. The Importance Value Index was calculated for each tree species and ground cover in each of the study sites.

The differences in plant community composition between Brumbun and Cekik savanna were tested using abundance data (cover). The data were square-root transformed prior to constructing a resemblance matrix based on the Bray-Curtis similarity index (Valessini 2009). A Non-metric Multidimensional Scaling (NMDS) ordination diagram was then generated based on the resemblance matrix. The difference in species composition between savannas was then tested for significance using one-way ANOSIM (analysis of similarity). The R_{ANOSIM} statistic values, generated by ANOSIM, are a relative measure of separation of the *a priori* defined groups. A zero (0) value indicates that no significant difference existed among the groups, and one (1) value indicates that all samples within groups are more similar to one another than any samples from different groups (Clarke 1993). This multivariate analyses made use of the PRIMER v.6 package (Clarke & Gorley 2005).

RESULTS AND DISCUSSION

Based on the bird observations analysis, the starling is mostly found in a relatively open vegetation (such as savanna and open shrubland) and along their boundaries with other vegetation types in the Bali Barat National Park (BBNP) (Fig. 1). This confirms the reports of (De Iongh *et al.* 1982; Dirgayusa *et al.* 2000). Based on the BBNP manager's report, the bird was observed at or near the ecotones between savanna and forest, savanna and cropland, savanna and shrub land, settlement and cropland, and finally, the forest and shrubland.

This report is supported by the NDVI analysis for the three-year record of the species locations in 1984, 1994 and 2003 which showed a shift in the preferred habitat of the Bali starling from primary forest habitat in the 1980s to more open vegetation areas including, but not limited to, dry forest/monsoon forest, secondary forest and savanna (Fig. 2). These results further confirmed those of van Balen *et al.* (2000) that the Bali Starling range on Bali Island has shrunk to the fire-induced open shrub and savanna woodland below elevations of 150-175 m in the northeast part of the Prapat Agung Peninsular of the Bali Barat National Park.

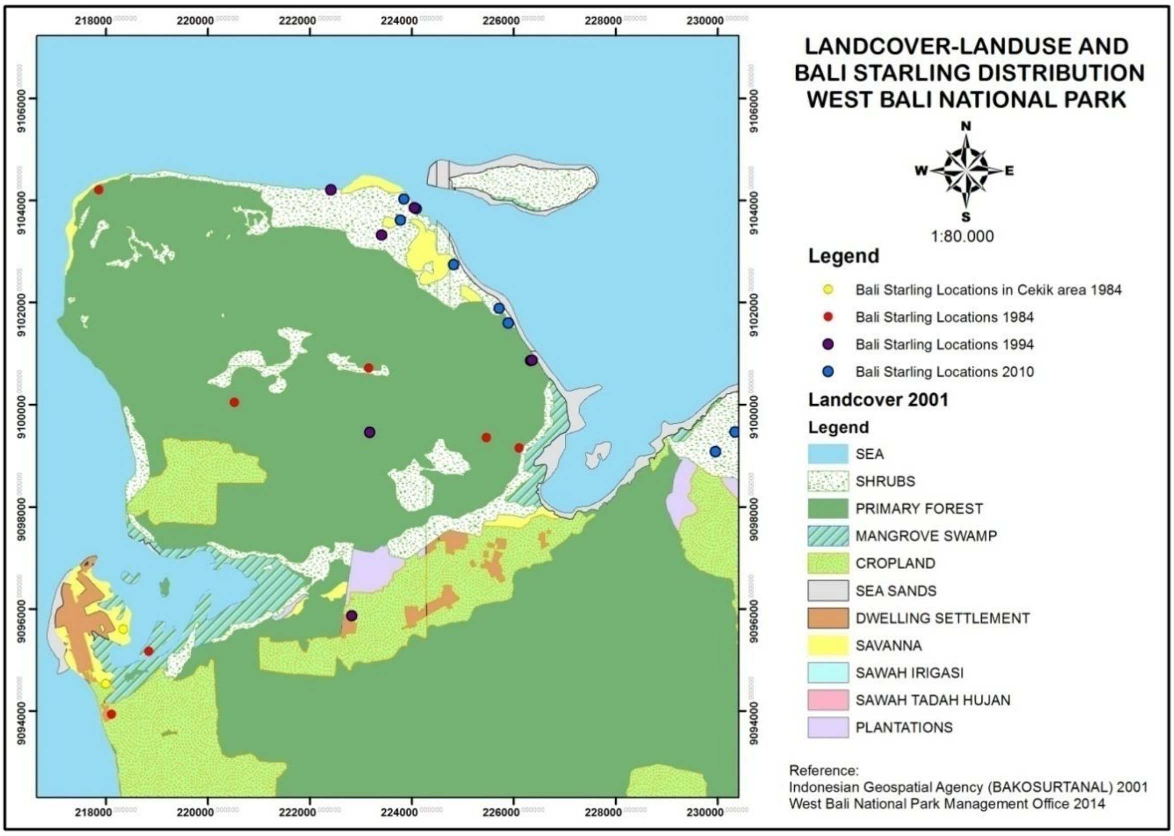
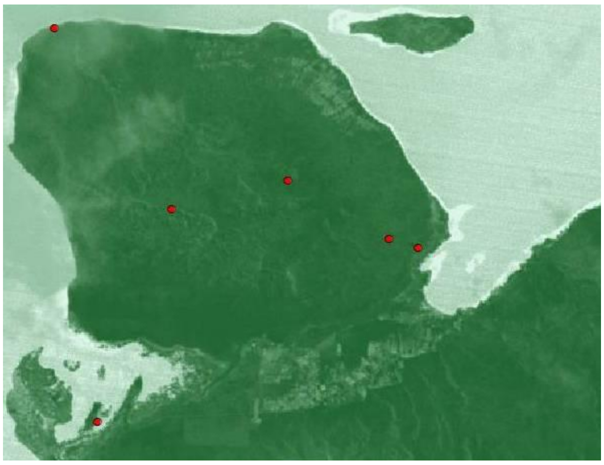
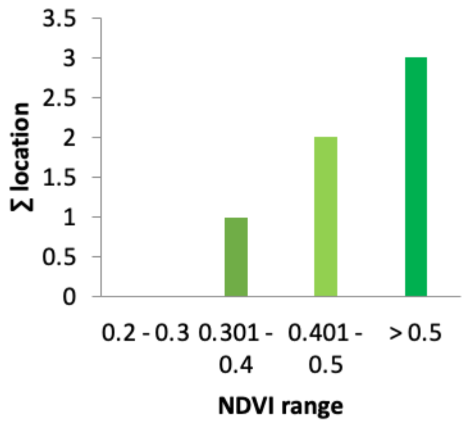


Figure 1 Overlay of Bali Starling occurences with the 2001 Land Use map of Bali Barat National Park
Notes: 'Sawah tadah hujan' refers to a rain fed paddy field. 'Sawah irigasi' refers to irrigated paddy field.



1984



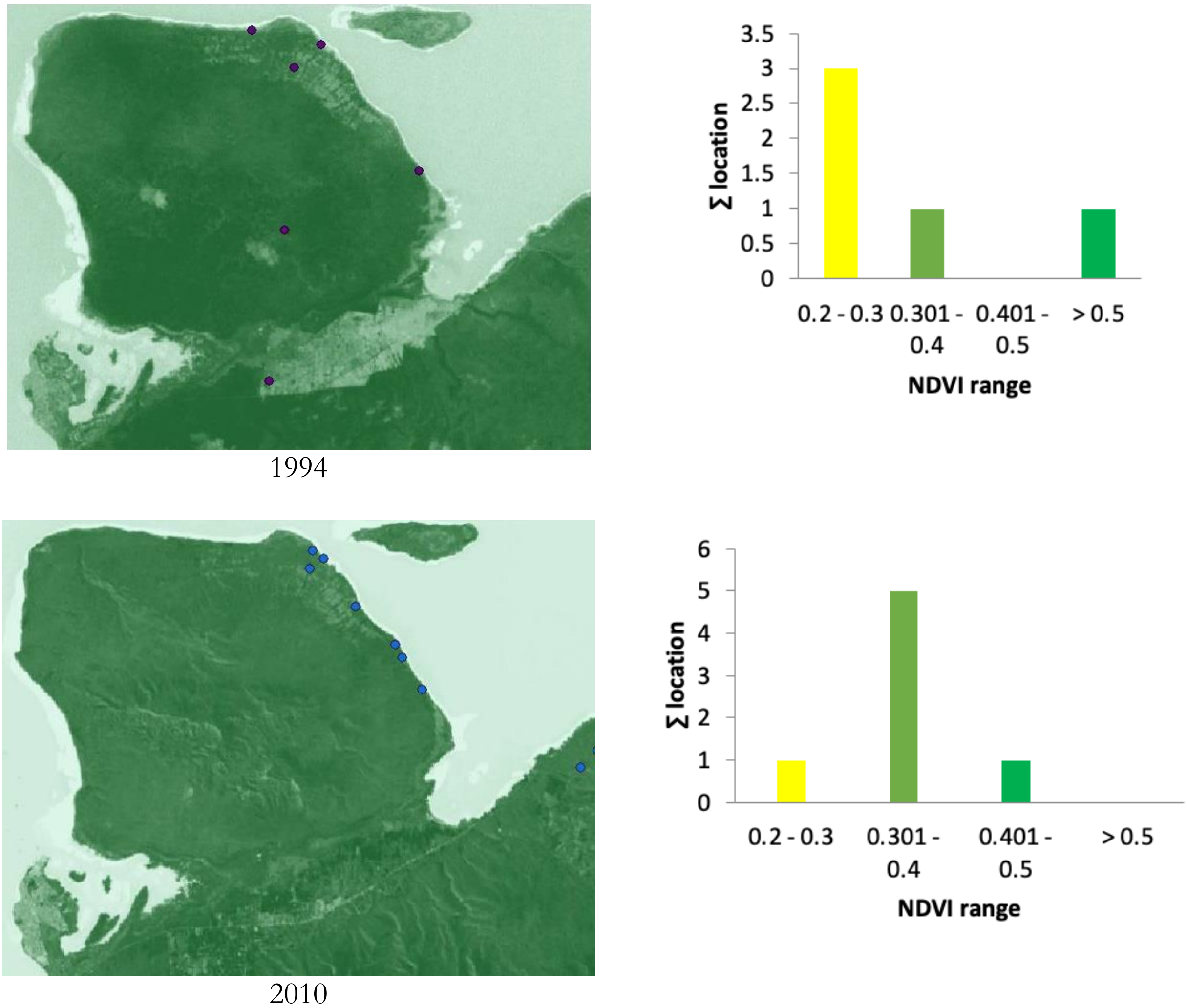


Figure 2 Bali Starling habitat distribution based on their Normalized Difference Vegetation Index (NDVI) range class
Notes: Habitat and localities are presented for 1984 (upper, aligned with NDVI image data 21/03/1989), 1994 (middle, aligned with NDVI image date 12/11/1999) and 2010 (lower, aligned with the NDVI image data 11/06/2016); Ranges of NDVI: 0.2 - 0.3 = Cropland-grassland-savanna; 0.301 - 0.4 = Savanna-shrubland-mangrove; 0.401 - 0.5 = Dry forest-monsoon forest; >0.5 = Primary forest-broad leaves-evergreen forest. This NDVI classes follow Siswoyo (2014).

This apparent shift in the habitat preference of Bali starling is likely to have been influenced by several interacting factors, primarily, the lack of fire in the BBNP. Changes in fire regime has resulted in the presence of more shaded habitat as very little grasslands/savannas have become available. Secondly, the increased human population and associated infrastructure and land use (dwellings, roads, croplands) in the areas adjacent to BBNP, that led to a decreasing available habitat for the Bali starling. The Cekik-Gilimanuk area has experienced a major increase in human-dominated land uses, mainly through conversion of savanna. Accounts of the local inhabitants indicate that the conversion of monsoon forest to agricultural land had a negative impact on Bali starlings (van Balen *et al.* 2000). Lastly, the shift in habitat preference is perhaps due to changes in plant species composition and vegetation structure (which is also related to the lack of fire) which has affected the Bali starling utilization of plants for food and nesting.

Some 22 plant species belonging to 14 families were recorded in the two savannas. At Cekik 10 species belonged to eight families, whereas at Brumbun 20 species were from 12 families. Significant differences were observed using the Bray-Curtis species similarity index between the savanna sites (R_{ANOSIM} = 0.228; P<0.003) (Fig. 3).

Eight species were present in both savannas (Cekik and Brumbun sites) namely *Chromolaena odorata, Lantana camara, Desmodium laxiflorum, Grewia eriocarpa, Bridelia stipularis, Cynodon dactylon, Calamagrostis australis*, and *Ziziphus mauritiana* (synonym *Z. jujuba*). Using the Shannon-Wiener species diversity index, no significant difference (P>0.05) was observed between Brumbun and Cekik, however species richness was significantly different (P<0.05) between the two savannas (Fig. 3). Brumbun had more species than Cekik.

Plant species composition was categorized based on their different uses by the Bali starling, namely: food, shelter (nesting) or a combination of both (Table 2). As plant-food source, Cekik has generally higher cover. Six species used as a food source for Bali starling were *Ziziphus mauritiana, Grewia eriocarpa, Schleichera oleosa, Streblus asper, Azadirachta indica*, (tree species) and *Lantana camara* (herbaceous). Two species, *Borassus flabellifer* (Arecaceae) and *Acacia leucophloea* (synonym *Vachellia leucophloea*) (Fabaceae), were both used for shelter. The latter (*A. leucophloea*) was also utilized as a food source (combined). Some of the plant species used, *S. oleosa* and *B. flabellifer*, were present only in Cekik whereas *S. asper, A. indica* and *A. leucophloea* were found only in Brumbun. Some plant species were present in both of the locations such as *Z. mauritiana, G. eriocarpa* (tree species) and the invasive exotic climber *L. camara* (Table 2).

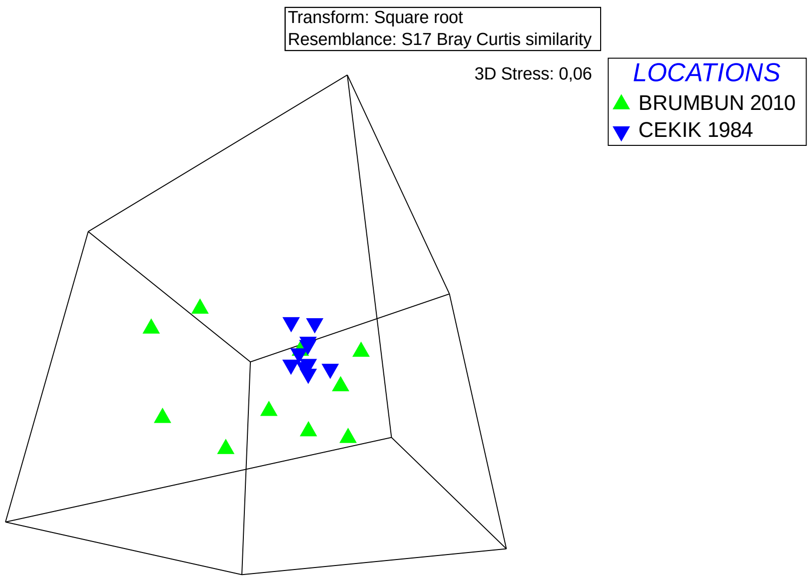


Figure 3 Non metric Multi Dimensional Scaling (NMDS) ordination based on the Bray-Curtis Similarity Index on plant species abundance and composition between Brumbun and Cekik savanna areas at Bali Barat National Park

Table 2 Plant species used by Bali starling at the sampling sites (Brumbun and Cekik) in Bali Barat National Park

Species	Family	Habitus	Usage	Found at and IVI
Ziziphus mauritiana	Rhamnaceae	Tree	Food	Cekik (32.5) and Brumbun (32.5)
Grewia eriocarpa	Malvaceae	Tree	Food	Cekik (16.25) and Brumbun (16)
Schleicera oleosa	Fabaceae	Tree	Food	Cekik (16.25)
Borassus flabellifer	Arecaceae	Tree	Nest	Cekik (61.25)
Streblus asper	Moraceae	Tree	Food	Brumbun (16)
Azadirachta indica	Meliaceae	Tree	Food	Brumbun (16)
Acacia leucophloea	Fabaceae	Tree	Nest, food	Brumbun (16)
Lantana camara	Asteraceae	Herb	Food	Cekik (26.14) and Brumbun (9.8)

The Bali starling was not observed in Cekik since the mid 1990s, although this area has plant species (*Schleicera oleosa* and *Borassus flabellifer*) that are known to provide shelter and food for the bird (Widodo 2014). Unlike similar areas, i.e., Brumbun with its *Acacia leucophloea*, that have been successfully re-colonized by Bali starling in recent times. This is probably related to several factors like plant species diversity and richness, increases in human habitation that might have led to the decrease in plant species richness-diversity as well as the increasing risk of poaching. Plant species in Brumbun is richer compare to Cekik. Different species of tree dominate in Cekik and Brumbun however, the composition of the groundcover between the two locations was relatively similar where exotic invasive species such as *Chromolaena odorata* and *Lantana camara* dominate the understory. However, the Bali starling habitat in the late 1990s were open woodlands which were dominated by *A. leucophloea* trees with an undergrowth of *L. camara* and *C. odorata* shrubs, and *Imperata cylindrica* grass, and intersected by moister and more densely forested valleys with dominant trees of *Grewia eriocarpa*, *Vitex pubescens*, *B. flabellifer* and *Schoutenia* ovata (van Balen *et al.* 2000). This vegetation type might, however, be sub-optimal habitat for the Bali starling and the bird might have been driven there by poaching pressure (van Balen *et al.* 2000). In West Java, a relatively low bird species diversity on the southern Bandung (urbanized areas) was attributable to humans (Fardila & Sjarmidi 2012). Land use and other aspects of the environment were interrelated to such an extent with bird communities distribution in North Bandung, West Java (Fardila & Sjarmidi 2012). In other studies, bird species richness was significantly higher in natural than in urban habitats in Spain (Palomino & Carrascal 2006).

One factor in the decline of the Bali starling have been the conversion of savanna and forests to non-native tree plantations, crop land and villages (Collins & Smith 1994). This was clearly observed in the Cekik area. The absence of the Bali starling in Cekik might also be due to land use changes (fragmented landscape) and the increasing human presence in the area. Cekik is located near Gilimanuk, a busy port of Bali that connects the island with Java Island. Whereas Brumbun, is located on the Prapat Agung Peninsula, a more remote area of the national park located near the ranger's outpost in the northern tip of the national park. In fragmented landscapes, species persistence depends on their ability to use different habitats, so that less suitable habitats may still favour the connectivity of the most suitable habitats in the landscape (Calviño-Cancela *et al.* 2012). Remaining fragments of native habitats such as forests are often surrounded by a matrix of modified semi-natural habitats, such as tree plantations and croplands, which can still provide habitat for species associated with natural forests (Lindenmayer & Hobbs 2004). In Spain, fragmented land, eucalypt plantations has lower species diversity than native forest, but eucalypt plantations provide habitat for species typical of shrublands when young, but do not contribute significantly to the maintenance of the understory biodiversity associated with native forests (Calviño-Cancela *et al.* 2012). Both locations, Cekik and Brumbun, provide suitable habitats for Bali starlings, although Cekik is decreasing into a savanna-forest size, it is more open and more human-populated. Most of the bird's former habitat has been converted into coconut and kapok plantations, and human settlements. Cekik ability to provide habitat for the species, the relatively similar species richness with Brumbun, and the distribution of specific plant taxa that influence the availability of shelter, feeding and breeding resources (*Ziziphus mauritiana, Grewia eriocarpa, Schleicera oleosa,* and *Borassus flabellifer*), distinctly contribute to their importance for Bali starlings.

Poaching is the major threat to Bali starlings. In the 1960s, the birds were trapped intensively to provide the demands of Indonesian, American and European private aviculturists. In 1966, the IUCN listed the species as endangered (Collins & Smith 1994). The Indonesian government responded with the 1971 law prohibiting the hunting, capture and export of the bird (van Balen *et al.* 2000). However, poaching has continued in spite of efforts to increase patrols by the park rangers (Collins & Smith 1994; Dirgayusa *et al.* 2000). In the Bali Barat National Park, specifically in Cekik, the local rangers often encountered illegal poachers checking the handcrafted "pigeon holes" made by the Bali Barat Management to facilitate the survival of post-captivity bred starlings that were recently released in the area.

This study further confirmed the importance of examining habitat characteristics and dynamics of endemic birds within landscapes that are influenced by multiple factors interacting in space and time (Fardila & Sjarmidi

2012; Orians & Wittenberger 1991). Habitat structure and floristic composition, such as percent canopy cover, tree species diversity and the distribution of specific plant taxa, are known to exhibit a significant role in defining bird species' occurrences in space (James & Wamer 1982; Rice *et al.* 1984; Wiens & Rotenberry 1981).

CONCLUSION

In summary, this study suggests that both forest and savanna are important land cover types and habitat for Bali starling at Bali Barat National Park considering that the changes in the relative proportions of these types, as well as availability of ecotones between them, are likely to be particularly important for this species. The increase in woody plant cover in the remaining savannas of northern BBNP, which may reflect a lack of burning in the area where the Bali Starling is known to currently occur, is therefore of primary concern. In Cekik, it is suggested to intensify protection efforts and, where feasible, to restore the native species of Bali starlings to its best or much improved conservation stautus.

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