JAVAN RHINO (*RHINOCEROS SONDAICUS*),BANTENG (*BOS JAVANICUS*)& OTHER MAMMALS COEXISTENCE IN UJUNG KULON NATIONAL PARK: SPATIAL AND TEMPORAL OVERLAP

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ABSTRACT

Ujung Kulon National Park (UKNP) is home to some threatened and iconic species including Javan rhinoceros (*Rhinoceros sondaicus*,) and banteng(*Bos javanicus*). Based on anecdotal observations, some conservationists suggest that these species are competing over space in the relatively small area of the Park.There is a growing concern that managing the habitat that benefit one species may reduce habitat availability for the other. This study investigates the use of space and time byJavan rhinos and banteng that may suggest coexistence of competitions between the two species. We used photographic samples from camera trap deployed in 2013 to monitor rhinos in UKNP. We used single-season occupancy model to determine important habitat variables for both species. Spatial co-occurrence of these species were investigated using conditional two-species occupancy model. Temporal overlap between two species was analysed using kernel density estimation (KDE) on circular time data. We found that both species are likely to be independent in using space and time. Probability of banteng occupancy when rhinoceros was present (PsiBA) higher(0.84) than occupancy of banteng when rhinoceros was not detected (0.81). Species interaction factor (SIF) for both species was1.039, indicating that both species werelikely to be independent and no indication of avoidance. Temporal coefficient of overlap for both species based on kernel density estimation was 0.79,which indicate that both species were active at around the same time. The results suggest that there wasno evidence of avoidance for both species as the indicator of competition. This impliesthat even both species have the potency to compete each other on food resources, this study could not find evidence for such a hypothesis. As the comparison, the same procedure in analysing temporal overlap done for other mammals pair of potential competitor (Muntjak and wild pig) and potential predator (wild dog). Mutjak and wild pig have time overlap with Javan rhinoceros of 0.51 and 0.47 indicates a very different time uses. Time overlap coefficient for wild dog and Javan rhinoceros is 0.49 indicates that wild dog preferred to hunt other mammals with more time overlap (mutjak (0.76) and wild dog (0.82)).

Keywords: Banteng (*Bos javanicus*), conditional two-species occupancy, inter-specific competition, Javan rhinoceros (*Rhinoceros sondaicus*),niche partitioning, Ujung Kulon National Park, world heritage.

1. INTRODUCTION

Ujung Kulon National Park (UKNP) is home to several endangered species, including Javan rhinoceros (*Rhinoceros sondaicus*, Desmarest 1822) and Banteng (*Bos javanicus*, d'Alton 1823). Javan rhinoceros is listed as Critically Endangered (IUCN 1996) and included on the Appendix I of CITES (Cites, 2016) due to the fact that,across the entire world, currently only a single population of 63 individuals in UKNP exists. (UKNP 2016). Meanwhile, bantengis Endangered under IUCN criteria. Both are, therefore, priority conservation target of UKNP. Banteng population size in UKNP is still remain unknown due to lack of population monitoring activity in UKNP for this species. Some rumours said that there still hundreds individual still remain in UKNP even the scientific based calculation is still hardly to be found.

As both Javan rhinos and banteng are large herbivores having some overlaps in their diets, many believe that these species are competing for food, space, and other resources. Javan rhinoceros browse on tip of leaves, small branches, treebark and lianas (Hoogerwerf, 1970). Banteng mainly graze (Hoogerwerf, 1970). However, some researchers found indications of competition between these two species in obtainingfood items due to the overlap on food plant preferences (Dharmakalih 1977, Mulyati, 1998 and Muntasib, 2000). About 57% (62 out of 109) types of rhinoceros food plants are also consumed by banteng (YMR, 2002). Similarly, Muntasib (2000) found that 75 types of food plants consumed both by javan rhinoceros and banteng. Javan rhinoceros and Banteng have similarities on shelter preference and water dependent as well as food preference (Suhono, 2001). Alikodra has indicated the change of banteng behaviour from grazer to become a browser (Alikodra, 1985). Those study suggest that javan rhinoceros and Banteng are likely to compete each other in the form of indirect competition as known as exploitative competition.

Previous studies conclusions of competition between Javan rhinoceros and Banteng was the conclusion of potential competition that might happened due to similarities of resources needs between two species. In this study, we used camera trapping data deployed to monitor Javan rhino population in 2013 to investigate possible competitions between the two species as indicated by overlaps in the use of space and time between the two species. UKNP has been using camera trap as a tool to monitor the dynamics ofJavanrhinoceros population since 2011. Since then, twenty three species of animal including javan rhino and banteng has successfully recorded in almost Eighty thousand video clip (UKNP, 2015).

2. MATERIALS AND METHODS

Study Area

This study was conducted in Ujung Kulon National Park, the westernmost tip of Java island in Indonesia, wherethe only world population of Javan rhinoceros inhabits ~30.000 hectares of the area. Mount Payung in the western part of this area was excluded as we believe that it is not habitable by both of these species due to steep terrain. Elevationof the study area variesfrom0 to 150 meters above sea level (USGS DEM) with land cover compositions include lowland primary forest (46.27%), low land secondary forest (20.7%), bushes and grassland (26.7%), as well as mangrove and coastal forest (4.57%). Land cover data were obtained from supervised classification on Landsat 8 imagery ofJune 2015 (WWF 2015).

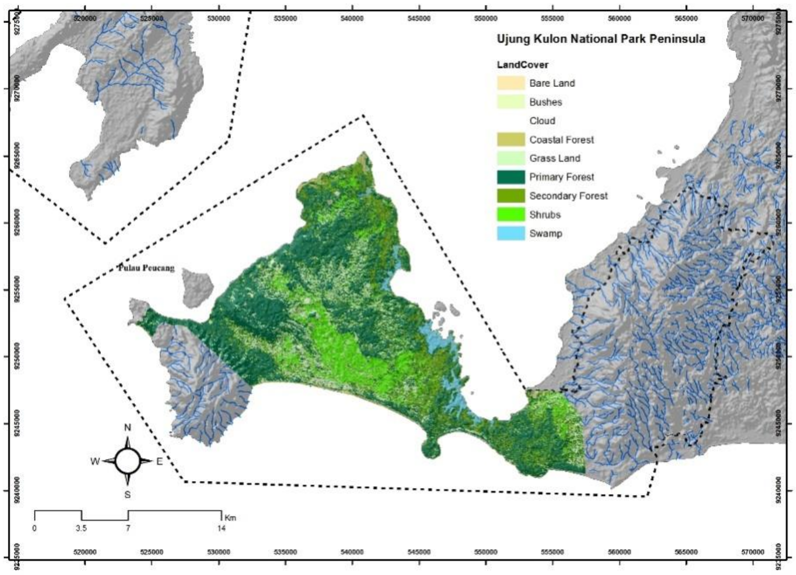

Figure 1. Map of the study area in Ujung Kulon Peninsula. Land cover information obtained from supervised classification on Landsat 8 imagery acquired in July 2014 (WWF 2015).

Camera trap and site covariates sampling

UKNP management has been using camera traps as a tool for wildlife monitoring since 2011 with Javan rhinoceros as the primary target. Camera trap is able to record photographic samples of the primary target as well as other species that pass through the range of its sensor (Sunarto et al, 2013). Data from camera trap of UKNP peninsula from 2013 survey were used for this study. The types of cameras used were Bushnell Trophy Cam®119406/119416.Twenty three species including javan rhinoceros and banteng, were recorded (UKNP, 2016). At least one camera was systematically deployed in every two by two kilometres grid cell, and covered all area known as potential habitat ofJavan rhinoceros and banteng.Tomaximise detection probability,up to three cameras were installed in different one by one kilometre square subcell within two by two kilometres cells based on the level of abundance of Javan rhinoceros sign from previous survey. In total, 36,104 clips were recorded, that include 1660 (5%) clipsof Javan rhinoand 3062 (8%) clips of Banteng. In this study, 176 sites were used for data analysis (Fig 2).

Information of variables assumed to be impacting species activities were carefully documentedin 50 metres range from every the camera trap station. They include elevation (meter ASL), topography (varies from flat to very steep, recorded as a scale from 0 (very flat) to 5 (very steep), vegetation's densities,scaled from 0 (open area) to 5 (very dense) and human disturbance level scaled from 0 (very low) to 5 (very high). Rumpang is log of distance to site from javan rhinoceros feeding ground were calculated based on rhinoceros feeding ground point locations (based on existing data from previous survey) to the camera stationusing geographic information system (GIS) techniques. Land cover types of each site were determined based on the land cover layer produced from the supervised classification on 2015 Landsat 8 imagery. Trapping rate data of Javan rhinoceros, banteng, muntjak (*Muntiacus muntjak*), wild pig (*Sus scrofa*), and wild dog (*Cuon alpinus*) were used as site covariates for the species assumed to be influencingeach other.

Land cover data extraction

Land cover information in this study extracted from Landsat 8 imagery acquired date of June 18, 2015 with resolution of 30 metre. Panchromatic sharpening technique is used to improve the spatial resolution into 15 metres. Three bands used to build the composite imagery are band 5, 6 and 7. Band 5 measures the near infrared, or NIR. This part of the spectrum is especially important for ecology because healthy plants reflect it – the water in their leaves scatters the wave lengths back into the sky. Bands 6 and 7 cover different slices of the shortwave infrared, or SWIR. They are particularly useful for telling wet earth from dry earth, and for geology (USGS, 2013). This composite of bands (657) will produce "false green" composite that sensitive enough to differentiate almost all surface feature on earth.

The composite imagery then classified using the supervised classification technique using maximum likelihood method and manually corrected by interpreter based on the field experiences of Ujung Kulon Peninsula condition. The groundchecking is needed to determine the accuracy level of this land cover data.

Habitat use modelling

Detection histories weredeveloped using detection - non detection of each species in the camera traps.Single-season occupancy model (MacKennzie et al, 2006)implemented in R package WIQID (Meredith, 2014) was usedto determine the factors impacting habitat used by Javan rhinoceros and banteng. We developed model to calculate single covariate effect in every model and compare each other based on model weight and Akaike Information Criteria/AIC (Brunham & Anderson, 1998) to determine the covariate affecting the species most. Two covariates influencing most for each species then selected to be used as covariate in conditional two-species occupancy model.

Analysis

Species interaction

Spatial co-occurrence

Overlap in the use of space between Javan rhinoceros and Banteng was investigated using conditional two-species occupancy model (Richmond et al, 2010) developed based on the likelihood-based two-occupancy model (Mackenzie et al, 2004, 2006) on detection history constructed from camera trapping photographic samples. Mackenzie builtthe likelihood-based two-species occupancy model that accounts for imperfect detection for analysing species co-occurrence pattern from repeated presence-absence survey data. The model directly estimates a “Species Interaction Factor” (SIF) that is a ratio of how likely the two species to co-occur compared to what would be expected under the hypothesis of independence. However, the limitation of the two-species model occupancy by Mackenzie et al (2004, 2006) is the failure to converge when covariatesare included and SIF is directly estimated (Richmond et al, 2010). The model developed by Richmond successfully incorporates the covariates in the analysis. Parameters estimated in the analysis are outlined in Table 1, where species A was assumed to be the dominant species while species B was assumed to be the subordinate species in the conditional two-species occupancy model.

Table 1. Description of the parameters used in the conditional two-species occupancy model

Parameter	Description
psiA	probability of occupancy of species A
psiBa	probability of occupancy of B if A is absent
psiBA	probability of occupancy of B if A is present
pA	probability of detection of species A if B is absent
rA	probability of detection of species A if both are present
pB	probability of detection of species B if A is absent
rBa	probability of detection of species B if both are present but A was not detected
rBA	probability of detection of species B if both are present and A was detected

Note: Javan rhinoceros assumed to be superior species (Species A) and Banteng assumed to be subordinate species (Species B).

The formula below was used to calculate SIF in the conditional two-species occupancy model:

$$SIF = \frac{Psi^{A}Psi^{BA}}{Psi^{A}(Psi^{A}Psi^{BA} + (1 - Psi^{A})Psi^{Ba})}$$

If two species occur independently, the SIF is equal to one. An SIF less than one indicates that species B is less likely to co-occur with species A (avoidance) under the hypothesis of independence, whereas value greater than one indicates that species B is more likely to co-occur with species A (co-existence) than expected under the hypothesis of independence.

The data were then pulled into seven days unit as occasion unit from the camera trap detection histories data due to the occurrenceof errors when using daily unit as occasion unit, which indicated that the daily detection probability was too small to be calculated in the model.

Temporal co-occurrence

Temporal co-occurrence between Javan rhinoceros and banteng was investigated based on their daily activity patterns. As a comparison, the temporal co-occurrence between pairs among Javan rhinoceros, banteng, muntjak, wild pig, and wild dog using kernel density estimation (KDE) on their activity circular data (Ridout & Linkie, 2009)were used to characterize activity pattern for each species and to calculate the coefficient of overlap (Δ) between their equation of 3.1 with a smoothing parameter (c) of 1.25.

3. RESULTS

Effort & General Results

Javan rhino monitoring with 120 units of camera trap in 2013 has successfully recorded 36,104 clips of 23 species including javan rhino and banteng. The effort varies between 50 to 286 active days for every sites and summarized in one by one kilometre square cell unit as shown in figure 2.Capture rate varies between 0.1 to 6.2 clips perday.

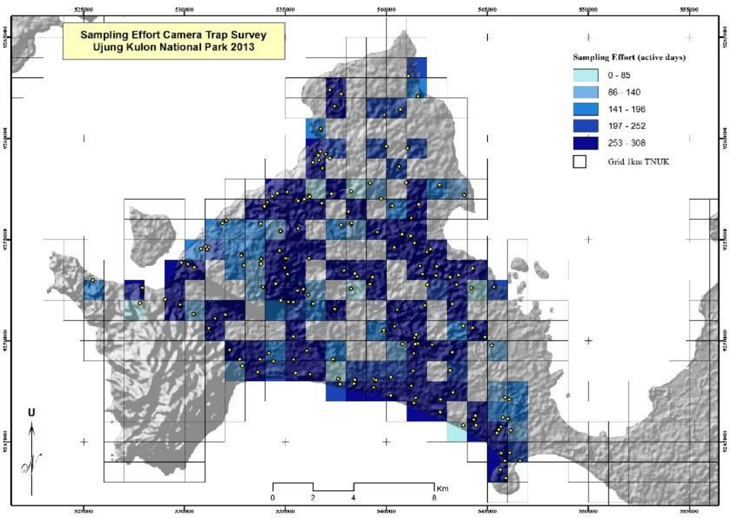

Fig 2. Camera trap active day information from every 1x1 km square area study

Habitat Model

Table 2. Single season occupancy model for Javan rhinoceros with Psi based on 'habitat' univariates

Models	Nparameter	AIC	DeltaAIC	ModelWt
RoccSSpsiRumpang	3	3378.177	0	0.485
RoccSSpsi_bos	3	3380.962	2.785	0.121
RoccSSpsi_constant	2	3382.121	3.944	0.068
RoccSSpsi_elev	3	3382.341	4.163	0.061
RoccSSpsi_Top	3	3383.1	4.923	0.041
RoccSSpsi_cuon	3	3383.938	5.76	0.027
RoccSSpsi_VegDens	3	3383.962	5.785	0.027
RoccSSpsi_panpar	3	3383.963	5.785	0.027
RoccSSpsi_LC	4	3384.03	5.853	0.026
RoccSSpsi_Disturbance	3	3384.092	5.915	0.025
RoccSSpsi_munmun	3	3384.121	5.943	0.025

The best model for single season occupancy model of Javan rhinoceros is the one that calculates Psi depending on the Rumpang (Javan rhinoceros feeding ground). Delta AIC difference ofmore than 2 points and model weight more than twice larger in comparison to the second best model means that this model was"significantly" better than the other models (Burnham & Anderson, 1998). The Javan rhinoceros was less likely to occur as the value of Rumpang become greater (Table 3) meaning that the Javan rhinoceros preferred to get closer to their feeding ground.

Table2a. Single season occupancy model for Javan rhinoceros where Psi depends on Rumpang covariate in beta value.

Model	est	SE	lowCI	uppCI
Psi~(Intercept)	0.6759526	0.17968662	0.3237733	1.0281319
Psi~logRumpang	-0.8883552	0.38579499	-1.6444994	-0.1322109

Tabel 3. Single season occupancy model for BantengwherePsi depends on covariates

AICtablen	Nparameter	AIC	DeltaAIC	ModelWt
nBoccSSpsi_Rhi	3	4130.559	0	0.567
nBoccSSpsi_cuon	3	4132.729	2.17	0.191
nBoccSSpsi_panpar	3	4133.64	3.081	0.121
nBoccSSpsi_constant	2	4137.272	6.713	0.02
nBoccSSpsi_elev	3	4137.564	7.005	0.017
nBoccSSpsiRumpang	3	4137.905	7.346	0.014
nBoccSSpsi_VegDens	3	4138.059	7.501	0.013
nBoccSSpsi_LC	4	4138.33	7.772	0.012
nBoccSSpsi_Disturbance	3	4138.934	8.375	0.009
nBoccSSpsi_munmun	3	4138.984	8.425	0.008
nBoccSSpsi_Top	3	4139.134	8.575	0.008

The best model for Banteng was the one where Banteng occupancy depends on Javan rhinoceros trapping rate as the covariate. This means that Javan rhinoceros trapping rate was the covariate that most influencing Banteng occupancy positively (table 5). The higher Javan rhinoceros trapping rate indicates the higher Banteng occupancy value. Delta AIC difference of more than 2 points from the second best model and other models meanno model competing. It is still unsure how the Javan rhinoceros trapping rates give positive impact to Banteng. This might be due to Javan rhinoceros feeding ground distance that equal to its trapping rate which makesthe Banteng easier to find food resource because 57% of Banteng food would be found in Javan rhinoceros feeding ground. Other factor such as the role of Javan rhinoceros asprotectors from predator consideredasthe biggest animal in UKNP could also be considered. Further analysis would be needed to investigate these findings more thoroughly.

Tabel 3a. Single season occupancy model for banteng where Psi depends on Javan rhinoceros trapping rate covariate in beta value.

/odel	st	;E	ɔwCI	ppCI
Psi~(Intercept)	2.319184	0.706466	0.934535	3.703832
Psi~raterhison	5.984706	3.900624	-1.66038	13.62979

Spatial and Temporal Co-occurrence

Spatial Overlap

Conditional two-occupancy models were run to examine and conclude the type of interaction between Javan rhinoceros and Banteng. Questions to be answered including the likelihood of these two species to occur independently, the possibility of Banteng being less likely to co-occur (avoidance) which indicates the presence of competition, and the possibility of Banteng being more likely to co-occur (aggregation) which indicates a mutualism. The model exhibiting maximum interaction was the best out of 95 models run, where AIC difference was more than two indicating there was no model competing. Conditional two-species occupancy model was used with maximum interaction to describe the type of interaction between Javan rhinoceros and Banteng spatially.

Tabel 4. The 20 top-performing conditional two-species occupancy models examining interaction between Javan rhinoceros and Banteng.

no	Model Name	Para-meter	AIC	Delta	Model Weight
1	RB_psiAr_rAbos_psiBArhi_psiBarhi_rBacuon	13	7330.33	0	0.179
2	RB_psiAr_rAbos_psiBArhi_rBARHi	12	7330.704	0.374	0.149
3	RB_psiAr_rAbos_psiBArhi	11	7330.888	0.558	0.136
4	RB_psiAr_rAbos_psiBArhi_rBacuon	12	7331.129	0.799	0.12
5	RB_psiAr_rAbos_psiBArhi_rBaRHi	12	7332.533	2.203	0.06
6	RB_psiAr_rAbos_psiBArhi_rBAcuon	12	7332.701	2.371	0.055
7	RB_psiAbos_rAbos_psiBArhi_psiBarhi_rBArhi	13	7333.167	2.837	0.043
8	RB_rAbos_psiBArhi_psiBaRHi	11	7333.205	2.875	0.043
9	RB_rAbos_psiBArhi_rBARHi	11	7333.907	3.577	0.03
10	RB_psiAbos_rAbos_psiBArhi_rBARHi	12	7333.928	3.598	0.03
11	RB_rAbos_psiBArhi	10	7334.09	3.759	0.027
12	RB_psiAbos_rAbos_psiBArhi	11	7334.107	3.777	0.027
13	RB_psiAbos_rAbos_psiBArhi_rBacuon	12	7334.32	3.99	0.024
14	RB_rAbos_psiBArhi_rBacuon	11	7334.323	3.993	0.024
15	RB_rAbos_psiBArhi_rBaRHi	11	7335.729	5.399	0.012
16	RB_psiAbos_rAbos_psiBArhi_rBaRHi	12	7335.768	5.438	0.012
17	RB_psiAbos_rAbos_psiBArhi_rBAcuon	12	7335.911	5.58	0.011
18	RB_rAbos_psiBArhi_rBAcuon	11	7335.912	5.582	0.011
19	RB_rAbos_psiBArhi_psiBarhi_rBarhi_rBAcuon	13	7336.675	6.345	0.008
20	RB_psiAr_rAbos_psiBAcuon_rBArhi	12	7350.912	20.582	0

The best model with maximum interaction indicated that Javan rhinoceros occupancy (PsiA) with the assumption of no interaction was lower (not significant) than Javan rhinoceros occupancy (PsiA) with interaction happened between Javan rhinoceros and Banteng.The probability of occupancy of Banteng in the absence of Javan rhinoceros (PsiBa) was shown to be lower (not significant) than the probability of occupancy of Banteng as independent species. Meanwhile, the probability of occupancy of Banteng in the presence of Javan rhinoceros was shown to be higher (not significant) than the probability of occupancy of Banteng as independent species. The result reveals that Javan rhinoceros and Banteng were likely to be independent in their way to occupy a certain space. There was an indication of positive impact of the Javan rhinoceros presence although not statistically significant.

Detection probability of Javan rhinoceros in the absence of Banteng (pA) was shown to be significantly lower than the detection probability of Javan rhinoceros as independent species (no interaction). On the other hand, detection probability of Banteng in the absence of Javan rhinoceros (pB) was shown to be significantly lower than the detection probability of Banteng as independent species (no interaction). Detection probability of Javan rhinoceros if both javan rhinoceros and Bantengwerepresent (rA) was shown to be higher (not significant) than the detection probability of Javan rhinoceros as independent species. Detection probability of Banteng when both Javan rhinoceros and Banteng were present but Javan rhinoceros was not detected (rBa) was lower (not significant) than detection probability of Banteng as independent species. The detection probability of Banteng if both javan rhinoceros and Banteng were present and detected (rBA) was significantly higher than detection probability of Banteng as independent species. Banteng seemed to be influenced positively with the presence of Javan rhinoceros according to the result of maximum interaction model for conditional two-species occupancy in this study.

We calculate SIF for Javan rhinoceros and Banteng based on the best model (maximum interaction) result. SIF for Javan rhinoceros and Bantengwas 1.039 meaning that both were likely to be independent of each other considering the SIF value was close to one. The result of this study implies that even though Javan rhinoceros and Banteng are potentially competing with each other due to food plant resource overlaps, however this indication of competition was not detected in 2013 survey data.

Table 7. Conditional two-species occupancy model result for Javan rhinoceros and Banteng

No interaction				**Maximum interaction**			
	est	**lowCI**	**uppCI**		**est**	**lowCI**	**uppCI**
psiA	0.6506	0.5720	0.7219	**psiA**	0.6818	0.5858	0.7645
psiBa	0.8249	0.7530	0.8792	**psiBa**	0.8149	0.5606	0.9382
pA	0.1787	0.1659	0.1924	**psiBA**	0.8442	0.7264	0.9171
pB	0.1897	0.1777	0.2023	**pA**	0.0531	0.0254	0.1077
				pB	0.1321	0.1087	0.1597
				rA	0.1889	0.1752	0.2034
				rBa	0.1812	0.1658	0.1976
				rBA	0.3193	0.2825	0.3584

Temporal Overlap

Kernel density estimation analysis on Javan rhinoceros, Banteng, mutjak, wild pig, and wild dog's circular data of their daily activity pattern (Table 8) shows that Javan rhinoceros and Banteng had similar activity pattern [Δ=0.798]. Activity pattern of mouse deer was similar with activity pattern of wild pig [Δ=0.806]. Wild dog which is a predator suspected to be the main threat for Javan rhinoceros had a very different activity pattern when compared to Javan rhinoceros [Δ=0.493] or its other potential prey species. Wild dog is considered to be top predator of Javan rhinoceros after the Javan tiger was reported to be extinct. Wild dog was most likely to co-occur based on activity pattern with wild pig [Δ=0.821], mouse deer [Δ=0.761], and Banteng [Δ=0.624] consecutively. When the activity pattern similarity between predator and potential prey was used as indicator of prey preference for predator, then it could be concluded that wild dog's most preferred prey in consecutive order was wild pig, mouse deer, and Banteng. Javan rhinoceros would be the last species expected to be hunted by wild dogs.

Based on the analysis of spatial and temporal overlap in this study, no indication of competition between Javan rhinoceros and Banteng was found. Javan rhinoceros and Banteng were likely to occur independently.

Table 8. Overlap coefficient of activity pattern based on Kernel density estimation on circular data

Species	Javan rhinoceros	Banteng	Muntjak	Wild pig	Wild dog
Javan rhinoceros	1				
Banteng	0.7987704	1			
Muntjak	0.5100416	0.6602768	1		
Wild pig	0.4725833	0.6018588	0.806473	1	
Wild dog	0.4938083	0.6249953	0.7617438	0.8219245	1

0 indicates no overlap in activity time and 1 indicates complete overlap in

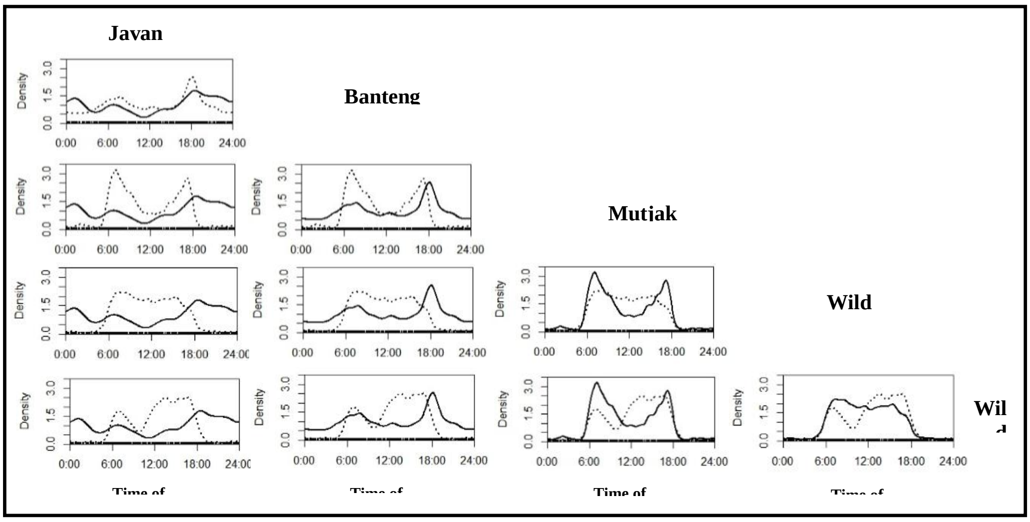

Figure 3. Overlap of activity patterns based on Kernel density estimation on circular data. Solid linesrepresent species in each column; dotted lines represent species in the row.

4. DISCUSSION

Habitat model

Habitat variables used in the model to determine habitat variable important most for javan rhinoceros and banteng are habitat variables recorded during the camera trap survey in 2013 and habitat variable that important for javan rhinoceros and banteng based on the previous study (YMR 2000 and Muntasib, 2002) which is rumpang. Rumpang assumed to be the hotspot for both species in seeking of food and rumpang is the place where most of food plant types for javan rhinoceros can be found (Rahmaningsih, 2013). Rumpang is the place where interaction between javan rhinoceros and banteng would be higher than other habitat types. Sign of selected species (javan rhinoceros, banteng, muntjak, wild pig and wild dog) were observed during the survey in purpose to be used in the species analysis. In this study, trapping rate of selected species are used rather than the finding rate of sings of selected species observed during the survey due to time range of camera trap active days are longer than the time range of sign’s observation. This makes the data of trapping rate are more complete and represent the same time range with the detection non-detection data of javan rhinoceros and banteng than the rate of signs observed during the survey. Other habitat variables assumed to be important for both species – Wallow for javan rhinoceros (Rahmat, 2012), salinity and mineral sources for example - may be used in the future study to find more complete understanding of javan rhinoceros and banteng needs in the habitat.

The model built in this study to determine habitat variable important for javan rhinoceros and banteng was only compared single variable in every model influencing the occupancy value (psi). Single variable influencing the probability of detection and combined variables influencing both occupancy and probability of detection may be compared in the future study to get better estimation according to the AIC and model weight value.

Species interaction

Spatial co-occurrence and time overlap

Co-occurrence analysis between javan rhinoceros and banteng is using detection non-detection data from camera trap survey on javan rhinoceros monitoring in 2013. The data pulled into seven day unit as occasion unit due to the very small probability of detection when using daily unit as occasion unit and the convergence was not reached in the model. The model cannot generate AIC value using R program in WIQID (Meredith, 2014) package and generate unrealistic standard error value (SE are hundred or even thousand times the estimate value) in the PRESENCE program (Hines, 2010) when using daily unit as occasion unit. That unrealistic results are due to the very small probability of detection when using the daily unit as occasion unit. Seven day unit (weekly unit) as the closest unit that most people will familiar with is chosen to be used as occasion unit. Convergence was reached in the model using weekly unit as occasion unit. But using weekly unit as occasion unit made co-occurrence assumption become weak if the assumption of co-occurrence is the direct encounter of javan rhinoceros and banteng. Javan rhinoceros could be occurred on Monday and banteng could be occurred on another day yet the data of detection non-detection will still tell that both javan rhinoceros and banteng were detected in the same occasion. The longer occasion unit used the smaller probability of direct encounter will happen. Time overlap analysis from both species (javan rhinoceros and banteng) is used as the comparison with spatial overlap analysis in this study. If time overlap analysis conclude the same result as spatial overlap analysis, then the conclusion of this study could become stronger and if the time overlap analysis conclude the opposite result with the spatial overlap analysis, then further analysis is needed to get the proper result. Survey designed to get data with occasion unit that will gives highest probability of encounter for javan rhinoceros and banteng and able to give the data with higher probability of detection is highly needed in the future study as same as building the method that able to calculate a very small probability of detection and still able to give the plausible result.

The conclusion of time overlap between pairs of species in this study analysed based on camera trap data of javan rhinoceros monitoring survey in 2013. No independent clip interval were set to the camera trap data in this study because more than 90% site of camera trap were in animal trail. Animal only passing through this type of site and the chance to get clips recorded the same animal with a long duration of time will be very small. The thirty second duration of recording and ten second interval between one capture to another capture setting of the camera trap will record different individual of animals in the trail type of site. Independent clip interval setting to this kind of data will make the possibility of losing some independent clip of certain animal will be higher while not setting independent clip interval will make certain animals with "trap happy" (anilmal with high curiosity of new things) character have higher density of detection than reality which both setting give unequal data for all species. Independent clip interval would be needed based on the type of site and the character of species is needed in the future study to give the closest similarity with the real condition.

Interaction analysis between two species ideally is done based on the data observed from area of interest for both species where both species depend on the same resource. For example, interaction analysis for larger Virginia rail (*Rallus limicola*, Vieillot, 1819) and smaller California Black Rail (*Laterallus jamaicensis coturniculus*, Gmelin, 1789) done based on data observed from marsh area which is the area where both species depend their self in finding food (Richmond, 2010). If the resource is rich enough for both species then the dominant species will likely let the subordinate species to find the resource when dominant species is occur. And the dominant species will chase away the subordinate species or the subordinate species will likely avoid the dominant species if the resource is limited for both species. Rumpang is assumed to be the area of interest for javan rhinoceros and banteng while there are very few site types of rumpang in this study. Alternatively sites distance to rumpang is used in this study as covariate to how the model prediction on interaction varies with the distance of rumpang to the sites.Identification of the most important variable habitat for javan rhinoceros and banteng to be area of observation will make a better prediction on how likely javan rhinoceros and banteng to co-occur for future study.

Javan rhinoceros and Banteng are priority species for conservation action, globally and national level. The commitment at national level has been implemented based on Ministry of Forestry regulation No. P.57/Menhut-II/2008. Ujung Kulon National Park is home to both of these species.Previous studies indicate the presence ofcompetition between them. Reliable analysis is important to build an effective strategy on habitat and population management on both species. This study provides an insight into the condition of species interaction through plausible data analysis and conclude that no evidence found on javan rhinoceros and Banteng competition is happening based on spatial and temporal overlap analysis.

Single season occupancy analysis on some covariates for Javan rhinoceros indicates that "distance to feeding ground" to be the most important factor affecting Javan rhinoceros occupancy. Previous study indicated that distance to wallow is the factor most affecting Javan rhinoceros movement (Rahmat, 2002). Feeding ground and wallow are usually found to be closed to each other in UKNP. Browsing and wallowing are part of Javan rhinoceros daily activities.

Feeding ground is described as an area dominated by understory vegetation level with very low density of canopy cover. Feeding ground has a vast range of Javan rhinoceros food plant preferences (Rahmanigsih, 2013). With 57% javan rhinoceros food plant consumed by Banteng, this makes feeding ground an important habitat component for Banteng as well as Javan rhinoceros. Muntasib (2000) found Banteng signs on feeding ground where Javan rhinoceros signs were also found.

This study and Javan rhinoceros monitoring by UKNP found that Javan rhinoceros and Banteng are likely to co-occur temporally (BTNUK, 2006). Single season occupancy model for Banteng suggested that javan rhinoceros trapping rate is the most affecting factor for Banteng occupancy. It could be due to the same area for both species to find food resource (feeding ground) as Muntasib (2000) documented 75 types of vegetation are consumed by Javan rhinoceros as well as the Banteng. Species interaction factor for Javan rhinoceros and detection probability of Banteng in the presence or absence ofJavan rhinoceros indicated that higher likelihood for Banteng to co-occur with Javan rhinoceros. It could be due to Banteng avoidance from predator and Javan rhinoceros can be assumed to be a protector considered as the biggest mammals in the area. Even thoughthe indication of competition was not found in this study, the population monitoring of Banteng would be essential in order to capture the evidence of competition between both species for especially considering they have same food resource. There is also a possibility of mutual symbiosis between Javan rhinoceros and Banteng based on the spatial temporal co-occurrence analysis, however further study is needed to comprehensively describe this phenomenon. Strategy to optimize habitat carrying capacity for both species is needed as well as the plan on population management.

Assumption of wild dog as a threat for Javan rhinoceros is found to be less precise based on this study result. Activity pattern of wild dog overlaps mostly with the wild pig. If the value of activity pattern overlap of predator and potential prey species indicates prey preference for predator then wild dog would prefer to hunt wild pig and mouse deer than Banteng or javan rhinoceros. However, wild dog has apotency to hunt a prey with size much bigger than themselves because they hunt it in a group. Hunting in group enables them to build distraction strategy to separate the easier targetlike calves from their parent. Therefore, monitoring on wild dog and its prey population in UKNP is also important to catch early indication of wild dog over population as well as prey decreasing population that potentially become a serious threat for priority species in Ujung Kulon National Park such as the Javan rhinoceros and Banteng.

5. CONCLUSION

1. Rumpang (feeding ground) is the most important habitat variable for javan rhinoceros while banteng depend on javan rhinoceros occurrence in unknown reason based on this study.
2. Javan rhinoceros and Banteng are likely to co-occur independently, spatially (SIP=1.01) or temporarily [Δ=0.798] and indicate no competition happening. But even now indication of competition has not been found in this study, Banteng population monitoring is essential to capture indication of competition between both species for both species highly demand for the same food resource.
3. Monitoring on wild dog and its prey population in UKNP is important to catch early indication of wild dog over population that potentially become a serious threat for priority species in Ujung Kulon National Park such as javan rhinoceros and Banteng.

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