Interspecific correlations toward climatic factors in migratory raptor species across Mt. Sega, Karangasem, Bali

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Interspecific correlations toward climatic factors in migratory raptor species across Mt. Sega, Karangasem, Bali

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Abstract. It has been known that climate change can affect organisms in various ways. For example, studies found that climate change affect phenology i.e. migratory arrival of migratory species. This study was aimed to find out whether the migratory arrival of five species of bird of prey flying across Mt. Sega Karangasem – Bali correlates with climate factors in the region. This study took place from 1 October to 30 November 2018 by using look up method, and found that air temperature, cloud cover, humidity, and air pressure had a stronger correlation toward the migratory bird of prey species that crossed over the Mt. Sega compared to wind speed and precipitation. The air temperature, cloud cover and wind speed had a positive correlation toward the migratory bird of prey arrival, whereas the negative correlation was demonstrated by humidity, air pressure, and precipitation. The presence of the Chinese Sparrow-hawk and the Short-toed Snake Eagle were correlated with the humidity. Whereas the presence of the Peregrine falcon was correlated with the cloud cover. The presence of the Oriental Honey Buzzard was correlated with the wind speed, while the precipitation and air pressure were correlated with the presence of the Japanese Sparrow-hawk. The Japanese Sparrow-hawk arrived earlier at 10.00 whereas the other four species arrived later at around 12.00.

1. Introduction

Indonesia is one of the important places for birds of prey, namely as part of migratory flyway in the East Asian region, from the northern to southern hemisphere, and vice versa. One good location to monitor the birds of prey migration is in Mt. Sega, Karangasem Bali which is part of the Seraya Mountains Range [1]. This area serves as the bottleneck for migratory birds of prey in Bali. Research on migratory birds of prey crossing the Seraya Karangasem Mountains recorded 91,232 individual birds of prey of various species [2]. Recent study revealed five species of migratory bird of prey crossed over Mt. Sega [3]. Therefore, Mt. Sega Karangasem Bali serves as an ideal location to conduct such studies on migratory bird of prey.

Birds migration is a natural phenomenon that occur twice a year (spring migration and autumn migration) as part of their adaptation strategy to the changing climate [4]. Climate conditions vary either geographically or over time, and it can affect natural populations in many ways, including on their phenology or timing of annual events such as annual migration [5]. Studies on effect of climate change on migratory species needs to be conducted at various tropic level, because the response of each species or populations of each species is not the same [6] [7,8]. One phenomenon that occurs is, for example, the response of predator and prey is not the same to climate change, birds do not reproduce when the number of their prey is abundant therefore reducing the rate of reproductive success [6]. Although many

studies on bird of prey migration phenomena have been conducted in Bali, however, less studies on effect of climate on the birds' migratory arrival in Bali has been conducted [i.e., 9].

This study was aimed to find out whether the migratory arrival of five species bird of prey flying across Mt. Sega Karangasem – Bali correlates with climate factors recorded in the region. It was also aimed to find out whether their time of arrival during the day varied. Climate factors recorded were air temperature (°C), wind speed (kmh^{-1}), humidity (%), cloud cover (%), and precipitation (mm). In Israel, study found that small and medium size bird of prey species migrated when air temperature in morning was warmer (in May and April) compared to when in colder morning (in February and March) in which medium and big size bird of prey species migrated [10]. That study revealed that response given toward climate factors differs in different bird of prey species. The result of this study, therefore, will be useful as reference in bird of prey conservation efforts, including their habitats in a global scale, since multi disciplines approaches are required to manage the effect of climate change toward living organisms.

2. Methods

This study was conducted from 1 October to 30 November 2018 at Mt. Sega, Karangasem – Bali (8,37°-8,38° S and 115,63°-115,64° E; 750 m asl). Bird of prey arrival was observed from 08.00 to 18.00 WITA by using look up method [11]. When required, binoculars and DSLR camera were used to assist in species identification. Species identification was based on [12] and [13]. Climate factors, namely air temperature (°C), wind speed (kmh^{-1}), humidity (%), cloud cover (%), air pressure (MB) and precipitation (mm), were recorded for every one hour by using Accuweather software application version 5.4.2.

Multivariate analysis by using CANOCO versi 5.0 [14] was used to evaluate correlations between climate factors and bird of prey species migratory arrivals. Climate data were log transformed (LogX+1) and were normalized prior to analysis. Data of bird of prey arrivals (species and number) were square root transformed, then was analyzed by using *Canonical Corespondence Analysis* (CCA) with 499 permutation replications. Multivariate analysis was also conducted between the bird of prey species and their time arrival to support the CCA analysis on climate factors. Prior to analysis, the arrival time was grouped into three categories, namely morning (06.00-09.00), midday (10.00-13.00), and afternoon (14.00-17.00). Data then was log transformed (LogX+1) and was normalized by using PRIMER. Further, resemblance matrix was produced by using Euclidean distance index, then was their similarity was analyzed using ANOSIM. Visual ordination was later conducted by using NMDS (*Non-Metric multi Dimensional Scaling*) with 99 times permutation and minimum 2d stress 0.01.

3. Results and Discussion

In total, 696 observation hours was conducted from 1 October to 30 November 2018 at Mt. Sega, Karangasem – Bali. During the study period, 24.637 individuals of five species migratory bird of prey were recorded. They were the Japanese Sparrow-hawk *Accipiter gularis*, the Chinese Sparrow-hawk *Accipiter soloensis*, the Oriental Honey Buzzard *Pernis ptilorhynchus*, the Peregrine Falcon *Falco peregrinus*, and the Short-toed Snake Eagle *Circaetus gallicus*, as we published earlier elsewhere [3]. In particular, we recorded 20.245 individuals *Accipiter soloensis*, 2.915 individuals *Pernis ptilorhynchus*, 1.196 individuals *Accipiter gularis*, 3 individuals *Falco peregrinus*, and 1 individu *Circaetus gallicus*. Canonical Correspondence Analysis result explained that there was a correlation between climatic factors and the migratory bird of prey species observed, with analysis variation 83.3%. It can be seen from Figure 1 that air temperature, cloud cover, humidity, and air pressure had a stronger correlation toward the migratory bird of prey species that crossed over the Mt. Sega compared to wind speed and precipitation. The stronger correlation was indicated by the longer arrow they had compared to wind speed and precipitation. The arrow length for air temperature, cloud cover, and humidity was 0.7, whereas for air pressure the length was 0.8. Climate factors that had a less correlation such as wind speed and precipitation, their arrow length was 0.5. The air temperature, cloud cover and wind speed had a positive correlation toward the migratory bird of prey arrival, whereas the negative correlation was demonstrated by humidity, air pressure, and precipitation.

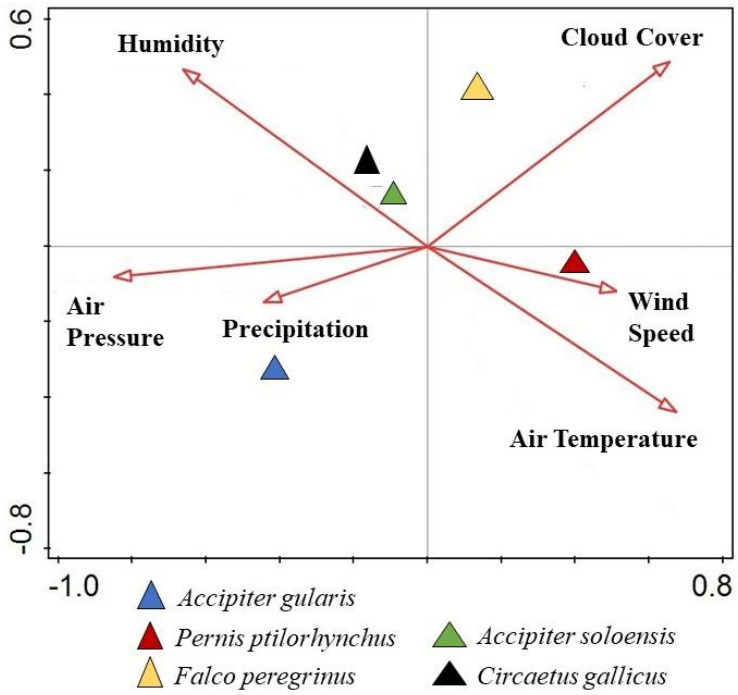

Figure 1. Canonical Correspondence Analysis between climate factors and migratory bird of prey species crossed over Mt. Sega, Karangasem, Bali.

It has been known that climate and weather may affect phenology of organism [15,16], for example the migration date of arrival can be affected by the climate condition at their migratory region [17]. This study found that air temperature had a strong correlation with the bird of prey arrival. Air temperature is known as the climate factor that has a strong correlation with the migration phenology [18]. This is because bird of prey utilizes thermal pile for soaring and gliding as their migratory flight strategy [19,20]. The air temperature has a contrast relationship to humidity in which the higher the air temperature the lower the humidity [21]. Air temperature also related to cloud cover; dense cloud cover decreases the amount of sun radiation reaching the earth surface, hence decrease the air temperature, and *vice versa* [22,23]. Our CCA biplot species (Figure 2) also supported that air temperature had a positive correlation with the bird of prey arrival; most bird of prey was observed during midday when the air temperature was the warmest during the day. The Japanese sparrow-hawk arrived earlier at 10.00 whereas the other four species arrived later at around 12.00. Similar observation was also reported in Thailand [24] that both the Japanese and Chinese Sparrow-hawk were observed from 10.00 to15.00 local time, with the peak of arrival was at midday.

As it has been revealed in several studies that species or metapopulations may have different response toward the changing climate [6,7,8]. For example, interspecific variation in the change of migration phenology that associate with climate change was found in songbird species in North America [25]. Interspecific variations towards the climate factors was also revealed in this study. The presence of the Chinese Sparrow-hawk and the Short-toed Snake Eagle were correlated with humidity. These species were both arrived when the humidity was low. The Peregrine falcon was observed when the cloud cover was dense. The presence of the Oriental Honey Buzzard correlated with wind speed in which they were predominantly observed during moderate wind (9-15 kmh^{-1}). When encountered with strong wind during their migratory journey, birds of prey will spread and fly following the land contour [19]. The Japanese Sparrow-hawk presence correlated with air pressure and precipitation. The Japanese Sparrow-hawk and the Chinese Sparrow-hawk were observed kept flying in the rain for their migration journey [19]. Their waterproof plumage may allow them to keep flying in the rain.

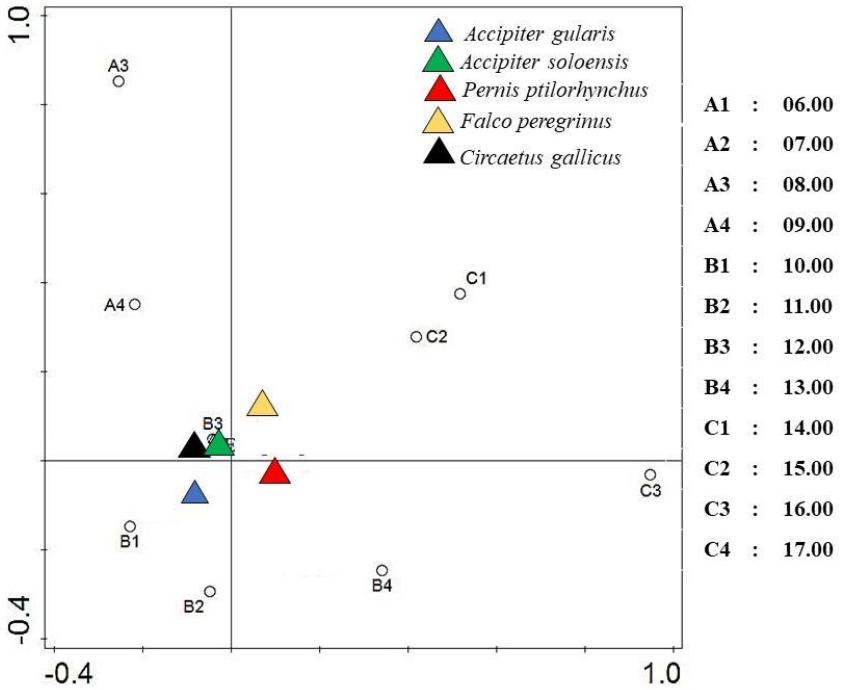

Figure 2. Canonical Correspondence Analysis between time of arrival and migratory bird of prey species crossed over Mt. Sega, Karangasem – Bali.

Those findings provide a baseline for further studies on bird of prey response toward climate change in Bali Indonesia as part of their migration flyway. This is especially true since climate changes per year, per decade, and even for a much longer time [26]. A long-term study (1981-2008) revealed that there was a variation in phenology (i.e. migration arrival dates) among bird of prey species observed in France [27]. They found that long distance migrant species displayed stronger phenological responses than short distance migrant species, and advance their mean passages dates significantly. Changes in phenological responses due to climate change subsequently will affect other biological aspects of the birds, for example climate interaction toward their food sources will affect their reproduction [28]. When the peak availability of food source occurs earlier due the climate change, the migration and breeding season occur earlier as well [29]. Birds that arrive earlier may breed earlier and have more time to raise their offspring [30]. However, since the response of each species or populations of each species is not the same, the tendency of asynchronous response among interacting species is most likely to occur. One example, the birds had already been arrived when their food source was still scarce [6]. Accordingly, further studies (i.e. a long-term study) on phenological responses of migrant bird of prey toward climate need to be conducted, particularly in Mt. Sega Karangasem Bali since this area serves as the bottleneck for migratory birds of prey in Bali. Knowledge of phenological responses to different climates (i.e. climate change) in bird of prey species will enable us to make inferences about the fate of the species during global climate change.

4. Conclusion

To conclude with, this study found that air temperature, cloud cover, humidity, and air pressure had a stronger correlation toward the migratory bird of prey species that crossed over the Mt. Sega compared to wind speed and precipitation. The air temperature, cloud cover and wind speed had a positive correlation toward the migratory bird of prey arrival, whereas the negative correlation was demonstrated by humidity, air pressure, and precipitation. The presence of the Chinese Sparrow-hawk and the Short-toed Snake Eagle were correlated with the humidity. Whereas the presence of the Peregrine Falcon was

correlated with the cloud cover. The presence of the Oriental Honey Buzzard was correlated with the wind speed, while the precipitation and air pressure were correlated with the presence of the Japanese Sparrow-hawk. The time of arrival was differed in these species; the Japanese Sparrow-hawk arrived earlier at 10.00 whereas the other four species arrived later at around 12.00.

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