

Breeding behavior of different raptor species in human modified landscape

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Abstract. *Withaningsih S, Parikesit, Iskandar J, Megantara EN. 2017. Breeding behavior of different raptor species in human modified landscape. Biodiversitas 18: 1234-1242.* Raptors are important birds which sensitive to environment and mostly used as best indicator for knowing the health of the ecosystem. The breeding period is a critical phase for raptors and seems to be difficult leading to the status of those birds as an endangered species. The nest site selection is of importance to the success of raptor nesting program. Of this reason, the use of human-modified landscape as one of nesting location for raptors, located in Panaruban and Telaga Warna landscape, West Java, Indonesia has been assessed to know the breeding behavior among raptors. The aim of the study was to analyze the nest site, nesting period, and nest placement of raptors in human-modified landscape in Panaruban and Telaga Warna. The relationship among raptor nest occurrences was analyzed using four circular buffers at distances of 250, 500, 750 and 1000 m around each nest-tree. Data was collected by descriptive analysis and Geographical Information System (GIS) mapping. The four species of raptors i.e. the Javan Hawk Eagle (*Nisaetus bartelsi* syn. *Spizaetus bartelsi*), the Changeable Hawk-eagle (*Nisaetus cirrhatus* syn. *Spizaetus cirrhatus*), the Crested Serpent Eagle (*Spilornis cheela*), and the Indian Black Eagle (*Ictinaetus malaiensis*) showed to select nesting sites in different places. The landscape structure at different scales around the nest may contribute to the varied characteristics of nest site selection. The raptors had a different time of the breeding period in the same landscape. These differences might be a part of the strategy to decrease competition among raptors.

Keywords: Human modified landscape, Indonesia, Java, nesting period, nesting site, raptors

INTRODUCTION

Raptors have the role as "umbrella" species and some of them are known as "key" species. That role is related to the fact that the birds are mostly rare and charismatic. They sit at the top of the food chain and also as indicators of ecosystem health (Newton 1979; Donazar et al. 2002; Sergio et al. 2005; Poirazidis et al. 2007). Raptors had benefited from the various types of the ecosystem in the same landscape due to their wide range of flying areas. On the other hand, raptors are very sensitive to ecosystem changes, and vulnerable to pollution, so that the initiation of raptors conservation is very important. The conservation of raptors is an effort to protect raptors existences as well as to maintain the ecosystem health, which may have a direct impact on the global environmental conservation and further better life of human being.

Raptors are categorized as focal species which sensitive to the environmental changes. Therefore, comprehensive studies of raptors in term of the habitat characteristic related to the success of raptor reproduction are very crucial. Moreover, raptors are territorial and long-lived, having large nests frequently used year after year, which causes raptors as an ideal subject of study and conserved target. The habitat features related to the reproduction and fitness of raptors, and other bird species are well studied (Moller 1991; Newton 1991; Korpimaki 1992; Ens et al. 1992). Due to their mobility, raptors have the opportunity

to visit many different patches and assess their relative quality. Thus, they potentially have the opportunity to select a habitat, which maximizes their annual reproductive output and lifetime reproductive success (Selas 1997; Kruger 2004).

One of the critical factors for all species in the world is their habitat sustainability and availability (Morrison et al. 1992; Lindenmayer and Fischer 2006). Furthermore, understanding the suitable habitat for a particular species is important to recognize the impact of landscape changes for those species (Clark and Shutler 1999; Ortego 2007). Moreover, the habitat disappearance due to the transformation of protected forests to other land uses is the main factor declining the species number and the disappearance of certain species in nature (Gibbons et al. 2000; Sala et al. 2000; Primarck 2001; Lindenmayer and Fischer 2006). The transformation of the land use may cause habitat disappearance, and this becomes the main reason for the decreased number of biodiversity in recent years (Soule 1991; White et al. 1997).

The habitat selection of an organism in certain sites causes the different usage of specific resources, which may influence the resource availability (Hall et al. 1997). The distribution of animal species occurring at different spatial scales is the outcome of this process (Martinez et al. 2003). The habitat selection and distribution can be influenced by the occurrence of predators and intraspecific competition as well as interspecific competition (Newton 1998; Katzner et

al. 2003; Martinez et al. 2008; Sergio and Hiraldo 2008). In addition, the positive interactions among different species may also contribute to the habitat selection and distribution of species (e.g. Sergio et al. 2004) or con-specifics (Parejo et al. 2005; Sergio and Penteriani 2005).

The habitat selection and the raptor distribution at different spatial scales are being intensively studied because of their large sizes and conspicuous behavior (Penteriani et al. 2001). Moreover, raptors are classified as vulnerable species (Birdlife International 2004), so that the comprehensive ecological data of this species is required for further conservation and management purposes especially for biodiversity indicators (Newton 1979; Sergio et al. 2005). In addition, these birds are top predators in food chains (Sergio et al. 2005; Brambilla et al. 2006), so that they are subjected to many studies focusing on inter- and intra-specific competition (Katzner et al. 2003; Sergio et al. 2003; Vrezec and Tome 2004; Martinez et al. 2008). One of four raptor species observed in this study was Javan hawk eagle (*Nisaetus bartelsi* syn. *Spizaetus bartelsi*) that is known as an endemic species in Java with now in status of an endangered species. The population of this species decreases every year because of illegal hunting and deforestation. Another three observed raptors were Changeable Hawk Eagle (*Nisaetus cirrhatus* syn. *Spizaetus cirrhatus*), Black Eagle (*Ictinaetus malaiensis*) and Crested Serpent Eagle (*Spilornis cheela*). The status of these raptors is under the protection of Indonesian law (e.g. National Law Number 5, 1990) and noted as vulnerable species by IUCN.

Of these reasons, this study will focus on the implication of landscape structure with human intervention toward the presence of several raptors. In this regard, the human intervention is indicated by the changes of landscape structure becomes more heterogeneous, so that it is known as modified human landscape. Therefore, the aim of the study was to analyze the raptor nest including nest site, nesting period, and nest placement located in human-modified landscape in Panaruban and Telaga Warna.

MATERIALS AND METHODS

Study area

The research was conducted in Panaruban and Telaga Warna areas (Figure 1). Panaruban is located in the Tangkuban Perahu Mountain. Administratively, the location is a part of Desa Sagala Herang in the District of Subang, West Java Province, Indonesia. The area for the research covers 24,200 ha including natural forest (41.13%) in Tangkuban Perahu Mountain, mix garden or production forest (25.55%), Nusantara Plantation Ltd. or called *Perusahaan Terbatas Perkebunan Nusantara* (PTPN) XIII (23.42%), paddy field (4.88%) and the local village of Desa Panaruban with the population of 4.195 people (3.7%) and other used like pines and open space (1.39%). Panaruban is one of the areas in Java Island, which has a moderate climate and mountainous, tropical forests. This is why the area is ecologically important due to its richness in biodiversity. Telaga Warna is located in

the Puncak area (administratively the location is part of Subdistrict of Cisarua, in the District of Bogor, West Java Province, Indonesia). The area for the research covers only 4,300 ha which is covered by open space (6.04%), tea plantations (10.44%), lake (16.9%), production forest (32.25%) and natural forests (34.27%) as a part of Nature Reserve Mt. Mega Mendung and Mt. Hambalang Telaga Warna area is only 20% that of Panaruban, but the numbers of pairs of raptors occupying Telaga Warna is quite numerous.

Data collection

The data collection was divided into three phases: (i) determining the presence of several raptors, (ii) searching and mapping the nests of the bird, and (iii) determining the observation points. The field survey was conducted for the first phase. The survey first covered a very large area and then concentrated in smaller areas (certain areas where the birds were usually found) to ensure the survey would be effectively conducted (Bibby et al. 2000). The presence of raptors in Panaruban areas was examined by undertaking a survey of specific techniques focusing on a certain area. The researcher conducted the survey from the top of the hill (for 90-degree views) so that the top trees canopy and the predator birds flying could be observed from strategic posts with open-area position (Thiollay 1996). The study was conducted on four observation stations in each location (Panaruban and Telaga Warna). Systematic surveys were conducted for 3 years in order to locate the occupied breeding territories and active nest, using the onset of the breeding season as a starting point for each species. The data collection included the name of species, number of individuals, location, coordinate, the time and duration of contact time. Total contact time with the four eagles in Panaruban of 21,600 minutes and three eagles in Telaga Warna is 10,800 minute.

Data analysis

Data analysis used in the study was the qualitative method by using descriptive analysis and the quantitative one by applying Geographical Information System (GIS) for a map of SPOT 5 using open sources software (*Grass*). The study used four circular buffer at distances of 250, 500, 750 and 1000 m around each nest-tree to analyze the relationship among raptors' nest occurrences. Based on raptors and landscape data, spatial analysis was examined to discover the competition among raptors in the study area.

RESULTS AND DISCUSSION

The existence of the Javan Hawk Eagle nests in human-modified landscape of Panaruban has been known since 1998: the natural forests of Blok Ciasem. The breeding period of the Javan Hawk Eagle was started in June 1998 and it was continuously be managed to produce Javan Hawk eaglets. In 2001, the nest of the Javan Hawk Eagle was moved from a previous branching tree of *kitambaga* (*Eugenia cuprea*) to another new branch above the old one.

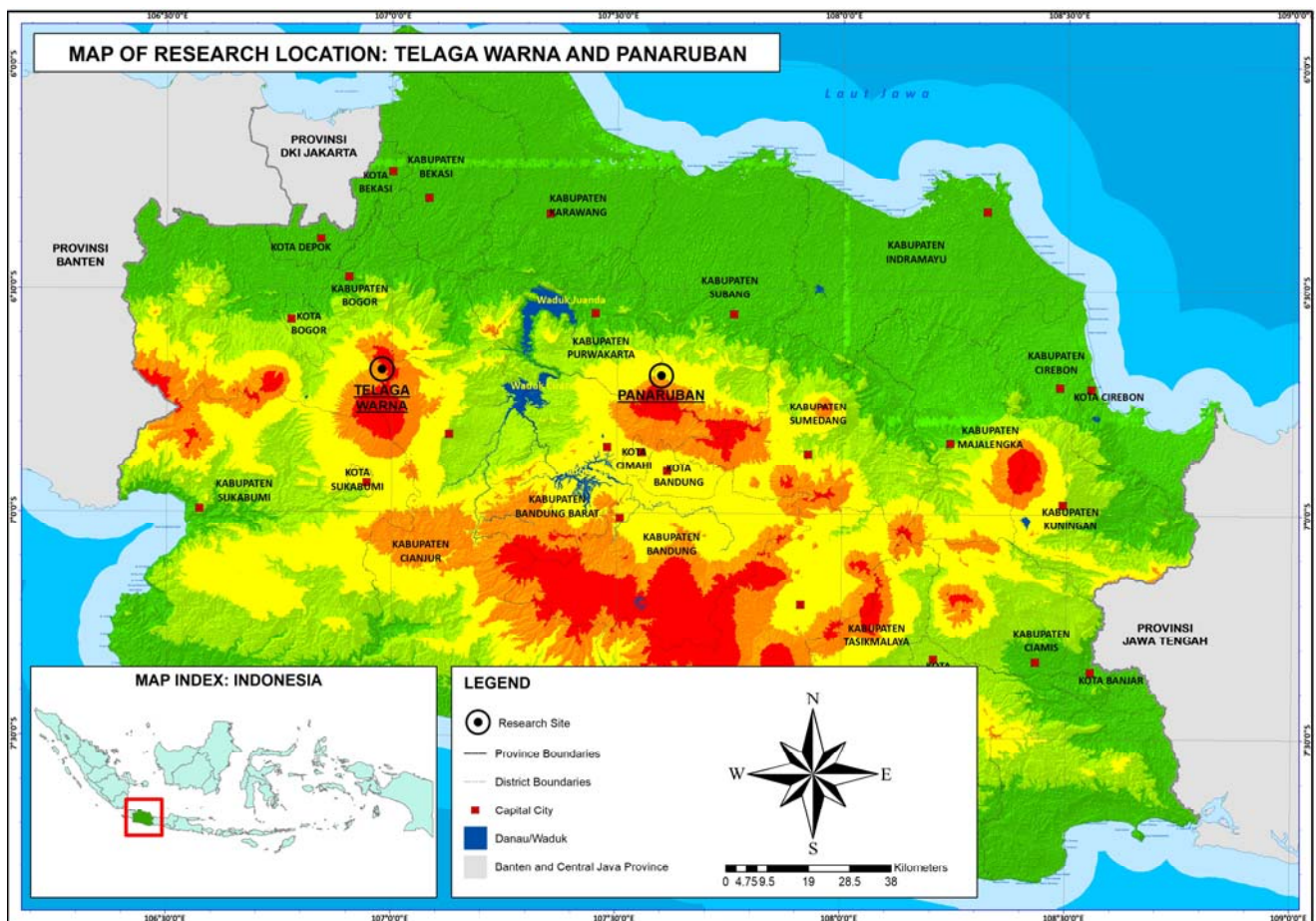


Figure 1. Study area in West Java, Indonesia. 1. Panaruban, Subang District, 2. Telaga Warna, Bogor District

This was because the old branching tree of the Javan Hawk Eagle nests laid in the previous year became brittle and broke. After the Javan Hawk Eagle had moved the nest, the couple started to breed again in late July and laid eggs in early September. However, the Javan Hawk Eagle breeding in 2001 was not successful because, at the end of October, the incubated eggs were pecked by raptors *Sikep Madu Asia* or Crested Honey Buzzard (*Pernis ptilorhynchus orientalis*), which migrated through Panaruban.

In 2003, the same pair of the Javan Hawk Eagle began to breed in May and laid eggs in June, but there was another failure marked by the disposal of the eggshell, which failed to be incubated by the female. Based on the preliminary research results, failure in the incubating period by the female was caused by the thinning of the eggshell (the result of laboratory analysis of samples taken from the egg shells under the nest), which was usually caused by the elevated levels of pesticides on eggshells. The thinning of eggshells caused the eggs to become brittle, and when the female tried to incubate them, they became broke, resulting in the failure of incubation. However, the Javan Hawk Eagle did another breeding activity and managed to lay eggs for the second time in the same year in July. After going through a period of hatching, the eggs hatched and produced eaglets, but not

long after, the eaglets died. It was probably caused by the bad weather conditions. The influence of the bad weather in the form of continuous rainfall was explored on the type of Crested Caracara (*Caracara cheriway*), proving that the continuous rain caused breeding failure. This was because the raptors had difficulties in obtaining food for their eaglets resulting in the eaglets' death (Morrison et al. 2009).

In 2007, the Javan Hawk Eagle moved its nest to another tree, still in the same type, with a distance of approximately 50 meters east of the old nest. The relocation of the nest was caused by the brittle-retaining branch, which eventually broke so that the Javan Hawk Eagle could not build a nest in the tree. Until 2010, this nest was the one used by the Javan Hawk during breeding.

Data related to the existence of Changeable Hawk-eagle nest on an eucalyptus tree in Kaletes Blok which served as a mixed-garden were identified in 2003 and in that year the breeding of the Changeable Hawk-eagle managed to produce eagles in *sub-adult* phase, which then left the human modified landscape of Panaruban. Then, every year the Changeable Hawk-eagle couple bred at the same nest; however, in 2009 they moved the nest to a tree about 50 meters to the south, located in Kaletes Blok which served as the secondary succession area and was adjacent to

natural forests Ciasem Block, still on the same type of tree. The relocation of Changeable Hawk-Eagle nest might happen due to the drop of the eaglets from the nest because of the high human activity under the tree. This activity was caused by the footpaths created by the people living in the surrounding areas, just below the eagle's nest. In 2003, the area under the eagle's nest was vacant, never used by passers by, and covered by bushes. Then in early 2009, the locals created a footpath to shorten the path leading to the forest just below the Changeable Hawk-eagle nest tree. Once footpaths have been opened, people went to the natural forest passing under the Changeable Hawk-eagle nest almost every day. That was why the couple moved the nest. Although not so far from the first nest, it was relatively safer because it was far from the path used by the locals.

The existence of the Black Eagle has long been known in the Panaruban landscape, but the existence of nest trees in the mixed garden was only known in 2010 based on the information from the locals around the area. The behavior and breeding period for the Black Eagle in this landscape has not been observed in more detail because, at the time discovery, the Black Eagle's nest was not used anymore. Based on the literature, it is estimated that the breeding period of Black Eagle in Java Island started in May (Mac Kinnon and van Balen 1998), but more detailed information about the breeding period of Black Eagle in the Panaruban landscape was not clearly known, yet.

The existence of Crested Serpent Eagle in the Panaruban landscape was first known in 2007; however, in 2008 the nest has been abandoned. It was in 2009 that the Crested Serpent Eagle built another nest in the same block and on the same type of tree, but it was shifted 50 meters to the southwest. The nest relocation of Crested Serpent Eagle happened due to the new pathway track that was opened by locals under the nesting tree. Another disturbance, such the theft of the Crested Serpent Eagle' eaglets by poachers, also damaged the nest.

The nest relocation of Javan Hawk Eagle, Changeable Hawk-eagle, and Crested Serpent Eagle to a new place, which is still located in the same area nearby the original nest, is caused by different factors. Some researchers claim that the selection of the nest's sites by raptors is influenced by several factors such as the physical structure of the nesting tree (Rhodes and Richmond 1985), the risk of predators (Hatchwell et al. 1999), and the availability of food around the nest (Wiehn and Korpimaki 1997). Additionally, other researchers show that the selection of the nest is an adaptive trade-off between the effort exhausted to find and maintain the nest with a reproductive advantage in the form of the success in the reproduction process in that place (Pulliam 1989; Wood and Bjorndal 2000). Based on these results, it can be concluded that the area around the three types of raptors nests were areas that had been deemed suitable to build nests, but because of a disturbance, either by nature (the breakage of the nesting branch) or by human activity (the creation of pathway around the nesting tree or the poaching of the Eagles' eaglet) then a relocation to another nesting tree still in the same area was needed (Table 1).

In general, the breeding period is divided into four periods: the period to build nests, lay eggs, hatch, and nurture the eaglets (Welty and Baptista 1988). Especially for raptors, it is divided into eight periods: the period to attract the opposite sex (*breeding display*), build a nest (*nest building*), lay eggs (*egg laying*), hatch (*incubation*), hatch eggs (*egg hatching*), and the eaglet period: flight training (*fledge period*) and caring for chicks (*parental care*).

An eagle is one of the classes of raptors found in the Panaruban landscape where four species of raptors i.e., Javan Hawk Eagle, Black Eagle, Changeable Hawk-eagle and Crested Serpent Eagle, that live and settle together in the same place. During this study, nests for all four types of raptors were found, but only the nest of three raptor species that could be observed, while the nest of Black Eagle was found inactive condition so that the breeding period could not be further observed. The map of nest distribution of four raptor types in the Panaruban landscape could be seen in Figure 2.

Based on the observations done from 2009 to 2010 in the Panaruban landscape, the period of attracting the opposite sex (*breeding display*) for the Javan Hawk Eagle starts between July and August, while the Changeable Hawk-eagle is from April to May, and another raptor type, the Crested Serpent Eagle is from January to February. This period is characterized by the specific behavior of the four raptor types in terms of the pattern of flying formation such as flying up and down (*undulating*), circling in pairs (*mutual soaring*), *mating*, and voicing (Setiadi et al. 2000). The comparison of the breeding period of three raptor types in the Panaruban landscape could be seen in Table 2.

After the period of sexual attraction, the next period is the nest building. The Javan Hawk Eagle begins to nest from August to September, while the Changeable Hawk-eagle is from May to June, and another one, the Crested Serpent Eagle is between February and March. Mostly birds use nests to lay their eggs (Pettingil 1985). They were usually built not far from where the couple copulates, but another factor such as the availability of materials for the nest, security, and the bird resting location influenced the nest building preferences of birds (Welty and Baptista 1988). The process of nesting is generally divided into three stages: (i) The selection and preparation of area and the supporting materials; (ii) building the floor and the sides; (iii) the nest lining. Some bird species, especially raptors, use the same nest every year. This nest will typically be maintained including the improvement and the enlargement of nest annually or the nest reparation when

Table 1. Natural and human disturbance of the raptor nest in Panaruban landscape of the District of Subang, West Java Province, Indonesia

	JHE	CHE	BE	CSE
Natural disturbance	▲	●	■	●
Human disturbance	▲	▲	■	▲
Nest relocation	▲	▲	■	▲

Note: ▲ = occur, ● = not occur, ■ = no record, JHE = Javan Hawk Eagle, CHE = Changeable Hawk Eagle, BE = Black Eagle, CSE = Crested Serpent Eagle

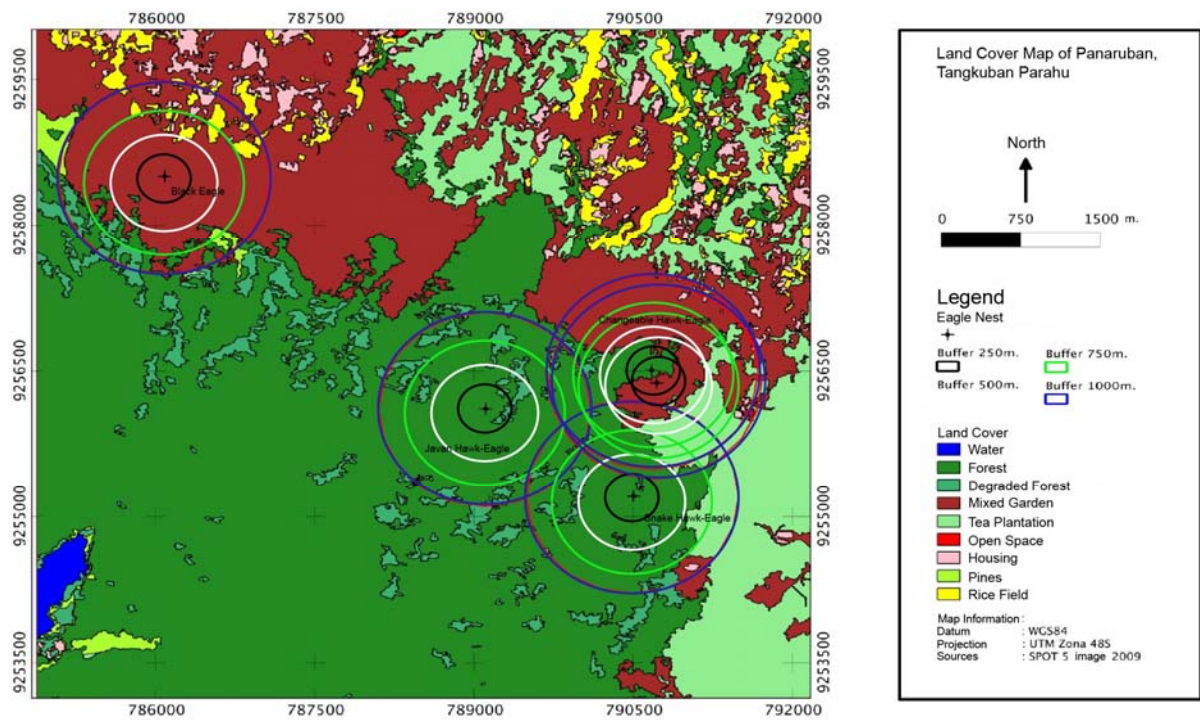


Figure 2. Land coverage map and nest distribution for the four species of raptors in Panaruban landscape of the District of Subang, West Java Province, Indonesia

Table 2. The breeding period of three raptors in human-modified landscape of Panaruban, District of Subang, West Java Province, Indonesia

Activities	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Breeding display												
Nesting building												
Egg laying												
Incubation												
Egg hatching												
Eaglet period												
Fledgling												
Parental care												

Note: ■ Crested Serpent Eagle, ■ Changeable Hawk Eagle, ■ Javan Hawk Eagle

the disturbances happen. A new nest will then be built not too far from the old nest as shown by the Javan Hawk Eagle, the Changeable Hawk-Eagle, and the Crested Serpent Eagle. After building the nest, the raptors will enter a period of oviposition (*egg laying*). The period of laying eggs for the Javan Hawk Eagle is in September, while the Changeable Hawk-eagle is in June, and the Crested Serpent Eagle is in March.

The egg laying period will immediately be followed by a brooding period (*incubation*). According to Pettingil (1985), hatching is a process of heat transfer from the bird to the egg. The incubation period of the Javan Hawk Eagle

began between September and October, while the Changeable Hawk-Eagle was between June and July, and the Crested Serpent Eagle was between March and April. The hatching behavior of all birds is generally the same. The birds will take a break in the nest by changing the position of sitting, standing, cleaning up, moving, and reversing the egg during the beak. The egg incubation is the period of regular undisturbed incubation from the beginning until the time of hatching (Pettingil 1985). Brooding birds are usually silent, although sometimes they respond to their partner's call with a lower tone. The arrival and departure from the nest are done quietly. For raptors having a nest in the tree, it is done by flying from the nest quickly in a downward direction and remaining at low levels for a short distance, sometimes taking advantage of the closure of bushes or lower bark. The method of arrival is the opposite of departure. Periods spent outside the nest are primarily aimed to find food, investigate, and move to areas around the nest. Copulation in incubation period is rarely performed (Pettingil 1985). The incubation period will end when the eggs hatched. For the Javan Hawk Eagle, this egg hatching period happened in October, while the Changeable Hawk-Eagle was in July, and the Crested Serpent Eagle was around April. The *egg hatching* period was then be followed by the *eaglet period*. In this period, the eaglets from the three raptors are still white and have a fluffy cotton feather. However, these feathers and colors would change as they mature until they are ready for their initial flight. The eaglet period for the Javan Hawk Eagle

occurred from October to December, while the Changeable Hawk-Eagle was from July to September, and the Crested Serpent Eagle was in April-May. The Javan Hawk Eagle and the Changeable Hawk-Eagle required a longer time in this eaglet period. The eaglet period was followed by a period of flight training (*fledge*). The exercise period for the Javan Hawk Eagle was in December, while the Changeable Hawk-eagle was in September and Crested Serpent Eagle was in May. As for the future care of the eaglets (*parental care*), the Javan Hawk Eagle began from January to March, while the Changeable Hawk-eagle was between September and November, and the Crested Serpent Eagle was from May to July. In this period, the parent will teach the eaglets how to search food and to survive.

Different with the obtained results in the Panaruban landscape, in the Telaga Warna landscape, only three out of the four-raptor species was found i.e the Javan Hawk Eagle, the Black Eagle, and the Changeable Hawk-eagle. The nests of Crested Serpent Eagle could not be found until now because the breeding period for the Crested Serpent Eagle in Telaga Warna landscape still could not clearly be determined. Additionally, the breeding period observed during the study period in Telaga Warna landscape was only one species namely the Changeable Hawk-eagle. 12 nests were found in the landscape including five active and one inactive nests of the Javan Hawk Eagle, five active nests of the Black Eagle, and one active nest for the Changeable Hawk-eagle (see table 3). The nest distribution map for the three types of raptors in Telaga Warna landscape could be seen in Figure 3.

The size area of Telaga Warna landscape is only a half of that in Panaruban, but the number of pairs of eagles which occupies Telaga Warna is quite numerous. In the preliminary study, it was noted that the number of pairs of eagles which occupied Telaga Warna landscape was twelve, consisting of five pairs of Javan Hawk Eagle, five pairs of Black Eagle, one pair of Changeable Hawk-eagle with the eaglet, and one pair of Crested Serpent Eagle. The Javan Hawk Eagle in Telaga Warna landscape began its breeding period in December, March or June depending on the weather changes. The breeding period was delayed if the weather was unfavorable such as continuous rain. However, the breeding period of the Black Eagle began in December and was not affected by the changes of the weather, while the breeding period of the Changeable Hawk-eagle usually occurs in March and April beginning with a *display*. The phenotypic performance of Changeable Hawk-eagle in Telaga Warna landscape is similar to Changeable Hawk-eagle with bright body colors (*light morph*).

Table 3. Number of raptor nests in Panaruban and Telaga Warna of West Java, Indonesia

	JHE	BE	CHE	CSE
Panaruban (AN)	1	1	1	-
Panaruban (IA)	1	-	1	2
Telaga Warna (AN)	5	5	1	-
Telaga Warna (IN)	1	-	-	-

Note: AN = Active Nest, IA = Inactive Nest, JHE = Javan Hawk Eagle, CHE = Changeable Hawk Eagle, BE = Black Eagle, CSE = Crested Serpent Eagle

In this study, the Changeable Hawk-eagle was experiencing a period of breeding, so the breeding data of this type were more complete compared to another eagle. The breeding of Changeable Hawk-eagle pair was the same object pair which was observed between 2005 and 2007 (Supaman 2017, pers. comm.). The tree used to build the nest was also the same nesting tree that was used in the breeding observation between 2005 and 2007. The tree used as a nest was a *puspa* tree (*Schima walichii*) located on the sharp slopes at an altitude of 1,576 m above sea level. It was an emergent tree and was located in a dense natural forest. The characteristics of nesting tree of the Changeable Hawk-eagle were: (i) located in the highest and the strongest tree with a height of 43 meters, which also had a most protruding tree among the trees in the vicinity, making the Changeable Hawk-eagle bring food easily to its eaglets, glide, care for, and teach the eaglets to fly, (ii) having a horizontal and strong branching to support the nest and make it easy for the eagle to get a comfortable perching position, (iii) having an open view of the nest towards the valley, making it easier to fly from and toward the nest, watching around the nest and supervising the eaglets for hunting purposes.

Results of field observations showed that the number of the Changeable Hawk-eagle population remained the same from 2005 to 2010 with means of 3 individuals although the individual birth of new eaglets had been recorded between 2005 and 2007 (Supaman 2017, pers. comm.). It might happen as one of Changeable Hawk-eagle's strategy to survive in habitats and also to expand the distribution of this species to another area. Generally, the parents of Changeable Hawk-eagle would take care and maintain their eaglet up to the certain age around a few months until the eaglet be able to survive by its self. Afterward, eaglet would then be immediately separated from its parents in order to find and define its own habitat. Based on the *compression territory* theory about the insistence or pressure from the same territory of individuals, the size area and the surrounding conditions of the habitat could affect the survival rate of young Changeable Hawk-eagle. In this study, the size area of the Telaga Warna Nature Reserve was only around 375.85 hectares with most of this area was densely inhabitants might cause the survival rate of young Changeable Hawk-eagle individuals was relatively low. The eaglet of the Changeable Hawk-eagle searching for new living habitat will potentially face the high risk of death if the eaglet cannot compete with other raptors except for that who could be able to compress or exhort with another eagles' cruising areas.

The characteristics of the Changeable Hawk-eagles in Telaga Warna landscape was almost the same as the ones in the Panaruban landscape. Although those in Panaruban initially made a nest in the mixed gardens with a slightly open vegetation structure, they will subsequent move to Blok Kaletes natural forests with a more lush vegetation structure. The Changeable Hawk-eagles in both Panaruban and Telaga Warna landscape had a different breeding period from other eagles around the landscape. This was in contrast to the period of breeding between the Black Eagle and the Javan Hawk Eagle happened often concurrent or

slightly different in the same time range, so that the competition between the Javan Hawk Eagle and the Black Eagle was higher during their breeding activities. The observations in both places showed that the competition of those two species could be seen from the attacking activity in the air especially when one type tried to approach or fly towards the nest of other competitors. Results from the distribution of the three types of nests for raptors founded in Telaga Warna landscape showed that the distance of several nests was apparently close each other with a radius of 250 m or a more distant radius. The types of nests within a radius of 250 m belonged to Javan Hawk-eagle number 1 and number 6. The nest number 6 was an inactive condition because the couple moved to the nest number 1 (Supaman 2017, pers. comm.). From the map observation, it could be seen that the Javan Hawk Eagle nests were widely spread out, and none of them had a close distance until the radius of 1000 m. This suggests that inter-specific competition of the Javan Hawk Eagle was likely high. On the other hand, two nest number of Black Eagle in the radius of 750 m was in active condition with two different pairs of Black Eagles i.e. number 1 and number 2 living in those nests. This means that the inter-specific competition of Black Eagle was lower compared to that of the Javan Hawk Eagle. Another closer nests were the nests of Javan Hawk Eagle and the Black Eagle with a radius of 500-750 m. Although the competition between the Javan Hawk Eagle and the

Black Eagle was often seen especially during the breeding period and in the placement of the space, both of them could still live together in a minimum radius of 500 m. This shows that despite the existence of inter-specific competition, the fact that they have different preferences of food making that inter-specific competition was relatively low. In another word, inter-specific competition may only happen during the selection of nest placement. The intimate nest preferences of the Javan Hawk Eagle and the Black Eagle showed that the niche type of those species overlapped each other; however, that overlapping niches did not cause a high competition between these two types of eagles. This is in contrast to the overlapping niche amongst the Javan Hawk Eagle, which tended to be smaller indicated by the wide distribution of nest placement. This spreading pattern of nests was in line with Schoener (1984) who stated that raptors prefer to form their own communities leading to the widespread niche because they sit on the top of food chain, which only has few predators (Schoener 1984). The spread of these niches occurs in various dimensions including habitat, food, and time depending on the order of importance (Schoener 1974). In addition, the Javan Hawk Eagle in Telaga Warna landscape had a fairly large cruising range, about 519 ha (Mikoyan 2004), making it easier for them to build nests that are not adjacent to other Javan Hawk Eagle couples.

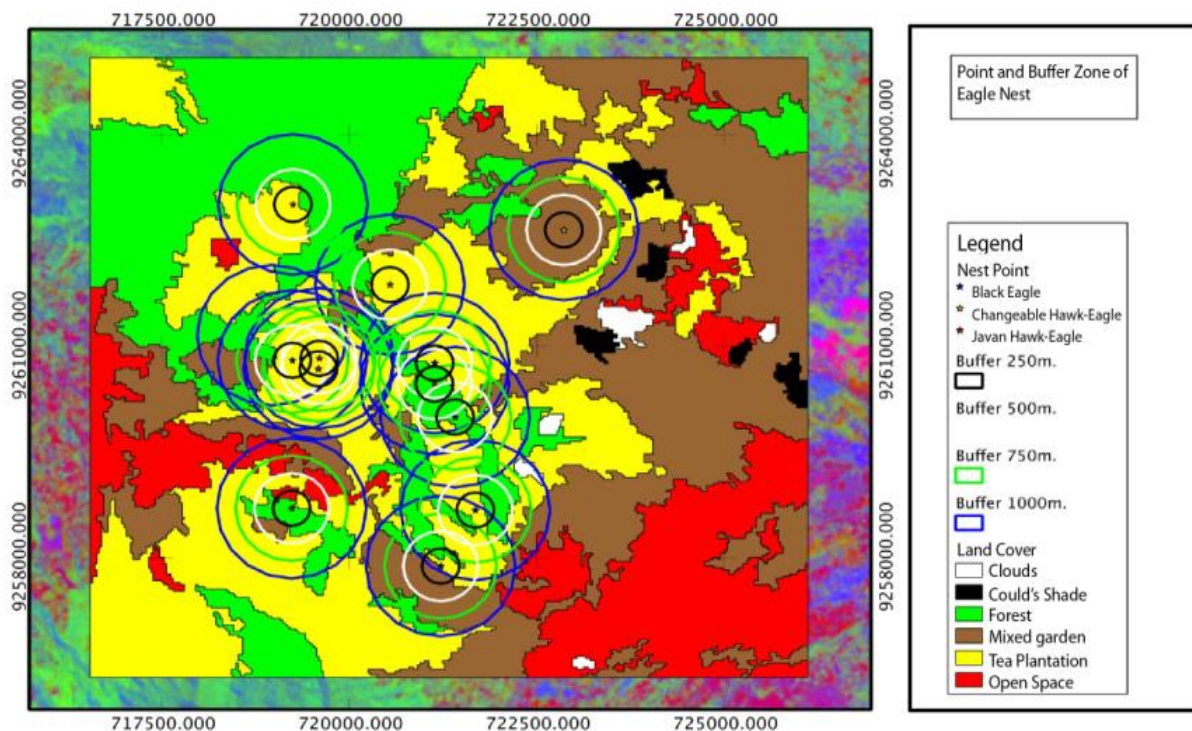


Figure 3. The nest distribution map for all three types of raptors in the Telaga Warna landscape, in the District of Subang, West Java Province, Indonesia

The use of a specific habitat is one of the basic considered-requirements for the co-existence of different species of sympatric raptors (Newton 1979; Bechard et al. 1990). In Telaga Warna landscape, despite the different preferences of main dietary among three species were found in the observed nests, those birds had also hunting new locations to reduce a conflict between species living in the landscape. One of the Black Eagles' nests, located near to one active and inactive nest of the Javan Hawk Eagle shows that inter-specific competition for determining the nest location has a less impact on the distribution of nests for both types. These results are consistent with the results of the same research conducted in Greece (Poirazidis et al. 2007), in Kazakhstan (Katzner et al. 2003) and Finland (Solonen 1993; Martinez et al. 2008) regarding with the comparison of nest selection patterns of four different sympatric raptors prior to conservation purposes.

It could be highlighted that four species of raptors that live together in Panaruban landscape and Telaga Warna had a different breeding period. Furthermore, it also showed different preferences in the nesting location amongst these four raptors showing that they selected their living habitat. This could clearly be seen in the selection of nesting place in Panaruban, where each kind of raptors has different characteristics of landscape elements. Therefore, it could be concluded that the use of the landscape during nesting period of four raptors observed in human-modified landscapes in Panaruban and Telaga Warna was varied based on the selection of nesting site and breeding period. This difference is probably one of the strategies to reduce the occurrence of competition in the breeding period. In general, the structure of the landscape in Panaruban and Telaga Warna simultaneously supports the presence of the raptor species so that made possible by the availability of food for those raptors could be varied.

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