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Comparative behavioral ecology of the White-Bellied Sea Eagle and Brahminy Kite (Aves: Accipitriformes) in Northwestern Malaysia

Abolghasem Khaleghizadeh[1*] and Shahrul Anuar[2]

[1]*Agricultural Zoology Research Department, Iranian Research Institute of Plant Protection, Agricultural Research, Education and Extension Organization, Tehran, Iran*
[2]*School of Biological Sciences, Universiti Sains Malaysia, USM 11800, Pulau Pinang, Malaysia*
Corresponding author✉: *akhaleghizadeh@gmail.com*

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Abstract

Behavioral events of two raptor species, the White-bellied Sea Eagle, *Haliaeetus leucogaster* Gmelin, 1788 and Brahminy Kite, *Haliastur indus* Boddaert, 1783 were studied once every two weeks in two locations in northwestern Malaysia, namely Balik Pulau and Kuala Sepetang, from September 2012 to September 2013. The average total number of behavioral events per hour was 45.9 (±40.3 SD), 117.0 (±131.7 SD), and 285.8 (±185.0 SD) for *H. leucogaster* at Balik Pulau, and *H. indus* at Balik Pulau and Kuala Sepetang, respectively. The total number of individuals of each species observed was significantly influenced by the time of day and weather ($p<0.05$). It was observed that the percentage of time spent for perching, flying, hunting and competition was significantly different between these two species and between two locations. The total number of behavioral events among observation dates was no different for the White-bellied Sea Eagle than that of the Brahminy Kite. Overall, the percentage of time that the birds spent perching, flying, hunting, social behavior and competition was different between species. The highest rate of successful predation was 94.6% for *H. leucogaster* while it was lower for *H. indus* at Balik Pulau (72.8%). The time of day was an effective factor for determining behaviors of *H. leucogaster* while it was not significant for *H. indus*. The effect of boat numbers and weather on behavior varied between species and locations. The state of the tide and the number of crows present did not have any significant effect on activities of these two species. Results of the comparison of the percentage of occurrence of five types of behavior between adults and juveniles showed that behaviors of perching, hunting and social behavior were different for *H. leucogaster*, behaviors of perching, flying and social interaction for *H. indus* at Balik Pulau and behaviors of perching, flying, hunting and social interaction for *H. indus* at Kuala Sepetang. However, they did not show different behavioral events of involving competition.

Key words: Behavior, Brahminy Kite, White-bellied Sea Eagle, Malaysia

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Introduction

Raptors can be divided into diurnal and nocturnal, and sometimes crepuscular, based on biorhythmic activities (Rodriguez-Estrella, 2000). Comparative behavioral studies of raptors usually compare behaviors of two or three coexisting species (Thiebot et al., 2012), examining behaviors such as perching, flying, predatory and other foraging behaviors, and aggressive competition (Koplin et al., 1980; Buttemer et al., 1986). Coexisting species may be comprised of a diurnal raptor and a nocturnal owl species (Sergio et al., 2003) or two diurnal raptor species (Olsen et al., 2006). Such studies have documented behavioral repertoires and time budgets of these species through reporting changes in behavior in response to time and seasons (Xirouchakis, 2007), weather conditions (Machmer and Ydenberg, 1990; Jiménez and Jaksic, 1991) and tidal states (Watson et al., 1991; Dekker et al., 2011).

Studies of behavior of raptors have involved direct field observations (Xirouchakis, 2007) and radio-tracking (Catry et al., 2011), as well as using caged animals (Scherzinger, 1974). Field observations typically involve either scan sampling or focal sampling (Altmann, 1974). In scan sampling, the simultaneous behavior of multiple individuals may be recorded at specified times, while focal sampling involves continuous observation of a particular individual. Behaviors can be recorded as discrete events (exhibition of a behavior at a point in time or expressed as a frequency per unit time) or as behavioral states (continuation or duration of a behavior of an individual) (Gaibani and Csermely, 2007).

The White-bellied Sea Eagle, *Haliaeetus leucogaster* Gmelin, 1788 and the Brahminy Kite, *Haliastur indus* (Boddaert, 1783) are resident raptors with diurnal activities living in the Southeast Asian and Australian regions. The eagle species is significantly larger than the kite species. They inhabit coastal areas and tidal ecosystems (Robson, 2002; Khaleghizadeh and Anuar, 2014a). Generally, *H. leucogaster* and *H. indus* share similar habitats, but they differentiate to a certain extent, according to microhabitats (Khaleghizadeh and Anuar, 2014b; Khaleghizadeh et al., 2014; Khaleghizadeh and Anuar, 2017). It can be stated that *H. leucogaster* prefers offshore islands covered with dipterocarp forest while *H. indus* prefers mangrove forests (Khaleghizadeh and Anuar, 2014a). Although both species are locally common in Malaysia, information about their behaviors are scanty (Indrayanto, 2011; Masduqi, 2011). This study seeks to address this knowledge-gap.

A habitat can be used for multiple purposes such as daytime perching and nighttime roosting of raptors (Becker, 2002). Evaluations of human-raptor interactions can be assessed through documenting the effects of human disturbance (number of events) on eagle numbers, distribution, feeding behavior, and flushing response. The number of individuals and area of hunting in a habitat differ between raptor species. The response of eagles to resume feeding after any disturbance is different and eagles were more sensitive when foraging compared to other behaviors (Grubb and King, 1991). Eagles were less tolerant of human recreationists when they were feeding on the ground than when perching in trees (Stalmaster and Kaiser, 1997). In Malaysia, *H. leucogaster* is the emblematic species of the Penang National Park and *H. indus* seems to have its highest population in Matang Mangrove Forest. Human disturbance caused by tourism seems to pose the greatest threat in Penang National Park. Agroforestry and fishing boat traffic are two main disturbances in Matang Mangrove Forest. Here we studied the behavior of *H. leucogaster* and *H. indus* in two of their important habitats in Malaysia.

Objectives of the present research were to examine the behavior of *H. leucogaster* and *H. indus* and their interactions in western Peninsular Malaysia. The current study aimed to document the behavioral repertoires and year-round changes in the prevalence of *H.*

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leucogaster and *H. indus*, as a function of various abiotic factors such as time-of-day, tidal states and weather conditions.

Material and Methods

Study areas

Fieldwork was conducted in two areas on the west coast of the Malaysian Peninsula, namely, Penang Island and Matang Mangrove Forest (Fig. 1). Penang Island contains several nests of both *H. leucogaster* and *H. indus* (Masduqi, 2011), and Matang Mangrove Forest holds nests of the Brahminy Kite (Indrayanto, 2011). Therefore, they are visible year-round at these two sites and monitoring behavioral events of these species is possible with sufficient data for different times spanning a whole year.

Two stations, where usually several individuals of *H. leucogaster* and *H. indus* have regularly been seen, were chosen for the behavioral study: a) Kuala Sepetang in Matang Mangrove Forest for *H. Indus*, and b) Balik Pulau for both *H. leucogaster* and *H. indus*.

Kuala Sepetang (4°50'05.52"N, 100°37'38.00"E) is a village adjacent to the central part of Matang Mangrove Forest (Fig. 2). The village is surrounded by mangrove forests, and the Forestry Office of Matang Mangrove Forest is located adjacent to the village. Large numbers of fishing boats pass through the channels around the village and many individuals of the Brahminy Kite forage in the area.

Kuala Sungai Pinang in Balik Pulau (5°23'31.15"N, 100°11'34.72"E) is adjacent to a village with the same name (Fig. 3). The river Sungai Pinang passes through the village. Several White-bellied Sea Eagles and Brahminy Kites forage around the mouth of the river throughout the year. Fishing boats frequently pass through the river mouth. The northern and southern parts of the village are linked to mangrove forests. This area is located at the southern edge of Penang National Park where there is a second gate to the park.

Field observations

After finding suitable locations for repeated observations on the behavior of *H. leucogaster* and *H. indus*, behavioral observations were conducted at Kuala Sepetang and Balik Pulau, from September 2012 to September 2013. Birds were observed at both sites twice per month; one in the first half and another in the second half of each month. Behavior was recorded for all adults and juveniles. All individuals of *H. leucogaster* and *H. indus* viewed from a distance of 500 m with the assistance of an Omicron 10x42 pair of binoculars. On each observation day, behaviors of birds were recorded three times: in the morning after sunrise (08:00–09:00), noon (12:30–13:30) and in the evening before sunset (17:00–18:00).

Following Gaibani and Csermely (2007), all-occurrence (or event) sampling was employed. The instantaneous scan method introduced by Altmann (1974) and later used by Tacha et al. (1985) and Palmer et al. (2001) was employed. Therefore, in the present study, activity of all individuals was sampled at one-minute intervals for a duration of 60 minutes. Overall, 158 hours of observations were made at both sites. Behavioral events seen in the field were categorized as perching (including preening), flying (including searching and soaring), hunting (including diving, failed attack, successful attack, and eating), social (including calling, breeding activities, and scavenging) and competition (inter-specific and intra-specific attacks). The rate of successful attack to total hunting attempts for the purpose of prey capture was also calculated as successful predation rate. At each time of the day, the tidal state (low,

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high, flooding or ebbing), weather conditions (sunny, cloudy, rainy), maximum number of crows within the observation field and the number of boats passed during the 60-minute periods were also recorded.

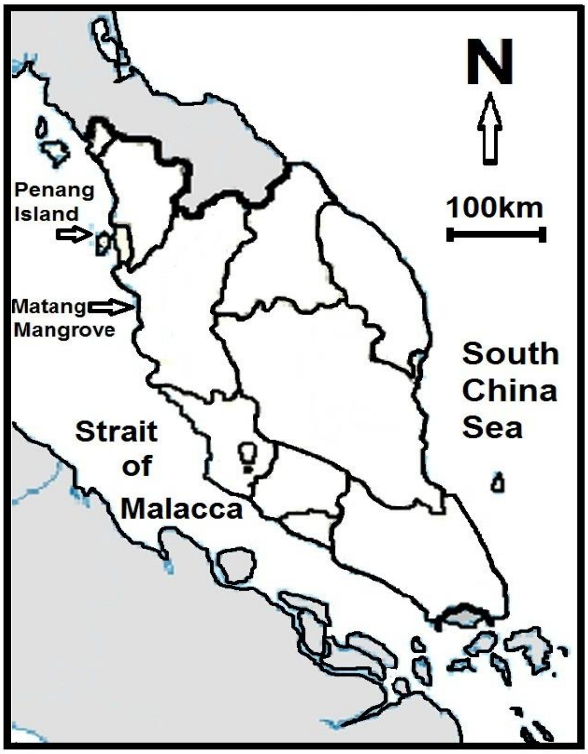

Figure 1: Map of Peninsular Malaysia showing location of Penang Island and Matang Mangrove Forest.

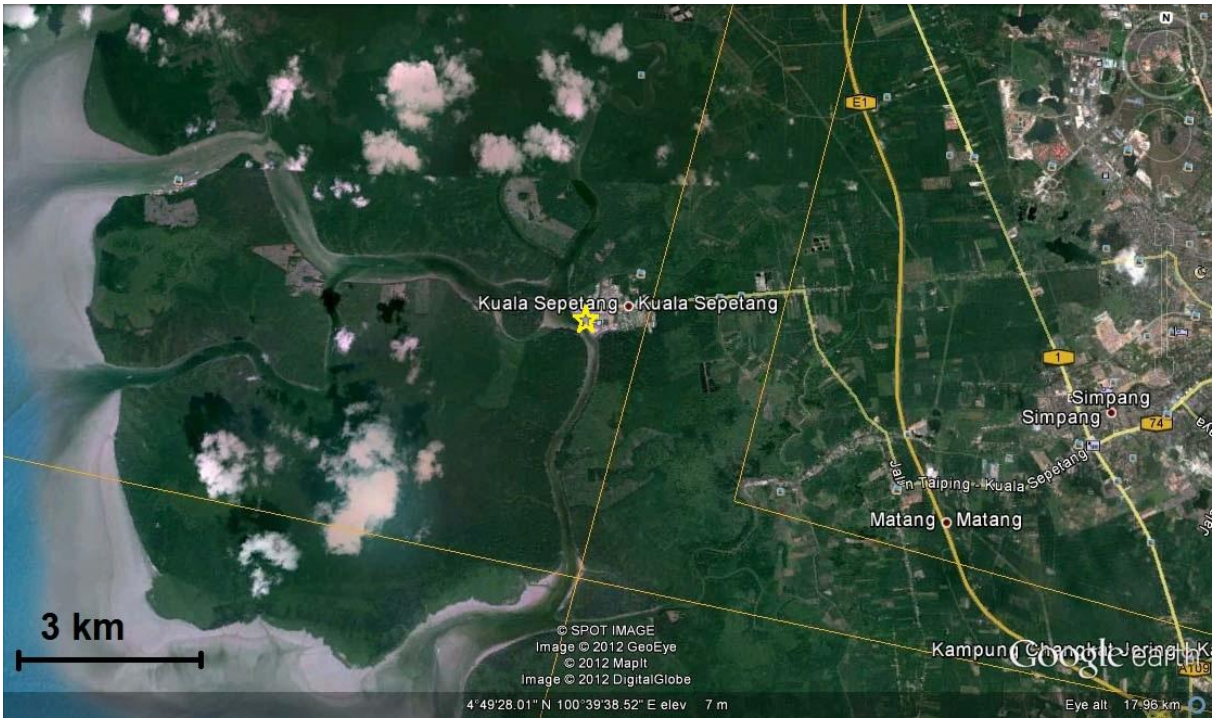

Figure 2: Map of Kuala Sepetang in Matang Mangrove Forest (SPOT 4 imagery).

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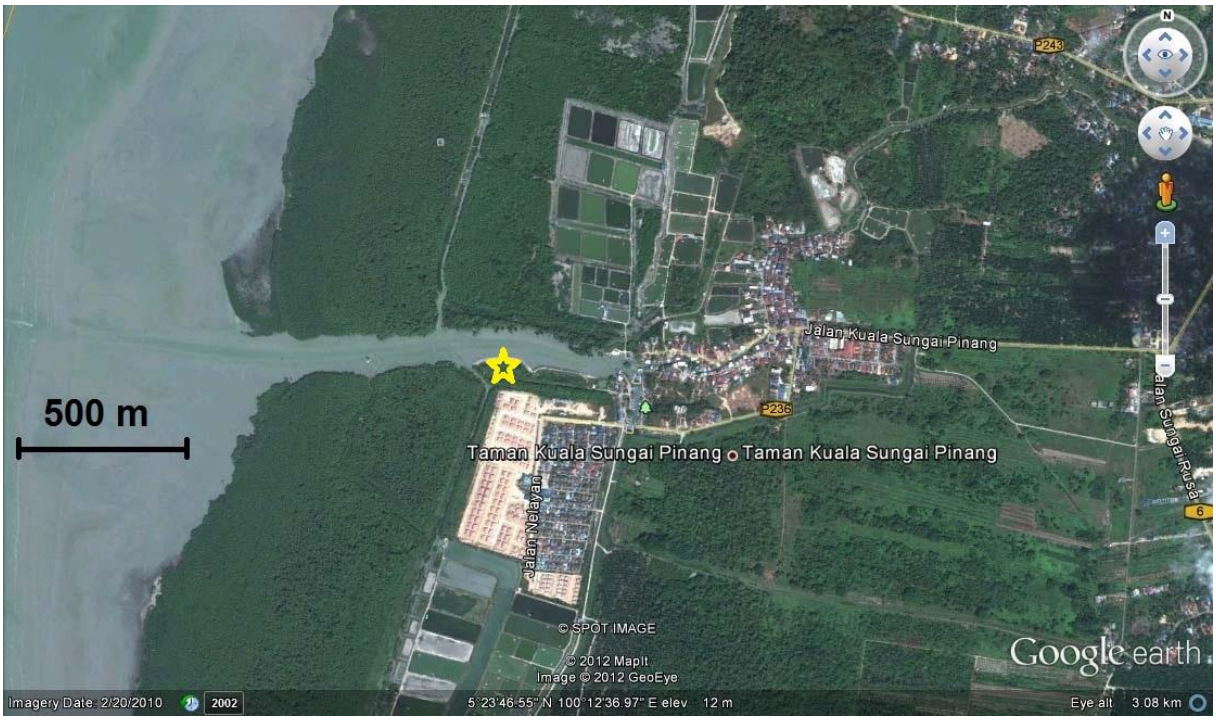

Figure 3: Map of Kuala Sungai Penang in Balik Pulau (SPOT 5 imagery).

Data analysis

Three sets of data were constructed for 1) *H. leucogaster* at Balik Pulau, 2) *H. indus* at Balik Pulau and 3) *H. indus* at Kuala Sepetang. Because *H. leucogaster* was very rare at the study station at Kuala Sepetang, its data could not be incorporated within the present study analyses. The type of behavior and total number of behavioral events at different times of the year were compared using the one-way ANOVA test. Mean total behavioral events were compared among observation dates using Kruskal-Wallis test. The percentage of the five types of above-mentioned behaviors was first transformed to square root (Parsad, 2005). Then five types of behavior of adults and juveniles were compared using two independent non-parametric (Mann-Whitney U) tests while the three data sets of successful attacks for prey catching was compared using a Kruskal-Wallis non-parametric test. The effect of the predictor variables (time of day, tidal state, weather condition and number of boats) on total behavior was analyzed using Multiple Regression analysis. Before this, dates with less than ten total behavioral events were excluded from the analyses. Multiple Categorical variables were transformed to Dummy variables. Before running Multiple Regression analysis, predictors were checked for existence of minimum correlation with total number of individuals of each raptor species. Independent variables were checked for possible multicollinearity using Tolerance and Variance Inflation Factor (VIF) values. Normal Probability Plot (P-P) was used to check overall normality of tests. Outliers were checked using Mahalanobis and Cook's values (Meyers et al., 2006). Data were analyzed with SPSS version 20.

Results

Total behavioral events

The average of total behavioral events per hour was 45.9 (±40.3 SD), 117.0 (±131.7 SD), and 285.8 (±185.0 SD) for *H. leucogaster* at Balik Pulau, *H. indus* at Balik Pulau and at Kuala

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Sepetang, respectively (Fig. 4). Based on a Kruskal-Wallis test, total behavioral events were not different among observation dates for *H. leucogaster* at Balik Pulau ($p>0.05$) and for *H. indus* at Kuala Sepetang ($p>0.05$) but it was significantly different for *H. indus* at Balik Pulau ($p<0.05$).

The percentage of the five types of behavior is presented in Table 1. A Kruskal-Wallis test showed significant differences among three sets of data (for two species and locations) for all behaviors, i.e. perching, flying, hunting, social, and competition ($p<0.05$, Table 1). In addition, comparison of the five types of behavior between adults and juveniles of these three sets (Tables 2-3) showed that the behavior of perching, hunting and social interaction was different between adults and juveniles of White-bellied Sea Eagle ($p<0.01$, Table 3). Brahminy Kite showed different behaviors of perching, flying and social interaction between adults and juveniles at Balik Pulau ($p<0.01$, Table 3) while this species showed different behaviors of hunting between adults and juveniles at Kuala Sepetang, in addition to significant differences of three previous behaviors ($p<0.05$, Table 3).

The rate of successful predation was significantly different among the three sets of data for species/location (Kruskal-Wallis, $p<0.05$). The rate was lowest for *H. indus* at Balik Pulau (72.8%) while *H. leucogaster* had the highest rate of 94.6% (Table 4).

Effect of environmental factors on behavior

All predictor variables for *H. leucogaster* were entered in the standard model of Multiple Regression (Adjusted R square= 0.320, $F_{8,59}$= 4.948, $p<0.001$) and the variables measuring noon and evening had a significant effect on the total number of *H. leucogaster* individuals ($p<0.05$, Table 5). All the environmental variables for *H. indus* at Balik Pulau were entered in the standard model of Multiple Regression but their overall effect was not significant (Adjusted R square 0.059, $F_{8,59}$= 1.522, $p>0.05$). However, among the predictor variables only the variable measuring cloudy weather condition had a significant effect on the total number of individuals of *H. indus* in Balik Pulau ($p<0.05$, Table 6). Also, all the environmental variables for *H. indus* at Kuala Sepetang were entered into the standard model of Multiple Regression (Adjusted R square = 0.001, $p>0.05$) and none of the variables had significant effect on the total number of the species in Kuala Sepetang ($p>0.05$, Table 7).

Compared with the morning, both noon and evening times showed significant effect on the total behavioral events of *H. leucogaster* ($p<0.05$). For *H. leucogaster*, the mean total number of behavioral events was 74.7, 23.8 and 39.2 in the morning, noon and evening, respectively. Cloudy weather conditions had a significant effect on the total behavioral events of *H. indus* at Balik Pulau ($p<0.05$). Tidal states did not show any significant effect in the Multiple Regression analysis ($p>0.05$).

Regarding boat numbers, there was no correlation between this variable and total number of behavioral events of *H. indus* at Kuala Sepetang (r= 0.116, $p>0.05$) nor at Balik Pulau (r= –0.008, $p>0.05$); but there was a significant correlation between number of boats and the total number of behavioral events of *H. leucogaster* (r= 0.298, $p<0.05$).

The crow species occurring at Balik Pulau was the House Crow, *Corvus splendens* Vieillot, while at Kuala Sepetang it was the Large-billed Crow, *Corvus macrorhynchos* Wagler. The average maximum number of crows was 1.32±2.24 at Balik Pulau and 1.35±1.65 at Kuala Sepetang. There was no correlation between the number of crows and the total number of behavioral events of either *H. indus* at Kuala Sepetang (r= –0.058, $p>0.05$) or at Balik Pulau (r= 0.041, $p>0.05$), nor *H. leucogaster* (r= 0.010, $p>0.05$).

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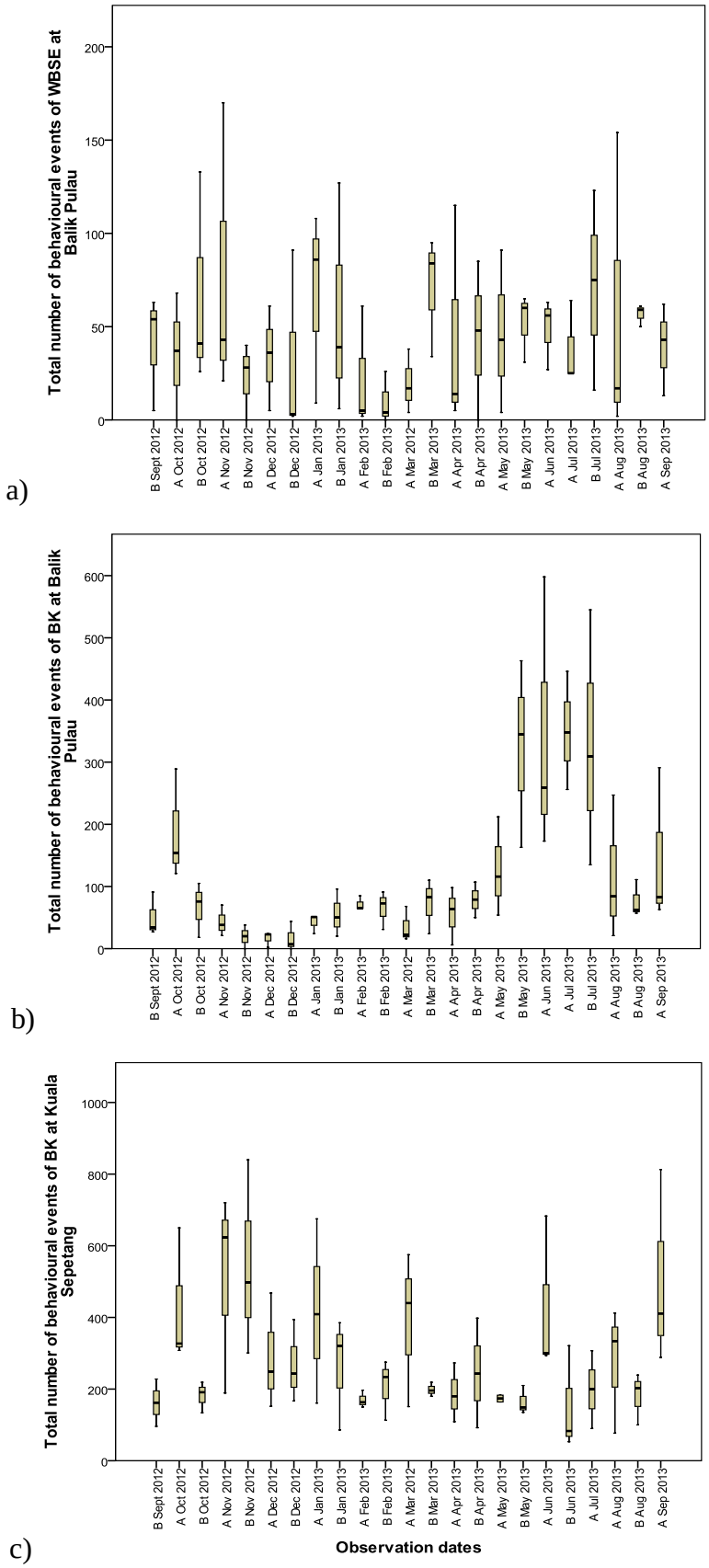

Figure 4: Total behavioral events of a) *Haliaeetus leucogaster* (WBSE) at Balik Pulau, b) *Haliastur indus* (BK) at Balik Pulau and c) *Haliastur indus* (BK) at Kuala Sepetang.

Table 1: Statistics of percentages of behavior (perching, flying, hunting, social, and competition) of *Haliaeetus leucogaster* at Balik Pulau, and *Haliastur indus* at Balik Pulau and Kuala Sepetang.

Type of behavior/ Species		No.	Mean	SD	Min.	Max.	Kruskal-Wallis test Asym. Sig.
Perching	*H. leucogaster*	65	6.390	3.503	0.000	10.000	H= 13.130, P= 0.001
	H. indus- Balik	67	6.943	2.880	0.000	10.000	
	H. indus- Sepetang	69	5.211	2.897	0.000	9.730	
	Total	201	6.197	3.171	0.000	10.000	
Flying	*H. leucogaster*	65	5.088	3.302	0.000	10.000	H= 21.201 P= 0.001
	H. indus- Balik	67	5.267	2.362	0.000	100.000	
	H. indus- Sepetang	69	7.187	2.307	1.710	9.930	
	Total	201	5.869	2.839	0.000	10.000	
Hunting	*H. leucogaster*	65	1.293	2.060	0.000	7.500	H= 19.631 0.001
	H. indus- Balik	67	1.846	1.766	0.000	6.550	
	H. indus- Sepetang	69	2.095	1.397	0.000	8.200	
	Total	201	1.753	1.778	0.000	8.200	
Social	*H. leucogaster*	65	1.299	1.427	0.000	5.940	H= 46.084, P= 0.001
	H. indus- Balik	67	1.194	1.074	0.000	4.300	
	H. indus- Sepetang	69	0.122	0.323	0.000	1.570	
	Total	201	0.860	1.164	0.000	5.940	
Competition	*H. leucogaster*	68	0.334	0.902	0.000	4.710	H= 26.522, P= 0.001
	H. indus- Balik	67	0.648	0.970	0.000	3.780	
	H. indus- Sepetang	69	0.869	0.701	0.000	2.190	
	Total	201	0.622	0.886	0.000	4.710	

Table 2: Statistics of five types of behaviors for adults and juveniles.

Type of behavior	Adult-Juvenile	White-bellied Sea Eagle at Balik Pulau			Brahminy Kite at Balik Pulau			Brahminy Kite at Kuala Sepetang		
		N	Mean Rank	Sum of Ranks	N	Mean Rank	Sum of Ranks	N	Mean Rank	Sum of Ranks
Perching	Adults	23	29.170	671.000	23	27.110	623.500	23	32.020	736.500
	Juveniles	23	17.830	410.000	18	13.190	237.500	23	14.980	344.500
	Total	46			41			46		
Flying	Adults	23	21.780	501.000	23	15.200	349.500	23	18.570	427.000
	Juveniles	23	25.220	580.000	18	28.420	511.500	23	28.430	654.000
	Total	46			41			46		
Hunting	Adults	23	28.610	658.000	23	21.280	489.500	23	19.430	447.000
	Juveniles	23	18.390	423.000	18	20.640	371.500	23	27.570	634.000
	Total	46			41			46		
Social	Adults	23	34.430	792.000	23	29.170	671.000	23	27.150	624.500
	Juveniles	23	12.570	289.000	18	10.560	190.000	23	19.850	456.500
	Total	46			41			46		
Competition	Adults	23	24.830	571.000	23	22.430	516.000	23	25.430	585.000
	Juveniles	23	22.170	510.000	18	19.170	345.000	23	21.570	496.000
	Total	46			41			46		

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Table 3: Statistics of two independent non-parametric test (Mann-Whitney U) for comparison of five types of behaviors between adults and juveniles.

Variable	Perching	Flying	Hunting	Social	Competition
White-bellied Sea Eagle at Balik Pulau					
Mann-Whitney U	134.000	225.000	147.000	13.000	234.000
Wilcoxon W	410.000	501.000	423.000	289.000	510.000
Z	-2.893	-0.870	-2.890	-5.906	-1.072
p-value	0.004	0.384	0.004	0.000	0.284
Brahminy Kite at Balik Pulau					
Mann-Whitney U	66.500	73.500	200.500	19.000	174.000
Wilcoxon W	237.500	349.500	371.500	190.000	345.000
Z	-3.697	-3.509	-0.171	-5.206	-0.914
p-value	0.000	0.000	0.864	0.000	0.361
Brahminy Kite at Kuala Sepetang					
Mann-Whitney U	68.500	151.000	171.000	180.500	220.000
Wilcoxon W	344.500	427.000	447.000	456.500	496.000
Z	-4.336	-2.494	-2.055	-2.391	-0.987
p-value	0.000	0.013	0.040	0.017	0.324

[a]. Grouping Variable: Adult-Juvenile

Table 4: Statistics of successful predation (%) of *Haliaeetus leucogaster* at Balik Pulau, and *Haliastur indus* at Balik Pulau and Kuala Sepetang.

Species/site	No.	Mean	SD	Min.	Max.	Kruskal-Wallis test Asymp. sig.
H. leucogaster at Balik Pulau	14	94.640	14.473	50.000	100.000	
H. indus at Balik Pulau	21	72.810	30.430	0.000	100.000	
H. indus at Kuala Sepetang	23	83.960	18.900	21.000	100.000	
Total	58	82.500	24.129	0.000	100.000	0.012

Table 5: Multiple Regression of total behavioral events of *Haliaeetus leucogaster* with environment variables at Balik Pulau.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	56.127	12.274		4.573	0.000		
Noon	-51.956	12.471	-0.614	-4.166	0.000	0.466	2.145
Evening	-35.034	10.484	-0.413	-3.342	0.001	0.665	1.505
Medium tide	24.680	13.149	0.217	1.877	0.065	0.757	1.321
High tide	10.548	9.850	0.127	1.071	0.289	0.724	1.382
Cloudy	17.473	9.735	0.195	1.795	0.078	0.858	1.166
Rainy	11.380	12.159	0.100	0.936	0.353	0.885	1.130
Boat at Balik	0.677	0.664	0.114	1.020	0.312	0.815	1.227
Crows at Balik	-1.180	2.063	-0.066	-0.572	0.570	0.772	1.296

[a]. Dependent Variable: Total number of behavioral events of *H. leucogaster* at Balik Pulau.

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Table 6: Multiple Regression of total behavioral events of *Haliastur indus* with environment variables at Balik Pulau.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	147.433	47.224		3.122	0.003		
Noon	-41.857	47.982	-0.151	-0.872	0.387	0.466	2.145
Evening	51.790	40.336	0.187	1.284	0.204	0.665	1.505
Medium tide	-48.820	50.591	-0.131	-0.965	0.338	0.757	1.321
High tide	-25.630	37.897	-0.094	-0.676	0.501	0.724	1.382
Cloudy	-85.037	37.455	-0.291	-2.270	0.027	0.858	1.166
Rainy	-26.611	46.782	-0.072	-0.569	0.572	0.885	1.130
Boat at Balik	1.293	2.556	0.066	0.506	0.615	0.815	1.227
Crows at Balik	-2.094	7.936	-0.036	-0.264	0.793	0.772	1.296

[a]. Dependent Variable: Total number of behavioral events of *H. indus* at Balik Pulau

Table 7: Multiple Regression of total behavioral events of *Haliastur indus* with environment variables at Kuala Sepetang.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	218.493	66.361		3.293	0.002		
Noon	29.187	64.180	0.075	0.455	0.651	0.555	1.800
Evening	109.738	70.679	0.282	1.553	0.126	0.461	2.168
Medium tide	-73.158	70.014	-0.140	-1.045	0.300	0.842	1.187
High tide	-41.683	54.407	-0.109	-0.766	0.447	0.748	1.337
Cloudy	37.792	50.533	0.102	0.748	0.458	0.810	1.235
Rainy	86.451	71.934	0.178	1.202	0.234	0.688	1.453
Boat at Sepetang	0.586	1.861	0.052	0.315	0.754	0.554	1.805
Crows at Sepetang	-2.857	14.707	-0.026	-0.194	0.847	0.879	1.137

[a]. Dependent Variable: Total number of behavioral events of *H. indus* at Kuala Sepetang

Discussion

The number of *H. leucogaster* individuals among observation dates was not different, because the study site at Balik Pulau has been used as a foraging area of the species with low numbers. The number of individuals for population of *H. indus* at Balik Pulau peaked from mid-May to late July, presumably after the release of juveniles (Indrayanto et al., 2011). The number of individuals of *H. indus* at Balik Pulau was changeable because of many factors such as weather conditions, prey availability, breeding season activities and the release of juveniles.

The study showed that only *H. leucogaster* had significant difference in the total number of behaviors among different times of the day, the highest rate was 74.7 in the morning, 39.2 in the evening and 23.8 at noon, while the total number of behaviors in *H. indus* was not different either in Balik Pulau or in Kuala Sepetang. Many raptors such as the Griffon Vulture, *Gyps fulvus* (Hablitz) had previously showed difference at various times of the day

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with two peaks in the morning and afternoon (Xirouchakis, 2007). The number of raptors among different daytimes was significant for flying birds but insignificant for perching birds (Applegate et al., 2003).

Perching is a sit-and-wait strategy in raptors (Baladrón et al., 2006). Wintering Eurasian Sparrowhawks, *Accipiter nisus* (Linnaeus) spent 62% of their time perching (Cresswell, 1996) while Red-backed Hawks, *Geranoaetus polyosoma* (Quoy and Gaimard) spent 78.8% of their time perching (Baladrón et al., 2006). Larger raptors such as the Golden Eagle, *Aquila chrysaetos* (Linnaeus) spend even more time perching (77.9%–84.7%) (Collopy and Edwards, 1989). In the present study, the proportion of perching activity of *H. leucogaster* individuals was significantly higher than *H. indus* at both sites. The higher rate of perching could also be related to higher rate of successful predation in large raptors. In *H. leucogaster* individuals, both the percentage of perching (63.5%) and successful predation rate (94.6%) were higher than *H. indus* (35.4%–58.8% and 72.8%–83.9%, respectively).

The rate of successful hunting varies from 33% to 76% among raptors (Toland, 1986; Baladrón et al., 2006). In the Common Kestrel, *Falco tinnunculus* Linnaeus, the rate was different between sexes, 35% by males and 27% by females (Kitowski, 2005). Some species such as the Merlin, *Falco columbarius* Linnaeus, have shown an even lower rate of 5% (Page and Whitacre, 1975). However, it seems that *H. leucogaster* has a higher level of successful attack rate (94.6%). The Brahminy Kite also had high rates of 72.8% and 83.9% but these rates include the scavenging of dead or immobile prey as well; while, hunting attacks of *H. leucogaster* were all on live prey (A. Khaleghizadeh, field observations).

The proportion of flight activities was significantly different between species and locations in this study, because they include soaring and searching or foraging flights. The lesser flight activities of *H. leucogaster* (24.3%) and the higher percentage for *H. indus* at Kuala Sepetang (56.9%) are probably because *H. leucogaster* is a hunter of fresh/live prey, while *H. indus* is a partial scavenger (Wells, 1999; Robson, 2002). It is also noticeable that individuals of *H. indus* sometimes gather from other parts of Matang Mangrove Forest at Kuala Sepetang at a crossing point of both large rivers and fishing boats. They gather to catch small and dead fish thrown by fishermen. This behavior was part of scavenging behavior of *H. indus* at Kuala Sepetang.

The proportion of competition among *H. leucogaster* individuals (0.71) was nearly half of those of *H. indus* (1.24–1.41) (Table 1). In the present study, although the crow species was different between the two study areas, the number of crows was not an effective factor on the total number of behavioral events. There is still debate on how crows impact negatively on raptors. However, it seems that the amount of mobbing by crows is considerable as demonstrated by the increased mobbing of taxidermic mounts of the Red-tailed Hawk *Buteo jamaciensis* (Gmelin, 1788) and Bald Eagle *Haliaeetus leucocephalus* (Linnaeus) rather than Western Ospreys, *Pandion haliaetus* (Linnaeus) (Marzluff et al., 2015). Crows can also compete with raptors by killing their potential prey, pursuit of raptors carrying prey, and harassment and pirating of prey (Simmons and Barnard, 2011). However, the Carrion Crow, *Corvus corone* Linnaeus also displayed more attacks on the Northern Goshawk, *Accipiter gentilis* (Linnaeus) than the Common Buzzard, *Buteo buteo* (Linnaeus) (Krüger, 2002) and corvids such as the Hooded Crow, *Corvus cornix* (Linnaeus) have been shown to steal prey from *F. tinnunculus* (Kitowski, 2005). During the present study observations, several individuals of the House Crow also showed mobbing behavior around perched *H. leucogaster* to chase them away.

Tidal states did not show significant effects on the total number of behaviors of *H. leucogaster* and *H. indus*. Foraging Bald Eagles need a water depth less than 4 m (to catch

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fish prey); and, they were also dependant on tidal flats (Watson et al., 1991). *Haliaeetus leucogaster* and *H. indus* often use the estuary of Pinang River as a foraging, predation and perching site, and even for nesting in *H. indus*.

In this study, only cloudy weather conditions had a significant effect on the total number of behavior of *H. indus* at Balik Pulau. Inclement weather had a negative effect on the breeding of the American Kestrel, *Falco sparverius* Linnaeus (Dawson and Bortolotti, 2000) and rain can also halt behavior of raptors (Thiollay, 1991); as observed during these field studies (A. Khaleghizadeh, field observations).

The number of boats was an effective behavior modification factor only for *H. leucogaster*. The effect was maximized when the number of boats and total behavioral events of *H. leucogaster* individuals were at their highest at times of ebbing and flooding tidal states (14.6, 66.1, respectively). Similarly, boat numbers have previously been reported to have an effect on Osprey, *Pandion haliaetus* distribution (Peters and Otis, 2005). Furthermore, the flush distance of *Haliaeetus leucocephalus* to boats was 126–127 m while perching but it was 218–237 m while feeding (Stalmaster and Kaiser, 1997). Previous studies on eagle behavior and disturbances have resulted in recommendations for protection of habitats of raptors (Richardson and Miller, 1997). Maintaining necessary buffer zones is based on the flushing distance to disturbances (Stalmaster and Kaiser, 1997). In the buffer zones, restrictions on human activities such as boating near eagle foraging areas will be implemented (Stalmaster and Kaiser, 1997; Wood, 1999).

In order to take into account the findings of the present study with respect to appropriate conservation and management measures, studies should also be carried out on the number of tourists, peak time of tourist activities and the number of boats (both tourist boats and fishing boats) moving about in the coastal areas of the Penang National Park. More studies are necessary to find out the relationship between the behavior of *H. leucogaster* and human activities and disturbances. Long-term assessment of behavior should focus on the response of *H. leucogaster* to changes in its immediate habitat and greater environment.

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