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## ASSESSMENT OF THE MANGROVE FOREST CHANGES ALONG THE PAHANG COAST USING REMOTE SENSING AND GIS TECHNOLOGY

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**Abstract:** Mangrove forests provide vital ecosystem services to the surrounding communities. Despite their importance, development in coastal areas impose a direct impact on reducing area cover. It is an important topic to understand the effect of coastal development on the carbon storing capacity of mangroves. This study aimed to examine the rate of erosion and accretion and estimate the amount of carbon stock change along the Cherating - Pekan coastline in Pahang, Malaysia. The rate of erosion and accretion from 2006 to 2014 was determined by using SPOT 5 satellite images. The normalised difference vegetation index (NDVI) was modelled to estimate carbon stock specific to the mangrove forest. Results from the study reveal that mangroves grew at only four locations along the 87 km Cherating-Pekan shoreline. Difference analyses unveil that the coastline had undergone erosion and accretion processes, with Cherating River and Penor River showing the most rapid change of 10.31 and 18.17 m/year, respectively, using the end point rate (EPR) method. Ular River and Kuantan River have been identified as areas prone to moderate erosion. The total carbon stock of mangroves in 2006 and 2014 was estimated at 499.78 and 520.48 t/ha, respectively. This finding provides the baseline information which would be helpful and should be considered when planning the future development as well as in the management of resources along the Pahang coastline.

Keywords: Carbon stock, erosion and accretion, NDVI, climate change, GIS.

### Introduction

Mangroves are valuable, unique in structure, and have a special ecological function while they are also ecologically vulnerable to environmental changes. Mangrove ecosystem is an important natural resource that provides multiple ecosystem services for the local communities. A comprehensive assessment of natural resources can provide important information required for the planning, management, and conservation of mangroves. Amir (2018) asserted that there is a need to improve the weaknesses in the planning, approval, and implementation processes of mangrove-related projects to

ensure the sustainability of their resources. Mangrove forests provide a wide range of products and services such as food sources for the coastal community, nursery habitats, biodiversity conservation, water filtration, shoreline stabilisation, storm protection, flood control, recreation, and tourism (McIvor *et al.*, 2012; Rahman *et al.*, 2013; Spalding *et al.*, 2014; Sandilyan & Kathiresan, 2015; Giri *et al.*, 2015).

Mangrove protection is increasingly believed to be crucial in terms of climate change mitigation and adaptation by virtue of the large amount of carbon available in the above and

below ground biomass. Donato *et al.* (2011) estimated that mangroves store the larger amount of carbon than any other types of forest, with a storage capacity of between 990 and 1074 t/ha. These forests have been recognised as highly productive and carbon sequester (Kauffman *et al.*, 2011; Adame *et al.*, 2013; Costanza *et al.*, 2014).

Despite their values, these ecosystems continue to shrink in area cover and are being degraded and converted for various reasons such as urban, aquaculture, and agriculture development (Giri *et al.*, 2011; Richards & Friess, 2016; Madihah *et al.*, 2018). In Malaysia, most of the mangrove habitat loss is due to the change in land cover as a result of agricultural expansion as well as aquaculture and urban coastal development (Richards & Friess, 2016). Polidoro *et al.* (2010) predicted that the impacts of future anthropogenic activities on coastal ecosystems would only worsen as the population in the coastal regions continues to increase. As a result, the pressures exerted by humans have been shown to be a major threat to the mangrove ecosystem. Ottinger *et al.* (2016) have found that the fastest growing animal-producing sectors, i.e., the aquaculture industry also poses a serious threat to the mangroves.

One of the main factors that have been decreased of the mangrove distribution along the Pahang coastline is coastal development. Ahmad *et al.* (2019) mentioned that these mangrove areas have been cleared to give space for developments such as human settlements, aquaculture farm, small markets, parking area, and others. Furthermore, Dasgupta & Shaw (2013) mentioned that the land near river and shoreline are low in value and affordable, therefore attracting developers to develop the area and causing severe destruction to the mangroves. The Malaysian mangroves provide multiple ecological, economical, and social benefits to the coastal population (Kanniah *et al.*, 2015).

The ability of remote sensing to estimate mangrove cover and biomass has improved significantly over time (Sharma *et al.*, 2009;

Kuenzer *et al.*, 2011). GIS and remote sensing are acceptable methods to evaluate the impact of the sea level rise, coastal erosion, and land use changes near the coastal area (Maulud & Rafar, 2015). Satellite remote sensing can give a more comprehensive and rapid assessment of coastal and mangrove area covers (Bandyopadhyay *et al.*, 2009; Sharma *et al.*, 2012). Proisy *et al.* (2007) reported that the advancement in technology has not only improved the accuracy of remote sensing for mapping and detecting change, but it also improved the ability to predict standing biomass. Kuenzer *et al.* (2011) described that remote sensing as a very consistent and reliable method for measuring and monitoring large forested areas. Therefore, this study aimed to assess the land use cover changes and estimate the aboveground carbon stock changes in the mangrove forest along the Pahang coastal area using the satellite remote sensing technique.

## Methodology

### Study area

The study was conducted in the low lying Cherating-Pekan shoreline of the Pahang state, which is located in the East Coast of Peninsular Malaysia, facing the South China Sea (between 04° 07' 38'' and 03° 32' 05'' N; 103° 23' 45'' and 103° 27' 41'' E). The Cherating-Pekan coastal area is nearly to 84-km long sandy shoreline. The mangroves areas are located at Cherating River, Ular River, Kuantan River and Penor River. The National Coastal Erosion Study (NCES) (1985) shows that these areas are a major resource for the local fishing industry as well as important spawning and feeding areas for many marine and intertidal species.

### Data

The data used in this research were obtained from both *in-situ* observation and satellite images. Two series of optical satellite images were used to determine the coastal land use cover change and mangroves aboveground carbon stock. The cloud free satellite images (SPOT 5) for 2006 and 2014 were obtained

from the Earth Observation Centre at Universiti Kebangsaan Malaysia. SPOT 5 has a 2.5-m pixel spatial resolution and four spectral bands, i.e., band 1- green (0.50–0.59  $\mu\text{m}$ ), band 2- red (0.61–0.68  $\mu\text{m}$ ), band 3- near infrared (NIR) (0.79–0.89  $\mu\text{m}$ ), and band 4-short wave infrared (SWIR) (1.57–1.75  $\mu\text{m}$ ). These optical satellites were selected because they allowed the vegetation indices to be determined by using the red and NIR spectral bands. The SPOT 5 images were corrected by atmospheric and radiometric

processes to obtain synchronised images with true surface reflectance values. The SPOT 5 images were selected because of their high spatial and spectral resolutions, and many researchers have used the normalised difference vegetation index (NDVI) for land use cover to monitor large vegetation area change along the shoreline (Munyati & Mboweni, 2013). Table 1 summarises the criteria of potential data for AGB stock changes and Table 2 enlists the characteristics of SPOT 5 satellite information.

Table 1: Overview of satellite used for carbon stock mapping.

No	Elements	Optical Remote Sensing	Radar Remote Sensing	LiDAR
1	Satellite types	Quickbird, Worldview, SPOT, Sentinel, Landsat and MODIS	Space-borne systems such as Terra-SAR, ALOS and PALSAR have become available since 2000	Light Detection and Ranging, a few LiDAR instruments currently operating from satellite platforms
2	Advantages	the best alternative to biomass estimation through field sampling due to its global coverage, repetitiveness and cost-effectiveness.  Spatial resolution less than one metre to hundreds of metres	this has enabled repetitiveness and cost-effectiveness.  SAR sensors can operate day or night while penetrating through haze, smoke, and clouds.	relatively new technology that has found favour in biomass estimation.  It has the ability to sample the vertical distribution of canopy and ground surfaces, providing detailed structural information about vegetation.  This leads to more accurate estimations of basal area, crown size, tree height and stem volume
3	References	(Hyde <i>et al.</i> , 2006), (li <i>et al.</i> , 2008), (Rahman <i>et al.</i> , 2005)	(Castel <i>et al.</i> , 2002), (Sarker <i>et al.</i> , 2013), (Le Toan <i>et al.</i> , 2011)	(Saremi <i>et al.</i> , 2014), (Lim & Treitz, 2004), (Garcia <i>et al.</i> , 2002)

Table 2: Satellite images data acquisition information and characteristics

Type of data	Date	Time	Event	Tidal Height	Spatial resolution
SPOT 5	2/7/2006	11.49 am	High Tide	2.5 m	2.5 m
SPOT 5	22/8/2014	11.00 am	High Tide	2.2 m	2.5 m
SPOT 5	20/7/2006	11.49 am	Low Tide	1.9 m	2.5 m
SPOT 5	5/8/2014	11.03 am	Low Tide	1.8 m	2.5 m

**Flowchart**

The method of carbon stock assessment in this research which involved field surveys, image analysis, model development, and quantifying AGC stocks is shown in Figure 1. These procedures are described in the subsequent sub-sections.

**Land Use and Land Cover (LULC) Classification**

In this study, the LULC of the area were classified into six categories: (1) coastal forest (mangrove), (2) other vegetation, (3) open development areas, (4) water bodies, (5) land, and (6) sand. The changes were determined in one kilometre buffer zone. This approach utilises a supervised classification by selecting homogeneous signatures of pixel classes which overlap with other classes and combining them to categorise the full extent of the original images by using the maximum likelihood algorithm (Misra & Balaji, 2015). Change difference analyses were carried out to estimate the changes in the study area

that were identified by comparing the results of two time date categories (Hamdan *et al.*, 2013). In this study, the spectral characteristics of mangroves appeared darker on satellite images because they grew in wet coastal regions, and used the combinations of bands 4, 3 and 2 of the SPOT 5 images for the selection of training area (Hamzah & Omar, 2009). The verification of land use and land cover categories was done through an extensive fieldwork observation. Prior knowledge and published data of several locations also helped in the result verification process (Kanniah *et al.*, 2015).

**Accuracy Assessment**

Accuracy assessment is an important part of classification. This technique is determined by comparing the image of LULC classification result with reference data such as field data, topographic map, and others. The kappa accuracy provides a statistically valid assessment of the quality of classification and was used to assess the overall class accuracy as shown in Equation 1:

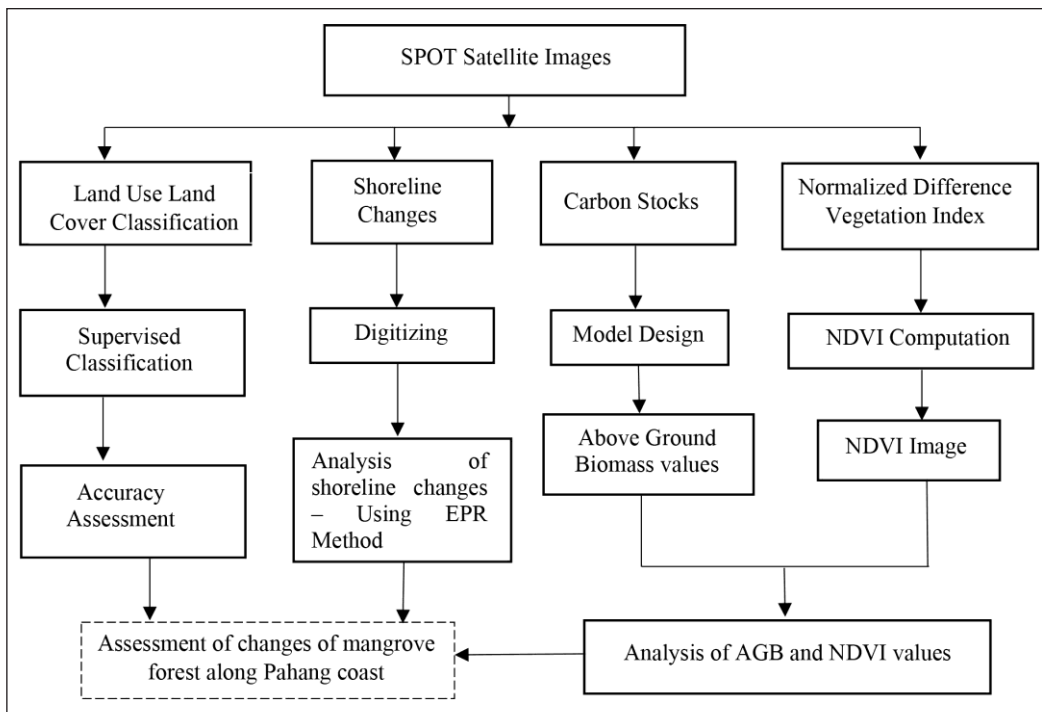


Figure 1: Flowchart of research

$$\hat{K} = \frac{N \sum_{i=1}^r X_{ii} - \sum_{i=1}^r X_{i+} X_{+i}}{N^2 - \sum_{i=1}^r X_{i+} X_{+i}} \quad (1)$$

Where:

- r: Number of rows/columns in confusion matrix
- Xii: Number of observation in row i and column i
- Xi+: Total number of row i
- X+i: Total number of column i
- N: Number of observations

### Shoreline Extraction

The shoreline is defined as the physical interface between land and water (Dolan *et al.*, 1980; Zakaria *et al.*, 2006). The determination of shoreline position in satellite data is very subjective. Previous researchers used various indicators for shoreline positioning, such as high tide mark (Fisher & Overton, 1998; Stockdon *et al.*, 2002), high water level (Fenster & Dolan, 1999), wet-dry mark (Overton *et al.*, 2011), vegetation line (Zarillo *et al.*, 2008), dune line (Stafford, 1971), berm of the beach (Norcross *et al.*, 2002), cliff base or top (Moore *et al.*, 1999), mean high water (MHW) level (Kankara *et al.*, 2015), etc. Thus, by considering these factors, the high water line (HWL) (i.e., the effective shoreline is equivalent to the wet/dry line of the previous tide), which is clearly recognisable in all images was the most appropriate shoreline for monitoring the changes (Chenthamilselvan *et al.*, 2014; Kankara *et al.*, 2015). Manual digitisation of shoreline is a time-consuming process and its accuracy is subjected to the knowledge of the interpreter; hence, it is very important that the interpreter is able to duplicate the results (Kankara *et al.*, 2015). The shoreline features were determined based on the differences in the colour pixels of the land and the sea. The band ratio technique was used to differentiate the land from the water pixels. A more advanced digitisation technique was used to obtain the shoreline features in the Arc-GIS software. Misra and Balaji (2015) stated that to further improve the results, a visual interpretation was done to edit the shoreline features so that they conform to the high tide line (HTL).

### Analysis of Shoreline Changes

The shoreline extracted from the satellite image was compiled in the ArcGIS 10.3 software. All shoreline positions were merged as a single feature on the attribute table, which allowed for the multiple coastline files to be appended into a single shapefile. Digital Shoreline Analysis System (DSAS) version 4.0, which is an extension of the ESRI ArcGIS developed by the USGS, was used to compute the shoreline change rate (Thieler *et al.*, 2009). The computation of shoreline changes was done in four steps: (1) preparation of shoreline position, (2) determination of baseline, (3) generation of transect line, and (4) computation of changes. The historical shoreline position was extracted using a digitising technique of the shoreline for 2006 and 2014. A baseline was determined to be 1 km from the shoreline by using a buffering technique and was the digitised onshore area. The baseline is located parallel to the shoreline, and the transect line was automatically generated by the DSAS tool, which produced 1068 transect lines with a 0.25-m interval between each transect line.

The computation of shoreline change for the short term analysis requires only two historical shoreline data set. The shoreline change rate was computed by dividing the distance of shoreline movement by the time elapsed between the oldest and the most recent shorelines. In this study, the digitised shoreline for 2006 and 2014 in the vector format were used as the input for the DSAS to calculate the rate of shoreline change.

The end point rate (EPR) is a simple and popular approach used to calculate the shoreline change rate. The EPR was obtained by dividing the difference of distance change by the number of years elapsed between the two shoreline positions. Linear extents with negative EPR values indicate erosion, whereas those with positive values indicate accretion (Misra & Balaji, 2015). A minimum of two shoreline dates is required for to calculate the rate, as shown in Equation 2:



$$EPR (m/y) = \frac{\text{Distance (X - Y)}}{\text{Time between latest and previous shoreline}} \quad (2)$$

### Normalised Difference Vegetation Index (NDVI)

Vegetation index has long been used in remote sensing application to monitor temporal changes associated with vegetation (Ofosu Anim *et al.*, 2013). The NDVI in the vegetation indices is one of the frequently used techniques in such analyses by the virtue of its strong correlation with the photosynthetic activity, which is the basis for its use in assessing the net primary production (Gadakh & Jaybhaye, 2016; Gu & Liu, 2012; Munyati & Mboweni, 2013). Hamdan *et al.* (2013) elucidated that NDVI is based on the characteristics of vegetation which has noticeable absorption in the red spectrum and very strong reflectance in the NIR spectrum. This technique has been used to monitor the greenness pattern of the natural vegetation on the earth surface. NDVI is computed using Equation 3:

$$NDVI = \frac{\text{Band NIR} - \text{Band Red}}{\text{Band NIR} + \text{Band Red}} \quad (3)$$

where band RED and NIR are the visible red and NIR reflectance value, respectively. The output of NDVI values ranges between -1 and +1. Healthy vegetation generally has high NIR reflectance and absorbs strongly in the

red spectral region (Lillesand & Kiefer, 2014). Positive values indicate different vegetation classes, whereas near zero and negative values indicate non-vegetation classes, such as water, snow, urban area, and barren land (Hamdan *et al.*, 2013).

### Aboveground Biomass Assessment (AGB)

The SPOT 5 satellite images were used to assess the aboveground carbon stock of the mangrove forests along the Pahang coast for the period between 2006 and 2014. In this context, remote sensing satellites provide an opportunity to monitor changes in forest carbon and able to estimate the forest carbon density over large extent in a continuous manner (Asner, 2009; Hamdan *et al.*, 2013; Kanniah *et al.*, 2015). Several researchers have used NDVI to estimate forest carbon, however in this study, the relationship between NDVI and AGB was established using the data obtained from the mangroves in Peninsular Malaysia (Figure 2). The AGB of the mangroves was estimated using Equation 4 (Shahrul, 2015) as follows:

$$AGB = 28.015e^{3.5546(NDVI)} \quad (4)$$

Where, AGB is the aboveground biomass,  $exp(\dots)$  = “raised to the power of (...)” and  $NDVI$  = Normalized difference vegetation index as shown in Equation 3.

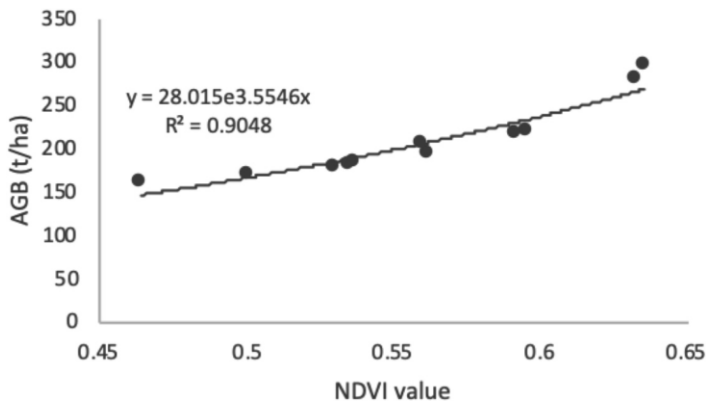


Figure 2: Relationship between AGB and NDVI value. Data obtained from the mangrove forest in Malaysia (Shahrul, 2015)

## Results and Discussion

### Land Use and Land Cover Classification

The distribution of the six categories of land use types for 2006 and 2014 (coastal forest, other vegetation, open development areas, water bodies, land, and sand) are shown in Figure 3. Table 3 shows that within eight years, Ular River has lost 1.36 ha (8.7%) of its coastal forest (mangrove), while Penor River shows a loss of 0.72 ha (7.2%). On the other hand, Cherating River and Kuantan River gained 0.28 ha (4.6%) and 0.95 ha (9.1%) of coastal forest (mangrove), respectively. The loss of mangroves in the

study area is due to urbanisation. According to Kanniah *et al.* (2015), the fastest growing of urban development will threaten the survival of mangrove forests. Shahbudin *et al.* (2010) also identified several types of coastal developments for several purposes such as tourism (Kuantan River waterfront and several resorts), jetty for fisheries landing, and mangrove clearing for commercial purposes (mainly for commercial building and residential areas) along the Pahang coast. Therefore, there is a need to implement necessary measures to prevent further loss of the existing mangrove cover.

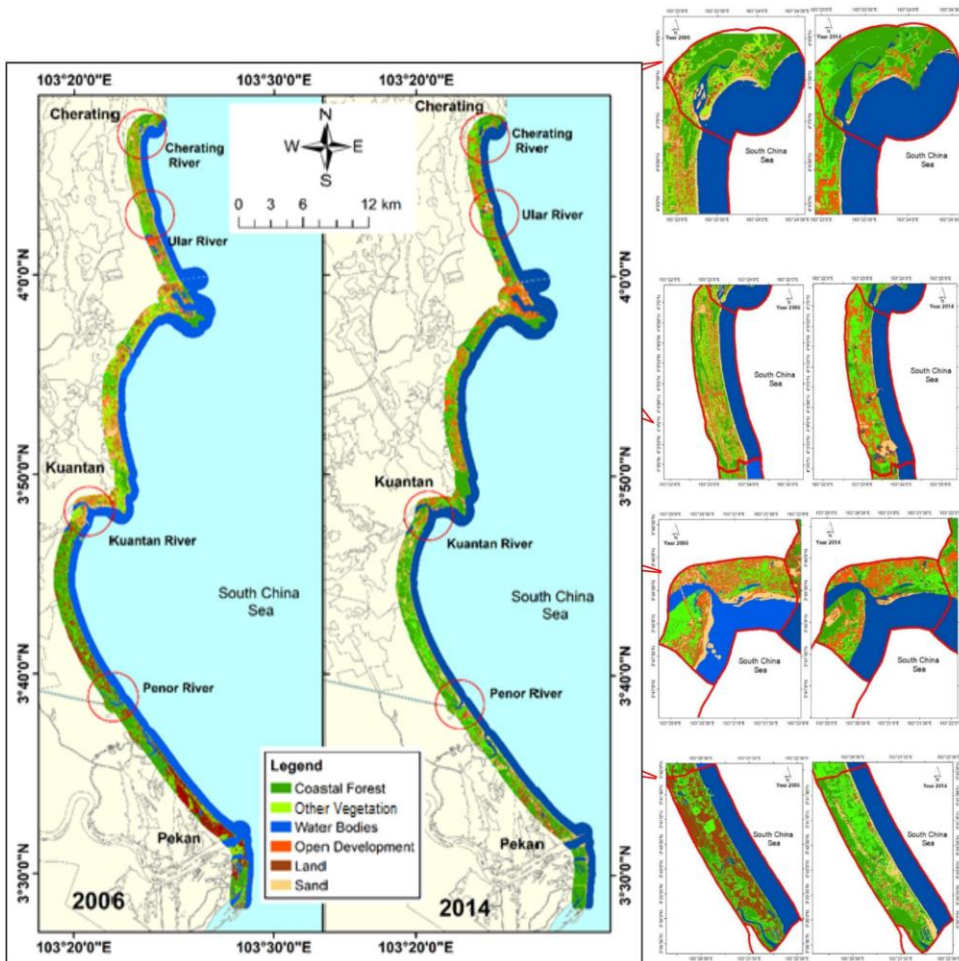


Figure 3: Land use and land cover map along the Cherating-Pekan shoreline in Pahang between 2006 and 2014

Generally, Cherating River and Ular River lost 0.26 ha (4.3%) and 0.28 ha (1.8%) of their other vegetation, respectively, during the eight years. The land category in the four locations lost from 1.8% to 8.5% (0.11 to 0.88 ha) during the same period. For the open development category, only Kuantan River remained unchanged during this period, while both Cherating River and Penor River lost as much as 0.11 ha (1.8%) and 0.02 (0.2%), respectively. The Ular River gained 2.25 ha (14.5%) of the open development area.

Table 3 also shows the changes in the land cover and land use categories for all locations of the study area. Cherating River shows that the areas for coastal forest (mangrove) and water bodies increased by about 0.28 and 0.37 ha, respectively, while the other vegetation shows a reduction of about 0.26 ha. Both the land and open development categories show a similar change of 0.11 ha. The sand category recorded a loss of 0.17 ha during this period.

Ular River shows the largest change in the coastal forest (mangrove) category. More than 1.36 ha of the total forested area was lost. The land category shows a decrease of 0.93 ha, which is the highest loss after the coastal forest category, followed by the sand and other vegetation categories. The decrease in the sand and other vegetation categories was around 0.31 and 0.28 ha, respectively. The area for the open development and water bodies categories show an increase of 2.25 and 0.63 ha, respectively.

The classification of land use and land cover for Kuantan River between 2006 and 2014 shows that the water bodies increased by about 1 ha (Table 3), while the coastal forest (mangrove) and other vegetation increased approximately 0.95 and 0.15 ha, respectively. The land and sand categories lost around 0.88 and 1.21 ha of their areas, respectively, during the study period. This is because, the attraction of living near the shoreline has increased the demand for residential areas such as near the Tanjung Lumpur area in Kuantan (Shahbudin *et al.*, 2009; Mohd *et al.* 2019).

Penor River shows a significant change in land use and land cover for the sand category,

which recorded an increase of 0.87 ha in total area. The largest decrease in the area of 0.80 ha was for the land category, followed by coastal forest (mangrove) (0.72 ha), and open development areas (0.02 ha). Shahbudin *et al.* (2009), also revealed that the small scale of cage culture industries was implemented in this area, which had been built by the villagers. Most of these cage structures have been built from mangroves and illegally cut down from the nearby mangrove forest. Other vegetation and water bodies within the area ~~between~~ show an increase of 0.65 and 0.02 ha, respectively, during the study period. Ibrahim (1998) also pointed out that these mangrove forests occurred in a small area and often fragmented along the six rivers in Pahang especially at Chenor River, Dua River, Kempadang River, Ular River, Balok River, and Cherating River. Ibrahim (1998) and Mohd *et al.* (2019) also stated that mangrove vegetation was mainly dominated by *Rhizophora* sp., *Avicennia* sp., and *Sonneratia* sp. along this shoreline.

Between 2006 and 2014, the land use in the area between Cherating River, Ular River, and Kuantan River was dominated by urban housing areas and forest areas, along with the development of high density urban housing near the industrial areas of Ular River in 2014. As mentioned by Hamdan *et al.* (2013), almost 31% of land use were converted for industrial and urban development. Kuantan, which is the capital city of Pahang, is located in the center between Cherating, Ular, and Penor. This could be the reason for the employment opportunity brought about by this new development. The expansion of beach resorts and tourism areas resulted in a change from a medium density to high density urban housing. In the area between Kuantan and Pekan, agricultural plantations such as coconut, paddy, rubber, oil palm, and development of new urban housing were observed to dominate the landscape. However, interestingly, this is contrary to a study conducted by Shahbudin *et al.* (2009) which showed the massive development activities in Kuantan had given enormous pressure to the coastal ecosystem. The current threats to Pahang's forest are primarily due to the residential and

Table 3.: Classification of land use and land cover for Cherating River, Ular River, Kuantan River and Penor River in 2006 and 2014

Classification	Location														
	Cherating River			Ular River			Kuantan River			Penor River			Total		
	2006 (ha)	2014 (ha)	Area Change (ha)	2006 (ha)	2014 (ha)	Area Change (ha)	2006 (ha)	2014 (ha)	Area Change (ha)	2006 (ha)	2014 (ha)	Area Change (ha)	2006 (ha)	2014 (ha)	Area Change (ha)
Coastal Forest (Mangrove)	1.60	1.88	0.28 (4.6%)	2.69	1.33	-1.36 (-8.7%)	2.63	3.58	0.95 (9.1%)	3.17	2.45	-0.72 (-7.2%)	10.09	9.24	-0.85
Other Vegetation	0.85	0.59	-0.26 (-4.3%)	3.94	3.66	-0.28 (-1.8%)	1.55	1.70	0.15 (1.4%)	1.52	2.17	0.65 (6.5%)	7.86	8.12	0.26
Land	0.26	0.15	-0.11 (-1.8%)	2.29	1.36	-0.93 (-6.0%)	1.85	0.97	-0.88 (-8.5%)	1.99	1.19	-0.80 (-8.0%)	6.39	3.67	-2.72
Open Development	0.41	0.30	-0.11 (-1.8%)	0.35	2.60	2.25 (14.5%)	0.00	0.00	0.00	0.02	0.00	-0.02 (-0.2%)	0.78	2.9	2.12
Water Bodies	2.62	2.99	0.37 (6.1%)	4.94	5.57	0.63 (4.0%)	3.00	3.99	0.99 (9.5%)	3.20	3.22	0.02 (0.2%)	13.76	15.77	2.01
Sand	0.29	0.12	-0.17 (-2.8%)	1.36	1.05	-0.31 (-2.0%)	1.37	0.16	-1.21 (-11.6%)	0.10	0.97	0.87 (8.7%)	2.12	2.30	0.18
Total area (ha)	6.03	6.03		15.57	15.57		10.40	10.40		10.00	10.00				

industrial development purposes, followed by aquaculture and other related activities.

Table 4 summarises the result of correlation matrix analysis between mangroves and LULC classification. The highest correlation was observed in the open development reflectance with  $r = -0.67$ . The biggest area changes for all land use land cover classification can be found in open development between four study locations in 2006 and 2014 with 2.12 ha (Table 3). The changes were contributed greatly by Ular River with 14.5% of changes. Therefore, the open development is a strong indicator for causing mangrove loss. In general, other vegetation, water bodies, and sand have a low negative relationship with  $r = -0.058$ ,  $-0.112$ , and  $-0.158$ , respectively. There was a moderate positive relationship between mangroves and land with  $r = 0.455$  because both categories were reduced with 0.85 and 2.72 ha of area, respectively. Therefore, there was no significant difference between the mangrove and land categories.

#### Accuracy Assessment

The supervised classification for land use and land cover of 2006 and 2014 were verified with topographic map, Google Earth and in-situ measurement. The accuracy assessments were accepted and the overall kappa (K) for supervised classification for 2006 and 2014 images was good, as listed in Table 5. The overall kappa for supervised classification shows the value of 0.83 and 0.91 with an overall accuracy of 85.42% and 94.00%, respectively.

From Table 6, the stratified random method provided a very high accuracy assessment for the coastal forest (mangrove), other vegetation, water bodies and sand categories with kappa (K) statistics of approximately 1. It also provided a high accuracy of 0.7–0.89 for the land and open development categories, respectively.

Table 4: Correlation matrix for each class

	Coastal Forest (Mangrove)	Other Vegetation	Land	Open Development	Water Bodies	Sand
Coastal Forest (Mangrove)	1					
Other Vegetation	-0.058	1				
Land	0.455	0.651	1			
Open Development	<b>-0.673</b>	0.545	-0.021	1		
Water Bodies	-0.112	0.907	0.435	0.717	1	
Sand	-0.158	0.695	0.603	0.249	0.450	1

Table 5: Accuracy Assessment of LULC classification on years 2006 and 2014

No	Classified Image	Overall Kappa (K')	Overall Accuracy
1	SPOT 5 Image 2006	0.83	85.42 %
2	SPOT 5 Image 2014	0.91	94.00%

Table 6: Summary of kappa (K') statistics of Land Use Land Cover classification

No	Classification Types	Year 2006	Year 2014
1	Coastal Forest (Mangrove)	1.0	0.95
2	Other Vegetation	0.85	1.0
3	Land	0.7	0.68
4	Open Development	0.82	0.89
5	Water Bodies	0.96	1.0
6	Sand	1.0	1.0

### Analysis of Shoreline Change

The result of shoreline change analysis was computed by dividing the distance of shoreline between the shoreline for 2006 and the shoreline for 2014. Results show that Cherating River experienced a higher rate of erosion, while the highest rate of accretion occurred at Penor River, as shown in Table 7. Between 2006 and 2014, the 10.31 m maximum rate of shoreline change as a result of erosion occurred at Cherating River, while the 18.17 m maximum rate of accretion occurred at Penor River.

On the other hand, the 0.01 m minimum rates of shoreline change due to erosion occurred at Ular River, while the 0.02 m minimum rate of shoreline change due to accretion occurred

at Cherating River. The present study found that 96.2% of the Cherating River experienced erosion. This result is in consistent with the findings made by Fazly *et al.* (2018) which reported that the Cherating River is very susceptible to erosion. This is because the shoreline is facing the South China Sea, which has strong waves that eventually caused erosion in this area. Fazly *et al.* (2018) also found that Cherating is an area with very high vulnerability to erosion. Cherating River is a fragile area which could easily undergo physical changes as a result of natural and anthropogenic activities. Azid *et al.* (2015) and Fitri, Hashim, Abolfathi, & Maulud (2019), also discovered that human activities, such as beach construction, land reclamation, and port construction activities have

a strong impact in the processes that occur in this area. Shahbudin *et al.* (2009) also found that Kuantan River, for example, is the main route for vessels to the South China Sea. Routine trips of these vessels along the river have generated short wave action from current wave. This may affect the mangroves especially certain species, such as *Rhizophora* and *Sonneratia*, which are at the front line of the mangroves. Erosion due to short wave action will cause the substrate to loose slowly and its roots will not be able to hold the tree and will collapse in a certain period.

### Carbon Stock Assessment

The NDVI value for the coastal forest (mangrove) and other vegetation categories obtained from

the SPOT-5 data was from 0.28 to 0.52. The changes that occurred between 2006 and 2014 were primarily due to the loss of vegetation as a result of deforestation, reservoir construction, and cropping activities (Shahbudin *et al.*, 2009; Mohd *et al.* 2019). At Cherating River, the highest NDVI values for the coastal forest (mangrove) and other vegetation categories were 0.52 and 0.49, respectively. Penor River has the lowest NDVI values for coastal forest (mangrove) and other vegetation in 2006 and 2014.

The results for carbon stock analysis for 2006 and 2014 are presented in Table 8. The carbon stocks for 2006 and 2014 ranged from 107.49 to 145.91 t/ha and 103.17 to 157.28 t/

Table 7: Rate of shoreline change determined using the EPR method

Study area	Cherating River	Ular River	Kuantan River	Penor River
Mean shoreline change (m/year)	2.49	0.63	0.00	5.05
The maximum rate of shoreline change (m/year)				
Erosion	10.31	5.77	7.43	1.77
Accretion	17.93	2.26	6.28	18.17
The minimum rate of shoreline change (m/year)				
Erosion	0.04	0.01	0.07	0.03
Accretion	0.02	0.1	0.06	0.1
Total transect				
Erosion	177	180	91	17
Accretion	7	90	93	414
Percentage (%)				
Erosion	96.2%	66.7%	49.5%	3.9%
Accretion	3.8%	33.3%	50.5%	96.1%

Table 8: The changes of the carbon stock

Area	Carbon stock value (t/ha)		Changes
	2006	2014	
Cherating River	115.11	157.28	42.18
Ular River	145.91	127.79	-18.11
Kuantan River	107.49	132.24	24.75
Penor River	131.27	103.17	-28.10
Total	499.68	520.48	20.80

ha, respectively. The results show that the overall carbon stocks in 2006 and 2014 were approximately 499.78 and 520.48 t/ha, respectively. Cherating River recorded the biggest change in carbon stock, followed by Kuantan River, Penor River, and Ular River. Nevertheless, these results are contrary to the findings of Hamdan *et al.* (2016) because the area factor covered by this study was only within a 1-km radius. Ular River recorded a slightly higher average carbon stock in 2006 (145.91 t/ha) than in 2014 (127.79 t/ha). This is due to the erosion phenomenon caused by wave and the monsoon season (Fazly *et al.*, 2018).

### Conclusion

The assessment of mangrove forest on the Pahang coast was done using remote sensing and GIS technology. The findings of the study are that these locations experienced higher rates of erosion and accretion, with Cherating River and Penor River showing the most rapid change of 10.31 and 18.17 m/year, respectively. Estimation of carbon stocks along the Cherating–Pekan shoreline was done using satellites images for 2006 and 2014 and the results show that the mangrove ecosystem at Cherating River, Ular River, Kuantan River, and Penor River were 107.49 to 145.91 t/ha and 103.17 to 157.28 t/ha, respectively. The determination of carbon stock associated with vegetation index distribution has become a key factor to facilitate the understanding of environmental dynamics of land use and land cover, and help in ensuring more responsible management of the resources available along the coast of Pahang. Therefore, there is a need to conduct a more in-depth study by using field measurement and high resolution satellite data for carbon stock estimation, especially along the 87-km Pahang shoreline to obtain a more accurate estimation of carbon stock. Local authority needs to implement many programmes and initiatives to increase the decline of mangrove forests as a result of rapid development in the coastal areas of Pahang. Mangrove forests are important in preventing erosion.

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## PHYSICAL CONDITIONS AND MICROCLIMATE OF TWO *Cynopterus* SPECIES ROOSTS IN AN ABANDONED VILLAGE IN LAMBOR, PERAK

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**Abstract:** This study aimed to investigate the microclimate and physical conditions of the detected *Cynopterus* fruit bats' roosts in an abandoned village, west coast of Peninsular Malaysia. Two abandoned wooden houses as permanent bat roosts were selected: one at an exposed spot with higher damaged condition; another one was less damaged and covered with wild vegetation. Bats were trapped in their roost, identified as *Cynopterus horsfieldii* and *Cynopterus brachyotis*. Microclimate conditions of both bat roosts were recorded twice at 08:00 and 12:00 each day for seven weeks. Microclimate analyses show the more covered roost had significant lower mean for roost temperature, light intensity, and wind speed than the more exposed roost, but no significant difference between the humidity of both roosts. Daily roost counts at noon reveals more *Cynopterus* bat individuals roosting at the less exposed and isolated roost consistently during the study, indicates this genus still prefer a more sheltered roost without human activities despite having adapted well to urbanisation. Our findings from this study and site observations on the returning wildlife suggested this abandoned anthropocene with vegetation regrowth has potential to be a refuge to forest bats and wildlife that are suffering from habitat loss yet cannot fully adapt to anthropogenic habitat..

Keywords: Roosting ecology, old world tropics, Peninsular Malaysia.

### Introduction

Malaysia hosts at least 110 species of bats, which is about 9% of the total 1,240 bat species in the world (Simmon, 2005; Tamblyn *et al.*, 2006; Lim *et al.*, 2017). Of more than 110 species, 13 of them are endemic to Malaysia (Simmons, 2005; Francis *et al.*, 2007). In terms of Pteropodid bats, both Bornean and Peninsular Malaysia host a total of 18 species from 11 genera place under subfamily Pteropodinae and Macroglossinae (Rovie-Ryan *et al.*, 2008).

*Cynopterus* genus, especially *C. brachyotis*, is the most common and widespread fruit eating bat genus in Peninsular Malaysia (Hall *et al.*, 2004; Mohd-Azlan *et al.*, 2005; Khan *et al.*, 2007; Francis, 2008; Tingga *et al.*, 2012; Jayaraj *et al.*, 2013; Azuan *et al.*, 2016; Zahidin *et al.*, 2016; Jayaraj *et al.*, 2016; Pounsinsin *et al.*, 2018; Muhamad Aidil *et al.*, 2018; Fakhrul-Hatta *et al.*, 2018; Mohd-Ridwan *et al.* 2018; Kahn *et al.*, 2019). To date, three species of *Cynopterus*

bat genus were recorded in Peninsular Malaysia i.e. *Cynopterus brachyotis* (Lesser Short-nosed Fruit Bat), *Cynopterus horsfieldii* (Horsfield's Fruit Bat), and *Cynopterus sphinx* (Greater Short-nosed Fruit Bat). These species can be morphologically distinguished based on the molar teeth's structure, muzzle's shape, forearm size range and body mass range when captured alive in the field (Kingston *et al.*, 2006; Francis, 2008). Of these three most widespread *Cynopterus* species, maternal phylogeography shows *Cynopterus brachyotis* is a complex of six distinct lineages that even haplogroups of *C. sphinx* and *C. horsfieldii* were nested within this complex (Campbell *et al.*, 2004). This complex has eight subspecies within Indo-Malayan region and *C. b. brachyotis* is the subspecies found in the lowland of Peninsular Malaysia (Simmon, 2005). *C. b. brachyotis* was later examined and found to consist at least two sympatric, ecological-distinct lineages, namely the Sunda lineage and the Forest lineage

from morphological and molecular approaches (Campbell *et al.*, 2004; Abdullah & Jayaraj, 2006; Kingston *et al.*, 2006; Francis, 2008; Jayaraj *et al.*, 2012a; 2013). Still, identification of Sunda and Forest lineages of *C. b. brachyotis* can be challenging, particularly identifying the bats alive in the field. Thus, Jayaraj *et al.* (2012a) developed a morphometrics-base multivariate analysis model to aid the process, to compliment traditional morphological and conservation genetics approaches (Abdullah, 2003; Campbell *et al.*, 2004; 2006a).

*Cynopterus* spp. is indeed an important seed disperser in Old World tropics: *C. brachyotis* feed on fruits from 54 plant species such as *Terminalia catappa* (ketapang), *Musa* spp. (banana), and *Psidium guajava* (guava) (Tan *et al.*, 1998). The main diet of *C. sphinx* consists of fruits (e.g. *Manilkara zapota* (ciku), *Psidium guajava* (guava), *Mangifera indica* (mango), *Musa* spp. (banana)) and nectar (e.g. from flowers of *Ceiba pentandra* (kapok tree) and *Parkia speciosa* (petai)) (Advani, 1982). *C. horsefieldii* consume “big bang” fruits and flowers from lowland rain forest during the season (Hodgkison *et al.*, 2004) but depend on the plant-base food resources from the secondary and urban habitats in the nearby forest the whole year (Hodgkison, 2001). The role of *Cynopterus* genus as seed dispersal for Old World tropical rainforest plant species may still be under estimated, as later study still reported fruit remnants from additional eight plant species in the diet of *C. brachyotis* and *C. horsefieldii* that had never been reported before year 2010 (Fletcher *et al.*, 2012).

Current knowledge on bat evolution in terms of morphology, physiology and behaviour for roosting inform us roost choice of bats plays a very important role in their ecology and evolutionary process (Kunz, 1982; Kunz & Lumsden, 2003), determining their survival and fitness to shelter from the weather, protection from predators, places of mate and rear young (Vonhof & Barclay, 1996; Kunz *et al.*, 2003; Carmi *et al.*, 2013). Therefore, each bat species has its own roost preferences to uniquely suit to their physical and physiological needs. This phenomenon can be easily observed on a bat

community roosting within the same cave, that certain bat species were found only roost within specific microhabitat inside the cave than other neighbouring bat species in the same cave (Wijayanti, 2011; Shazali *et al.*, 2017; Morni *et al.* 2018). Due to these special needs of roosts, many bats face problems associated with the physical structure and the microclimate conditions of roosts during the selection of roosting site (Craig & Brigham, 2005).

In terms of roost choice, *Cynopterus brachyotis* found either roosting as a small harem in the caves, buildings, broad and large leafed plants, or foliage-modified tents (Wijayanti, 2011; Hodgkison, 2001). *Cynopterus horsefieldii* was also observed to roost in small groups, under or in large leafed trees such as banana plants (*Musa* spp.), and foliage-modified tents. While roosting in the caves, *C. horsefieldii* prefer limestone solution cavities and close to the cave openings. Unlike *C. brachyotis*, *C. horsefieldii* are also reported to roost under the bird nest’s ferns (*Asplenium nidus*) and tree cavity high up at canopy level (Funakoshi & Zubaid, 1997; Hodgkison, 2001; Campbell *et al.*, 2006b). In fact, *Cynopterus sphinx*, *Cynopterus brachyotis* and *Cynopterus horsefieldii* have all been found to have tent-building behaviour occasionally when they roost in plants (Bhat & Kunz, 1995; Tan *et al.*, 1997; Campbell, 2016b).

*Cynopterus* spp. can be found co-existing in one area such as in Perlis State Park and Taiping, Perak (Campbell *et al.*, 2006a; 2006b) and in Gunung Stong State Park (Jayaraj *et al.*, 2012b). Interspecies niche overlap on roost sites happens in these three *Cynopterus* species in Peninsular Malaysia but at low chance (Campbell *et al.*, 2016b). Campbell *et al.*, (2006a) noted the height of roosts which is used by *Cynopterus horsefieldii* was observably lower than any of roosts that are occupied by both *C. sphinx* and *C. brachyotis*. In the vegetation type of roost, *C. sphinx* usually built their shelter about 2.4 – 6.0 meter above the ground for no more than a few days before they move out (Storz & Kunz, 1999). Although the knowledge on the microclimate of *Cynopterus* spp. preferable roost sites are still lacking, bats in general tend to select roost site

which can maintain an optimum microclimate for the bats (Betts, 1998; Sedgeley, 2001) and provide better insulation (Nicolai, 1986).

Kampung Lambor Kiri was founded roughly in 1890. It was abandoned for more than two decades and currently only three houses are still being occupied by the local farmers, with most of other houses and farms have been replaced by bushes and secondary forest. Some of the wildlife species such as *Cynopterus* spp., otters, squirrels, wild boars, fireflies, snakes, and hornbills were observed visiting the village (Raja Amir Bin Raja Harun, personal communication). Therefore, we presume the biodiversity here is increasing over the last twenty over years, which makes this village more interesting for biological studies. Thus, this study aims to describe the types of the detected *Cynopterus* bat's permanent roost from this abandoned anthropocene with vegetation regrowth habitat and investigate the microclimate of these roosts.

## Materials and Methods

### Field Site

Kampung Lambor Kiri is a small village located in Lambor Kiri, Perak Tengah district (4°16'24.9"N, 100°53'43.8"E), nine meter above sea level and 40 km from Ipoh city. The study area was focused on the area by the riverside, where abandoned houses can be found along Perak River bank (Figure 1). Kampung Lambor Kiri is believed to be established before World War II thus some of the houses were over 100 years of age (Late Mr. Megat Arifin Bin Megat Ahmad, personal communication, 1993). The size of Kampung Lambor Kiri population was estimated at about 300 peoples based on the last national census (Department of Statistics Malaysia, 2014). However, there were only three houses which are still permanently occupied during the time this study was conducted. Nearest primitive forest, Hutan Rizab Pulau Tiga, is about 4 - 5.5 km to the west (4°15'01.0"N, 100°56'18.1"E). Primitive vegetation in Kampung Lambor Kiri consist of many small herb species and woody plant species which grow from land to riverside

including kapok tree (*Ceiba pentandra*) and asam gelugur (*Garcinia atroviridis*). The crops that are planted systematically and in larger scale are oil palm, banana, paddy and durian. Fruit trees like guava, rambutan (*Nephelium lappaceum*), pulasan (*Nephelium mutabile*), kuini (*Mangifera odorata*), and papaya are mostly grown wild after significant human population decreased in the area near to three decades ago.

### Bat Captures and Handling

In the first night of this study (25 October 2014), all anthropogenic buildings in Kampung Lambor Kiri were surveyed for the occurrence of bats. For this, individual bats were captured inside buildings using either a hand net or mist nets. Mist nets were set up surrounding the building before 7.30pm, and afterward were checked with a time interval of 15 minutes for each. From each captured bat, several measurements were taken including those for the external bodyparts and body mass. Based on these measurements plus a few qualitative characters, captured bats were identified to species using keys provided by Kingston *et al.* (2006) and Francis (2008). Captured bats were released immediately after the process.

### Bat Occurrence, Physical Conditions and Microclimates of the Roosts

During the bat survey described above, two abandoned houses were confirmed to be utilised by bats as roosts (hereafter referred to as 'bat roosts'). For these bat roosts, we recorded their geographic coordinates, major building materials and opening directions. In addition, a measuring tape was used to measure their dimensions including lengths, widths, heights of the floors above the ground and heights from the floors to the ceilings.

Visits were made to the two bat roosts from 1 November 2014 to 21 December 2014, during which daily records were made of the number of roosting bats at noon (12.00 pm) without conducting bat captures. During this study period, a Lutron multifunction meter

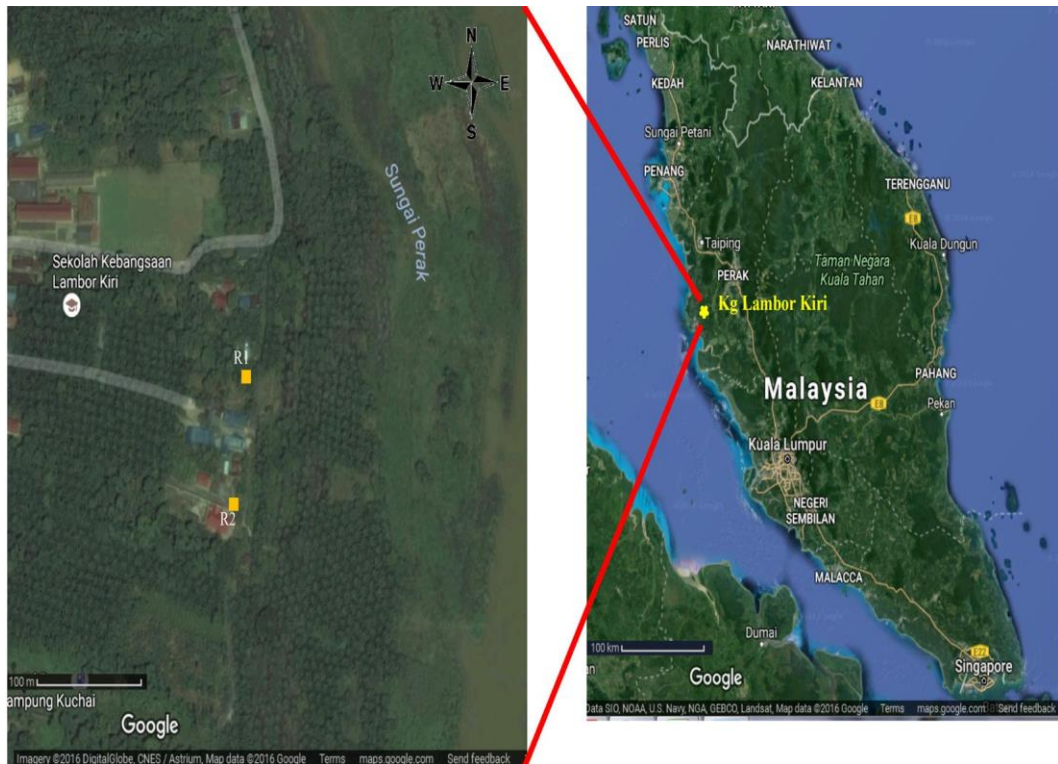


Figure 1: Satellite image of Kampung Lambor Kiri and the locations of the two identified roots in the village (left), as well as the location of the village in Peninsular Malaysia (right). (Google Maps, 2016)

model EM-9300SD was used to measure the microclimate parameters inside the roosts including temperature ( $^{\circ}\text{C}$ ), humidity (%), light intensity (Lux) and wind speed (m/s). Values of these parameters were automatically recorded by the Lutron meter daily at 8:00 h (e.g. a time during the day when most bats had just returned from forages, and thus microclimates then could be most relevant to bats' active choices of the roosts) and 12:00 h (e.g. during the mid-day which roost exterior received maximum sunshine and indoor temperature is expected to be the highest, with all the bats fully settling down and at rest.).

All four collected microclimate parameters were analysed to obtain their daily average and its standard deviation for morning readings, noon readings and overall daily (total of morning and noon) readings respectively. The median, minimum and maximum of each parameter for

the morning period were also determined for both respective roosts. The differences between the two bat roosts in terms of the four selected microclimate parameters were evaluated using Wilcoxon signed-ranked (WSR) tests. All calculations were performed in the *coin* package (Hothorn *et al.*, 2006; Hothorn *et al.*, 2008) of R (R Core Team, 2016).

## Results and Discussion

Among buildings in Kampung Lambor Kiri, including occupied and abandoned houses, small storerooms and shelters, two abandoned houses (Figure 2) were found to accommodate bats. The first one (R1) locates at coordinate  $4^{\circ}16'35''\text{N}$ ,  $100^{\circ}53'40''\text{E}$ . The second one (R2), which is 248 meters away from R1, locates at coordinate  $4^{\circ}16'31''\text{N}$ ,  $100^{\circ}53'47''\text{E}$ .



Figure 2: Two abandoned houses detected with bats. a) The front view of R1, hidden behind bushes and shrubs; b) R2 adjacent to a house (left) which is still occupied, with clear front yard and damaged roof and wall

R1 is a Malay traditional house which was abandoned since early 1970s (Haji Azmi Bin Kulop Ismail, personal communication, 28 October 2014). It faces northeast and thus sunrise radiated its front right side. The main building material of R1 was wood while the roof was covered by corrugated iron materials. Concrete elements were present on the house poles. The length and the width of the house were 6 m and 5 m, respectively. The ceiling was 2.4 m above the floor level, 1.5 m above the ground. The front yard and the back yard were filled with shrubs and wild growing trees, respectively, and the front window was partially covered by creeper plants. During the first visit to R1, a few bats were discovered hanging solitary or in pairs in the living room as well as in the centre of the house which was a corridor leading to the bedroom and the kitchen. One bat was caught with the use of a hand net, which was identified as *Cynopterus horsfieldii* (Table 1).

R2 is also a Malay traditional house which was abandoned since early 2000s (Puteri Norlila

Binti Megat Arifin, personal communication, 14 January 2015). This house faced northeast and the sunrise radiated its front right side. Like R1, R2 was mainly made of wood and its roof was also covered by the corrugated iron materials. However, R2 has additional building made of bricks and cement on the ground floor which was used as a kitchen. The length, the width, the height between the ceiling and the floor were 10 m, 5 m and 3 m respectively. The height of the floor level from the ground was 2 m. R2 was barely hidden by vegetation, endowing a relatively bright environment inside the house. Some windows were damaged and widely open, allowing wind to enter the room, promoting better air circulation. R2 is also build adjacent to another house which is still occupied by a family, and thus there are human activities at ground level of R2. In our first visit to R2, we found bats hanging solitary in the centre of the house, kitchen and bedroom. One bat was captured using mist net, which was identified as *Cynopterus brachyotis* 'Forest' lineage (Table 1).



Table 1: Bat individuals captured at the roost sites on 25 October 2014.

Roost	R1	R2
Species	<i>Cynopterus horsfieldii</i>	<i>Cynopterus brachyotis</i>
Body mass	69 gram	36 gram
Forearm length	75 mm	61 mm
Tibia length	27 mm	23 mm
Ear height	18 mm	16 mm
Tail length	15 mm	14 mm
Tail character	Distinct from membrane	Distinct from membrane
Lower incisors	2 pairs	2 pairs
Sex	Female	Male
Other characters	slenderer skull & elongated muzzle	short stout muzzle bright orange colours around shoulder

The microclimate parameters within the roosts were then investigated at 0800 am (e.g. during the time when the bats are actively choosing an ideal roost for resting) and at 1200pm (e.g. during the mid-day when most of the bats are at rest and the roost temperature may be the highest due to maximum and direct sunshine on the roost) for a continuous 51-day period within the subsequent two months after the first field trip. The trend for each microclimate parameter measured for both roosts were shown in Figure 3 and Table 2. Although both R1 and R2 were facing the same direction and located along the same road in the village but show different level of enclosure and thus provide slightly different microclimate conditions to accommodate the bats. Based on 51 days of record, R1 had the

minimum temperature of 27°C and maximum temperature of 33°C, with 50% of the time fluctuating between 28°C and 30°C. Average temperature of the R1 was 29°C±1°C. R2 had the minimum temperature at 27°C as well but its maximum temperature was 1°C higher than R1. R2’s temperature for morning and noon was on average at 30°C±1.04°C, which half of the data shown fluctuating between 29°C and 31°C (Figure 3a, Table 2). Humidity wise, R1 and R2 had the minimum humidity at 53% relative humidity (RH) and maximum humidity of 73% RH but R2 has an outlier reading at 52% RH. However, the higher enclosure level of R1 reduced the speed of indoor air ventilation, causing the humidity data of R1 to have a bigger range for the third and the first quartiles than

Table 2: Averaged temperature, humidity, light intensity, wind speed and occurrence of human activities of R1 and R2 for morning, noon and overall (morning and noon) sessions

		R1	R2
Average Temperature (°C)	morning	28±0.84	29±0.9
	noon	31±1.40	31±1.42
	overall	29±1.00	30±1.04
Average Humidity (%RH)	morning	66±4.69	65±4.48
	noon	59±5.80	63±5.42
	overall	62±3.67	64±3.61
Average light intensity (Lux)	morning	0.41±0.57	1.37±0.66
	noon	1.14±0.69	3.39±2.17
	overall	1±0.48	2±1.25
Average wind speed (m/s)	morning	0.02±0.04	0.07±0.08
	noon	0.02±0.05	0.09±0.10
	overall	0.0±0.04	0.1±0.07
Human activities		No	Yes

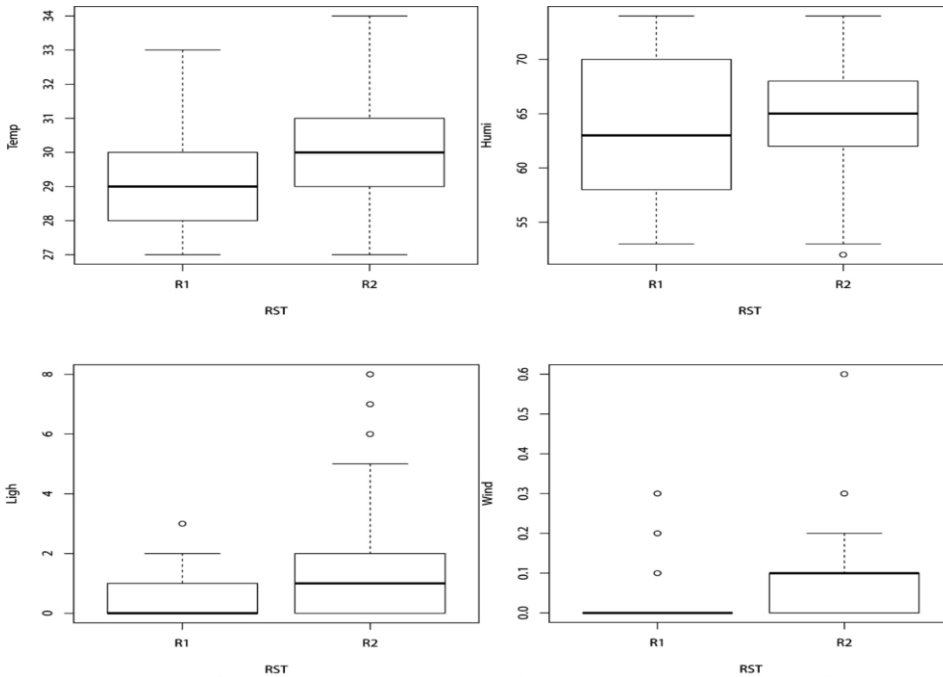


Figure 3: Box plots demonstrate the indoor microclimate of R1 and R2 in terms of a) temperature (°C), b) humidity (% Relative Humidity), c) light intensity (lux) and d) wind speed (meter/second). Bold lines within the plot indicate the median, upper and lower lines of the box indicate the third and the first quartiles respectively, lines not bold at extreme above or below the box are the highest or the lowest point whereas small circles are outliers

R2 (Figure 3b). The better enclosed conditions of R1 also remained at total darkness till 2 Lux and stagnant air most of the time, whereas maximum light intensity of R2 reached 5 Lux with maximum indoor wind speed that reached 0.2m/s (Figure 3c and 3d).

During the morning and noon within the study period, the average of indoor temperature, light intensity and wind speed were lower in R1 than in R2, while the humidity was about the same in these two bat roosts (Figure 4). Indeed, the differences in the former three parameters were statistically supported by WSR tests ( $Z$

$= -5.768, -6.097$  and  $-3.753$  for tests based on the temperature, the light intensity and the wind speed, respectively, and  $P < 0.001$  in all cases); in contrast, the WSR test detected insignificant difference between R1 and R2 in terms of humidity ( $Z = 0.568, P > 0.05$ ). The microclimate conditions between the two roosts were actually affected by the level of exposure of the roost, as R1 which was in better physical conditions and covered by vegetation regrowth had lower temperature, light intensity and wind speed, in comparison to R2 which had wall and windows of the building torn and broken, with no vegetation regrowth surrounding it.

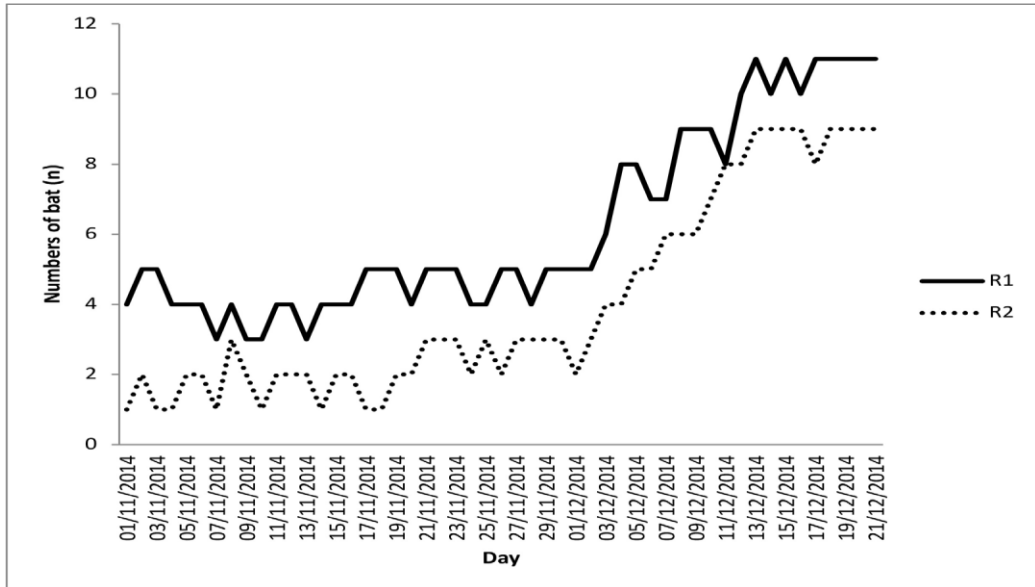


Figure 4: Roost counts on the total *Cynopterus* bats in R1 (bold solid line) and R2 (dotted line) at 12:00pm

Although *C. Horsfieldii* from R1 and *C. Brachyotis* were captured from R2, it did not mean that both houses were only roosted by the only identified species respectively. However, all bat individuals occupying R1 and R2 were observed to have characters including a white margin along the pinna and white finger bones, which are unique to *Cynopterus* genus, as described in Kingston *et al.*, (2006) and Francis (2008). Bats from the genus *Cynopterus* can co-exist in the same area and sharing the same roost, as reported by Jayaraj *et al.*, (2012b) based on their findings from Gunung Stong State Park, Kelantan, Malaysia. *Cynopterus brachyotis* was also found roosting under the trees as well as open areas of caves with brighter conditions (Khan *et al.*, 2007).

During the period of our survey, a number of bats in both roosts were changing each day but slightly increased in December (Figure 4). Figure 4 also shows R1 consistently accommodate more bat individuals than R2 throughout the period of the study. This may be due to the lower exposure within R1 than R2, making R1 a preferable roosting choice for the bats in terms of the darker, more stable microclimatic conditions and no human disturbance (Figure

3, Table 2). Some volant animals such as birds were found to prefer sheltered roost sites in terms of wind velocity and cold air for the benefit of their energy saving (Walsberg, 1985; Jenni, 1991). *C. brachyotis* and *C. horsfieldii* from 12 Javan caves chose to roost in hot and dry conditions of above 28.5°C and less than 65% of humidity (Wijayanti, 2011). Both *Cynopterus* roosts in our study also have roost temperature at least 28°C (R1) and the humidity level at noon for both roosts also around 59% (R1) and 63% (R2). However, the *Cynopterus* bats in Wijayanti’s (2011) study were roosting in far brighter conditions of at least 55 Lux, and more windy conditions (between 14.2-23.4 m/s) in the four out of five detected roosts. The fifth *Cynopterus* roost had 0 m/s, which is similar to the roosts in our study, R1 and R2. Comparison between our study and Wijayanti’s (2011) study indicate *Cynopterus brachyotis* and *Cynopterus horsfieldii* have high tolerance on light intensity and air ventilation of their roost. Bat species may show diverse preferences in roost selection and microclimate of the roost may not be the main factor to consider all the time. For example, *Pantheor lucasi* was observed to prefer a bright zone, *E. monticola* was occupying the

twilight and hottest zone, whereas Hipposiderid bats chose to roost in total-darkness and the coolest portion of Fairy Cave in Sarawak. (Rajasegaran *et al.*, 2018). However, another study on the Wind Cave's bat community with ten residential bat species also showed various roosting preferences and revealed the bats from Wind Cave selected their ideal roost based on their body size and echolocation ability. Hence, closely related bat species at family level may share common features in terms of preferred roost choice (Morni *et al.* 2018).

Apart from the microclimate, cave structure and other physical parameters of the roost also important in bat's roost selection (Reid *et al.*, 2011). The sound intensity within or surrounding the roosts, distance from cave entrance, cave passage dimension, light intensity, roost site structure, vegetation structure, distance from the roost to appropriate drinking and foraging areas are among the physical parameters that have been studied (e.g. Speakman *et al.*, 1991; Entwistle *et al.*, 1997; Jenkins, 1998; Reid *et al.*, 2011; Wijayanti, 2011; Rajasegaran *et al.*, 2018). In our case, since both roosts were built using similar materials and facing the same direction, the factors making R1 different from R2 would be the more sheltered conditions of R1 due to plant overgrowth as well as zero human visit or activities in R1. Given that the roost count of R1 was higher than the R2 all the time during our study period, indicates *Cynopterus brachyotis* and *C. horsefieldii* still prefer more sheltered roost with as low human occurrence as possible, if roost options are available (Figure 4). However, we are also not sure about their physiological change when roosting in more exposed roosts than the better sheltered roosts. This aspect is worth further study to understand the physiological fitness and life quality of fruit and nectar eating bats, which indirectly determine their survival in the short term and shape *Cynopterus*' evolution path in the long term. Nonetheless, the knowledge will also aid bat conservation programmes.

December 2014 (e.g. the second month of our study) onwards was the fruiting season in

Kampung Lambor Kiri. This season resulted in abundance of ripen fruits such as guava and rambutan from the abandoned fruit trees in the village as the fruits were not being harvested by human. Therefore, food source availability for frugivorous bats increased and the *Cynopterus* bat populations in the abandoned houses of the village also increased, as observed in R1 and R2 (Figure 4). In 1960s, *C. brachyotis* were observed to have two foraging seasons, which are the fruit foraging season and the floral parts foraging season (Lim, 1970). Marimuthu *et al.*, (1998) reported harem males of *Cynopterus sphinx* foraged less than one kilometer from their day roost and tended to switch their foraging habitat during the dry season and when their favourite fruits were available (Bumrungsri *et al.*, 2007). These foraging behaviours may cause *Cynopterus* bats switching their roost into Kampung Lambor Kiri during the fruiting season. Whether all species from *Cynopterus* genus share the same foraging behaviour or keep the same foraging behaviour over time regardless habitat change is another subject to be further examined.

Although *Cynopterus* bats, especially *C. brachyotis* are habitat generalists and adapted well in urban areas (Jayaraj *et al.* 2011), these bats are still exposed to threat of human-bat conflict (Fujita, 1988; Aziz *et al.*, 2016; Anand & Radhakrishna, 2017). Some residents allow bats to roost in their houses and accept the presence of bats within their areas. However, some other people, especially from the agricultural sector, consider bats as pests (Fujita, 1988; Agosta, 2002; Aziz *et al.*, 2016) and ultimately trigger conflicts between human and bats. Meanwhile, the impacts of world climate change also affect the microclimate of their roosts (Welbergen *et al.*, 2008) and may cause change in preferred roost choices for the bats. Therefore, studies on the roosting ecology of human-associated bat species in primitive and abandoned anthropogenic habitats should be encouraged to ensure the efficiency in human-associate bats' conservation programmes and facilitated in human-bat conflict solutions.

## Conclusion

This study reported the physical and microclimate conditions of two anthropogenic bat roosts accommodated bat species of genus *Cynopterus* in Kampung Lambor Kiri, an area which has been abandoned for nearly three decades with wild vegetation and food source regrowth. Conditions in roost R1 were more protected from light and wind, with lower temperature and no human activities. Meanwhile, R2 was more open to human presence and has more damaged windows and walls, causing the roost to be more exposed thus the high fluctuation in microclimatic parameters except humidity. Our two-month daily roost counts indicate R1 accommodated slightly more bat individuals than R2, even during the fruiting season when more *Cynopterus* bats shifted into the village, indicating the common *Cynopterus* bats which show successive adaptation to anthropocene still prefer sheltered roost sites isolated from humans.

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## BLOOD GLUCOSE METABOLISM, SERUM, AND URINE OSMOLALITY IN RESPONSE TO SODIUM-ENRICHED ACACIA HONEY DRINK CONSUMPTION DURING REHYDRATION AFTER EXERCISE IN HOT AND HUMID ENVIRONMENT

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**Abstract:** This study investigated the effectiveness of sodium-enriched Acacia honey drink as a post-exercise recovery aid on physiological parameters in the hot and humid environment (31°C, 70% relative humidity). Ten male recreational athletes (age:  $21.8 \pm 1.4$  years,  $VO_{2max}$ :  $51.5 \pm 4.1$  mL.kg<sup>-1</sup>.min<sup>-1</sup>) participated in this randomized cross-over study. In running trial before the rehydration phase (Run-1), participants were required to run on a treadmill at 65%  $VO_{2max}$  ( $7.7 \pm 0.75$  km.h<sup>-1</sup>) in the heat for 60 min. Participants had a fluid replacement with either plain water (W), Acacia honey drink (H) or sodium-enriched Acacia honey drink (HS) with an amount equivalent to 150% of body weight loss in three boluses (60%, 50% and 40% respectively) immediately at 0 min, 30 min and 60 min during two-hour rehydration phase. Blood and urine samples were collected and two-way repeated measure ANOVA was used for statistical analysis. Participants' body weight in W, H, and HS trials dropped after running for 60 min. Plasma volume changes showed significant reductions with W:  $7.2 \pm 3.4\%$  ( $p < 0.05$ ), H:  $6.6 \pm 3.4\%$  ( $p < 0.05$ ), and HS:  $6.6 \pm 4.2\%$  ( $p < 0.001$ ) at the end of the run. During the rehydration phase, there were significantly ( $p < 0.05$ ) higher levels of plasma glucose, plasma insulin, serum osmolality and urine osmolality in H and HS compared to W. Both H and HS drinks can be recommended as a recovery aid.

Keywords: Sodium-enriched acacia honey, honey, exercise, glucose, insulin.

### Introduction

Prolonged exercise in the heat can challenge the limits of human temperature regulation, body fluid and aerobic performance (Cheuvront *et al.*, 2010). This condition is also associated with fatigue, glycogen depletion and hypoglycemia (Nybo, 2008). It has been reported that consuming supplementation or drinks containing carbohydrate (CHO) during post-exercise is crucial for the enhancement of sport performance (Ahmad *et al.*, 2015; Beck *et al.*, 2015; Naclerio *et al.*, 2017; Peeling *et al.*, 2018). Ingestion of fluid containing CHO can prevent dehydration (Bandelow *et al.*, 2010) and a decline in blood glucose (Burke *et al.*, 2011). It is suggested that CHO be taken in the first two hours after exercise to allow the fast rate of glycogen synthesis (Beelen *et al.*, 2010). The previous study found

that the monosaccharide of CHO, fructose, is beneficial for the replenishment of glycogen (Peinado *et al.*, 2013). Consumption of fructose during recovery can increase the restoration of endogenous glycogen stores (Gonzalez *et al.*, 2017). The fructose contained in natural sources such as honey produces beneficial effects by maintaining a higher osmolality of blood effectively compared to plain water (Cheuvront *et al.*, 2004). The mixture of fructose, glucose, and sucrose ingestion resulted in approximately 65% higher exogenous CHO oxidation rates compared to glucose ingestion alone (Jentjens & Jeukendrup, 2005). Exogenous CHO oxidation rate reached a value of 1.75g/min whereas previously it was thought that a 1 g/min was the absolute maximum (Jeukendrup, 2010). Honey contains 75% of multiple transportable

CHO such as fructose, glucose, sucrose, and maltose which lead to increased fluid delivery, thus gastrointestinal distress may be diminished. Among types of honey in Malaysia, Acacia honey contains the highest amount of CHO compared to Lavender and Chestnut honey (Cotte *et al.*, 2003). As shown in Table 1, Acacia honey used in the present study contains several types of CHO, i.e. fructose, sucrose, glucose and maltose.

Honey can be ingested in the fluid. The amount of fluid should be directly proportional to sweat loss or close to it to maintain important physiological functions (Mack & Nadel, 2011). Carbohydrate can be ingested in a bolus feeding or dispersed in the interval. If water is consumed, the volume ingested needs to exceed the fluid deficit by approximately 150% to compensate for the urinary losses that occur with water ingestion (Sharp, 2006; Shirreffs & Evans *et al.*, 2017). During prolonged exercise especially in the heat, the body loses a large amount of water through sweating. It was reported that a 1% to 4% decrease in body weight may occur if plasma volume decreased by 10% (Hall *et al.*, 2012). Decrease plasma volume level that accompanies dehydration and high body temperature can disturb the physiological activity in the body (Nybo, 2008). It also leads to difficulty in maintaining high blood flow to muscle and skin and consequently may reduce heat loss and

resulting in a rise in core temperature (Wingo *et al.*, 2010).

Apart from CHO, sodium intake also plays a role during rehydration. The sodium content of Acacia honey from Malaysia is high and near to sesame honey from Egypt and multifloral honey from India (Moniruzzaman *et al.*, 2013). Sodium intake is important especially during rehydration because it could induce body water conservation (Rokova *et al.*, 2017), which subsequently will reduce urinary output, increase the rate of fluid restoration for fluid balance and glycogen replenishment (Rehrer, 2001). Evans *et al.* (2009) suggested that for rehydration purpose, hypertonic glucose-sodium drinks may be more effective at restoring and maintaining hydration status after sweat loss. The study also found that the participants remained euhydrated for one-hour longer with sodium-enriched glucose drink containing 25mmol/L of sodium with 10% glucose than sodium-enriched glucose drink containing 25mmol/L of sodium with 2% glucose. Similarly, beneficial effect on rehydration as reported by Evans *et al.* (2009) was also observed in our present study in which the sodium-enriched Acacia honey drink in our study contained 50mmol/L of sodium with 22.9% glucose. Rehydration beverage should contain at least 30 to 50 mmol/L (1.7 to 2.9g NaCl/L) of sodium to achieve effective rehydration following exercise (Wong & Chen,

Table 1: Composition of Acacia honey drink and sodium-enriched honey drink

Composition of honey	Amount in 100ml
Acacia honey	
Energy (kcal)	302.0
Carbohydrate (g)	75.0
-Fructose (g)	31.2
-Glucose (g)	22.9
-Sucrose (g)	9.9
- Maltose (g)	3.3
Protein (g)	0.5
Fats (g)	<0.1
Sodium (Na) (mg)	13.0
Sodium-enriched honey drink	
Additional sodium in sodium-enriched honey drink (mmol/L)	50.0

2011). If there is a sufficient amount of sodium in the beverage, even a small amount of CHO, i.e. 2%, may improve the rate of intestinal uptake of sodium and water (Jeukendrup, 2010). The effectiveness of sodium as recovery aid could also be seen in a sodium-enriched coconut water study (Ismail *et al.*, 2007). It was hypothesised that Acacia honey which contains multiple types of CHO such as fructose, sucrose, glucose, and maltose when combined with sodium, may elicit more beneficial effects compared to glucose alone-sodium drink as reported by previous studies of Jeukendrup (2010) and Ismail *et al.* (2007).

To our knowledge, to date, the effectiveness of sodium-enriched Acacia honey drink as a post-exercise recovery aid on physiological parameters such as blood glucose, insulin, cortisol, serum osmolality, plasma volume, urine osmolality, urine volume, tympanic body temperature, and body weight changes in the heat has not been well investigated. If the present study can confirm the beneficial effects of sodium-enriched Acacia honey drink on physiological parameters, thus it can be proposed to the athletes for enhancing their sports performance in the hot and humid environment.

## Materials and Methods

### Participants

Ten young male athletes who were able to run on the treadmill (Full vision INC, TMX425CP, USA) at 65%  $VO_{2max}$  (maximal oxygen consumption) for at least 60 min were recruited for this study. The participants were involved in sports competitions at the university, club or state level. The inclusion criteria of the participants were male, aged between 18 - 25 years, healthy and physically active, trained or exercised at least three times per week 30 min per session. The exclusion criterion was on medication. Participants were asked to refrain from ingesting any products containing honey for 48 hours before the main trials. They received explanations about the study procedures before

giving their consent. This study was approved by the Human Research Ethics Committee, Universiti Sains Malaysia, (USM/KK/PPP/JEPeM [228.3.(04)]).

### Preparation of Honey Drinks

The honey used in the study was Acacia honey. The honey was extracted from the same source and was used without additional processing and treatment before administration. Acacia honey composition was analysed by the Laboratory of the Department of Molecular Medicine in Universiti Malaya. Energy, CHO and mineral content of Acacia honey are shown in Table 1. The variability in CHO and mineral content may be dependent on the floral preference of the honeybee, from which protein and colloids are derived, and the presence of enzymes, which are from the honeybees themselves (Alvarez-Suarez *et al.*, 2010).

Regarding the preparation of the honey drink, 6.8% concentration of CHO in the honey drink needs to be prepared. This concentration is equivalent to the concentration of CHO in commercially available sport drinks such as 100PLUS, ISOMAX, and Gatorade drinks which contain 8.8% of CHO. Acacia honey contains 75 g of CHO per 100 ml of honey, and 100ml honey drink should contain 6.8 ml of honey (6.8% concentration of CHO in the honey drink). We considered that 6.8 g of honey contains 6.8 ml of CHO. Thus, 272 g of Acacia honey was needed to add in 3000ml of plain water for obtaining 6.8% concentration of CHO. Meanwhile, for preparing a sodium-enriched honey drink, the prepared honey drink was added with an additional 50mmol/L of sodium concentration which is equivalent to 8.7g.

### Experimental Design

This was a randomised cross-over study. Participants were required to perform three different trials with either plain water (W), honey (H) or sodium-enriched honey (HS) drinks in each trial. The trials were separated by a one-week interval. The prepared W, H and HS drinks were kept cool in a refrigerator

at temperature  $\sim 4^{\circ}\text{C}$  before being consumed. Participants were required to run on a treadmill at  $65\% \text{VO}_{2\text{max}}$  ( $7.7 \pm 0.75 \text{ km}\cdot\text{h}^{-1}$ ) in the heat ( $31^{\circ}\text{C}$ ,  $75\%$  humidity) for 60 min (Run-1). Participants had a fluid replacement with either W, H or HS with an amount equivalent to  $150\%$  of body weight loss in three boluses ( $60\%$ ,  $50\%$ , and  $40\%$  respectively) immediately at 0 min, 30 min, and 60 min during two-hour rehydration phase. Participants' tympanic temperature, body weight, plasma volume, plasma glucose, plasma insulin, plasma cortisol, serum osmolality, urine volume, and urine osmolality were measured.

### ***Preliminary Measurement***

Participants were required to perform two preliminary tests, i.e. a 16 min incremental submaximal treadmill running test to determine the relationship between running speed and oxygen uptake, and an uphill incremental maximal treadmill running test to exhaustion to determine each participant's maximum oxygen uptake ( $\text{VO}_{2\text{max}}$ ). From the data obtained in the submaximal running test and  $\text{VO}_{2\text{max}}$  test, the speed which elicited  $50\% \text{VO}_{2\text{max}}$  and  $65\% \text{VO}_{2\text{max}}$  of the participants were calculated.

### ***Main trial***

Participants reported to the laboratory at 8 a.m. after a 10-hour overnight fast. The following procedures were carried out before the commencement of each trial: (i) a standardised breakfast and 500 ml of plain water ingestion; (ii) determination of nude body weight; (iii) cannulation for blood samples drawing, (iv) reheat the heat chamber room to reach  $31^{\circ}\text{C}$  and  $75\%$  humidity (controlled by bathtub) and; (v) urine sample taking. All participants performed two trials i.e. 60 min of running trial before the rehydration phase which was identified as Run-1 and followed by a two-hour rehydration phase. Immediately before the warm-up of Run-1, blood samples were collected. Subsequently, participants were required to warm-up for 5 min by running at  $50\% \text{VO}_{2\text{max}}$ . Immediately after the completion of the warm-up, the intensity of running was increased to  $65\% \text{VO}_{2\text{max}}$ . In Run-1,

a blood sample was collected at 0 min and at the end of the 60 min run. After completing Run-1, the participants were weighed to determine the amount of body weight loss. Participants were required to rest by sitting on a chair for two hours in the rehydration phase. During the two-hour rehydration period, participants consumed either W, H or HS with an amount equivalent to  $150\%$  of body weight loss in three boluses ( $60\%$ ,  $50\%$ , and  $40\%$  respectively) at 0 min, 30 min, and 60 min. The drinks were given in random order to the participants. Blood and urine samples were taken every 30 min during the rehydration phase. Participants' final body weight was recorded at the end of the rehydration phase.

### ***Anthropometry Measurement***

The participants' body weight (kg) was measured by using a Bioimpedance analyser (Tanita, Japan). Body height (cm) was measured by using a stadiometer (SECA, Germany). Body mass index (BMI) was derived from the calculation of  $\text{BMI} = \text{Bodyweight (kg)} / \text{height}^2 \text{ (m)}$

### ***Tympanic Temperature Measurement***

Tympanic temperature was measured using digital infrared ear thermometer (Microlife AG 9435 Heerbrugg, Switzerland). The infrared tympanic membrane sensor was designed to primarily detect the infrared radiation emanating from the tympanic membrane. The infrared probe was equipped with a silicon mould to fit into the ear. The probe was gently introduced into the ear canal to correctly position the probe towards the tympanic membrane. All participants' ear canals were cleaned to remove any visible hair and cerumen before taking measurements. All measurements were done in the left ear.

### ***Blood Collection and Analysis***

A cannula (G-15, Venflon) was inserted in an antecubital vein by a medical officer. Before and after warm-up, immediately after Run-1, and every 30 min during the rehydration phase, 4 ml of venous blood was drawn from the participants. One ml of the blood was transferred into an EDTA

(Ethylenediamine tetra-acetic acid) tube and was used to measure the hematocrit level. Hematocrit was determined by micro-hematocrit centrifuge and Hawksley Reader (Hawksley England) in duplicate. The percentage change in plasma volume was calculated based on the results of hematocrit (Van Beaumont *et al.*, 1981). Two ml of blood were transferred into an anticoagulant sodium fluoride tube. After centrifugation at 3000 rpm for 10 min at 4°C, plasma was transferred into the 1.5ml tube and stored at -40 °C for analysis of glucose, insulin, and cortisol. Plasma glucose and insulin concentrations were determined using a spectrophotometer (Spekol 1200, Germany) and insulin EIA kits (enzyme immunoassay, US), respectively. Another 1 ml of blood was transferred into a plain tube and was then separated by centrifuge. Serum was stored at -20°C for analysis of serum osmolality. Serum osmolality was analysed by using a cryoscopic osmometer (Osmomat 030, Gonotec, Germany).

#### **Urine Collection and Analysis**

Urine samples were collected at 0 min, 30 min, 60 min, 90 min, and 120 min during the rehydration period. Urine volume was measured using a measuring cylinder, while urine osmolality was measured by using a cryoscopic osmometer (Osmomat 030, Gonotec, Germany).

#### **Statistical Analysis**

All data were reported as mean  $\pm$  SD. A two-way repeated measures ANOVA was used

to determine differences of blood and urine parameters within and between trials. A significant difference demonstrated in the two-way repeated measures ANOVA was followed by the analysis of the post-hoc Benferroni test. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) Version 24.0 (SPSS, Inc., Chicago, IL). Statistical significance was set at  $p < 0.05$ .

## **Results**

### ***Anthropometric Characteristic of the Participants***

A total of 10 male athletes completed the study. The physical characteristics of the participants and average running speed are shown in Table 2. All participants completed running on the treadmill at 65%  $VO_{2max}$  ( $7.7 \pm 0.75 \text{ km.h}^{-1}$ ) in the heat (31°C, 75% humidity) for 60 min.

### ***The Total Amount of Fluid Consumed, Urine Produced and Net Fluid Balance***

The mean of the total amount of fluid consumed during rehydration and total urine produced in each trial are shown in Table 3. The amount of drink consumed by participants in boluses of 60% of body weight loss was W:  $540 \pm 209.8 \text{ ml}$ , H:  $558 \pm 229.9 \text{ ml}$  and HS:  $492 \pm 164.4 \text{ ml}$ ; 50% of body weight loss was W:  $450 \pm 174.8 \text{ ml}$ , H:  $465 \pm 191.6 \text{ ml}$  and HS:  $410 \pm 137.0 \text{ ml}$ ; and 40% of body weight loss was W:  $360 \pm 139.8 \text{ ml}$ , H:  $372 \pm 153.2 \text{ ml}$ , and HS:  $332 \pm 110.0 \text{ ml}$ . The volume of fluid ingested during the dehydration

Table 2: Physical characteristics of the participants

<b>Variables</b>	<b>Mean <math>\pm</math> SD</b>
Age (years)	21.8 $\pm$ 1.4
Weight (kg)	59.9 $\pm$ 7.8
Height (cm)	171.6 $\pm$ 9.0
BMI	20.3 $\pm$ 2.2
$VO_{2max}$ (ml/kg/min)	51.7 $\pm$ 4.1
Running speed at 65% $VO_{2max}$ (km.h <sup>-1</sup> )	7.7 $\pm$ 0.75

Note: Data were expressed as mean (SD). BMI, body mass index;  $VO_{2max}$ , maximum oxygen uptake; W, plain water; H, honey; HS, sodium-enriched honey; N = 10

phase was not significantly different between trials. Different total urine volume for each trial was observed in the rehydration phase. There were significant differences between the trials ( $F_{2,18}=4.216, p<0.05$ ). Following up a significant difference between trials, the urine output in W group ( $p < 0.05$ ) was significantly higher compared to HS, resulting in lower cumulative urine volume in HS than W and H. Percentage fluid retention reflected these differences between trial:  $51.0 \pm 16.4\%$  (W),  $61.6 \pm 22.4\%$  (H), and  $64.6 \pm 30.8\%$  (HS). However, no significant differences were observed for fluid retention between all the trials.

Net fluid balance was calculated from the change in body weight, fluid ingested and urine produced. No significant difference in net fluid balance was observed between trials following Run-1. A higher overall net fluid balance was maintained during the rehydration phase in H and HS compared to W, with no difference between H and HS. The net fluid balance remained positive in all trials.

### Tympanic Temperature

Tympanic temperature increased significantly from rest (0 min) to the end of Run-1 in W ( $36.1 \pm 0.4$  to  $36.9 \pm 0.6^\circ\text{C}$ ,  $p < 0.001$ ), H ( $36.0 \pm 0.4$  to  $37.0 \pm 0.7^\circ\text{C}$ ,  $p < 0.05$ ) and HS ( $36.0 \pm 0.4$  to  $36.8 \pm 0.4^\circ\text{C}$ ,  $p < 0.05$ ). At the end of rehydration phase, tympanic temperature significantly decreased compared to the time point at the end of Run-1 in all the three trials, i.e.  $36.9 \pm 0.6^\circ\text{C}$  to  $36.1 \pm 0.4^\circ\text{C}$  ( $p < 0.05$ ) in W,  $37.0 \pm$

$0.7^\circ\text{C}$  to  $36.2 \pm 0.4^\circ\text{C}$  ( $p < 0.05$ ) in H and  $36.8 \pm 0.5^\circ\text{C}$  to  $36.2 \pm 0.4^\circ\text{C}$  ( $p < 0.05$ ) in HS trials. The tympanic temperature returned to resting values in all three trials after rehydration. There were no significant differences in this measured parameter between the W, H and HS trials.

### Body Weight Changes

The average percent body weight loss after 60 min dehydration exercise was  $1.50 \pm 0.5\%$ ,  $1.54 \pm 0.5\%$ , and  $1.38 \pm 0.4\%$  compared to pre-exercise body weight. The body weight after 60 min dehydration exercise was  $58.31 \pm 7.7\text{kg}$  in W,  $58.57 \pm 7.7\text{kg}$  in H and  $59.02 \pm 7.8\text{kg}$  in HS. The rehydrated body weight after two hours of rehydration was  $58.96 \pm 8.0\text{ kg}$  in W,  $59.28 \pm 8.1\text{ kg}$  in H, and  $59.08 \pm 7.9\text{ kg}$  in HS. The difference between pre-body weight and rehydrated body weight was  $-0.25 \pm 0.2\text{ kg}$  in W,  $-0.16 \pm 0.3\text{ kg}$  in H and  $-0.12 \pm 0.03\text{ kg}$  in HS.

### Plasma Volume Changes

Figure 1 illustrated the results of plasma volume changes. In the present study, plasma volume decreased significantly during Run-1 [W:  $7.2 \pm 3.4\%$  ( $p < 0.05$ ), H:  $6.6 \pm 3.4\%$  ( $p < 0.05$ ), HS:  $6.6 \pm 4.2\%$  ( $p < 0.001$ )], and increased significantly after rehydration [W:  $5.0 \pm 6.4\%$  ( $p < 0.001$ ), H:  $2.7 \pm 6.7\%$  ( $p < 0.001$ ), HS:  $4.2 \pm 3.1\%$  ( $p < 0.001$ )] in all the three trials. There were no statistically significant differences in plasma volume between W, H, and HS trials during the rehydration phase.

Table 3: The mean of the total amount of fluid intake, total urine volume, net fluid balance and percentage of water retention during rehydration in each trial

Variables	W	H	HS
The total volume of fluid consumed (150% of fluid loss) (ml)	$1350.0 \pm 524.4$	$1395.0 \pm 574.7$	$1234.0 \pm 411.0$
Total urine produced (ml)	$655.5 \pm 346.7^*$	$458.5 \pm 179.3$	$383.5 \pm 287.6$
Net fluid balance (ml)	$694.5 \pm 330.2$	$936.5 \pm 588.1$	$850.5 \pm 535.6$
Fluid retention (%)	$51.0 \pm 16.4$	$61.6 \pm 22.4$	$64.6 \pm 30.8$

Note: Data were expressed as mean (SD). W, plain water; H, honey; HS, sodium-enriched honey; N=10. \* Significantly different from the value in W trial at  $p < 0.05$

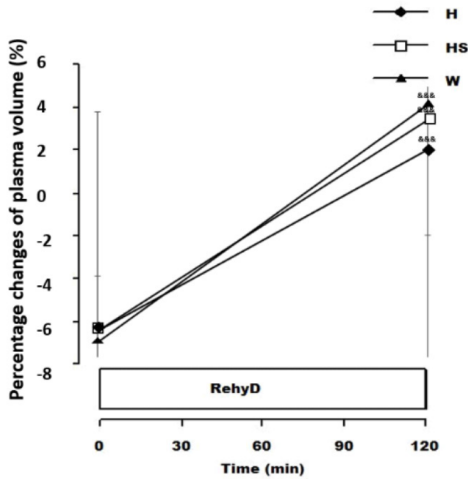


Figure 1: Plasma volume changes during rehydration of plain water (W), honey (H) and sodium-enriched honey (HS) trials. Rehyd, Rehydration phase; N=10

\*\*\* Significantly different from respective end of Run-1 ( $p < 0.001$ ) respectively

**Serum Osmolality, Urine Osmolality and Urine Volume**

Figure 2 illustrates the results of serum osmolality, urine osmolality and urine volume during rehydration. Both H and HS elicited statistically significant ( $p < 0.05$ ) greater values of serum osmolality compared to W during the rehydration phase (Figure 2A). Even though

there was no statistically significant difference in serum osmolality between H and HS, HS showed a slightly higher serum osmolality level than H during rehydration. HS also showed a higher level of serum osmolality than H starting from 60 min to 120 min during rehydration.

Generally, urine osmolality showed the trends of increase and then decrease by time for all three trials, (Figure 2B). In general, both HS and H showed significantly higher urine osmolality than W during rehydration. Urine volume showed the trends of decrease and then increase over time during the rehydration phase in all the three trials, with a more significant increase in W than H and HS (Figure 2C). There were no significant differences in urine volume between W, H, and HS.

**Plasma Glucose, Insulin and Cortisol**

Blood glucose, insulin, and cortisol changes are shown in Figure 3. Blood glucose concentration showed the trend of decrease in Run-1 generally in all three trials. The concentration of plasma glucose in H and HS increased significantly ( $p < 0.05$ ) until 30 min during the rehydration phase and the concentration reduced until the end of the rehydration phase. The trend of decrease in plasma glucose was observed in W. There were statistically ( $p < 0.05$ ) higher levels of plasma

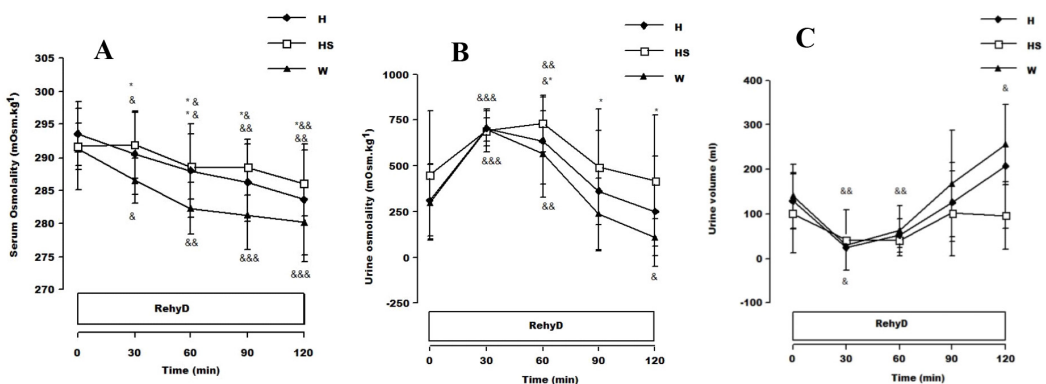


Figure 2: (A) Serum osmolality ( $mOsm.kg^{-1}$ ); (B) Urine osmolality ( $mOsm.kg^{-1}$ ); and (C) Urine volume (ml) during rehydration of plain water (W), honey (H), and sodium-enriched honey (HS) trials. Rehyd, Rehydration phase; N = 10

\*\*\* Significantly different from respective end of Run-1 at  $p < 0.05$ ,  $p < 0.01$  and  $p < 0.001$  respectively.

# Significantly different from the rehydration phase at  $p < 0.05$

\* Significantly different from the corresponding value in W trial at  $p < 0.05$

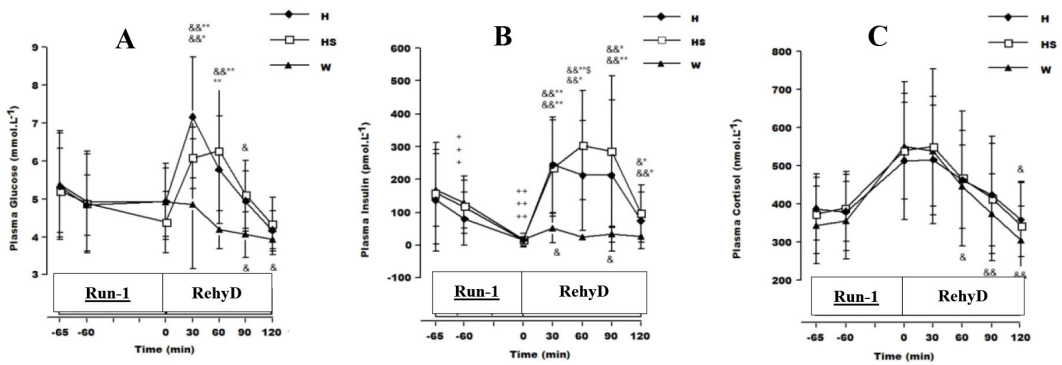


Figure 3. (A) Plasma glucose concentration (mmol.L<sup>-1</sup>), (B) Plasma insulin (pmol.L<sup>-1</sup>), and (C) Plasma cortisol (nmol.L<sup>-1</sup>) during Run-1, and rehydration of plain water (W), honey (H) and sodium-enriched honey (HS) trials. Run-1, Running trial before the rehydration phase. RehyD, Rehydration phase; N=10  
 &, && Significantly different from the respective end of Run-1 at  $p < 0.05$  and  $p < 0.01$  respectively.  
 \*, \*\* Significantly different from the corresponding value in W trial at  $p < 0.05$  and  $p < 0.01$  respectively.  
 +, ++ Significantly different from respective resting values (at rest) at  $p < 0.05$  and  $p < 0.01$  respectively

glucose in H and HS than W at 30 min and 60 min during the rehydration phase. Plasma insulin reduced significantly ( $p < 0.01$ ) to below resting values at the end of Run-1 in the three trials. As observed in plasma glucose, plasma insulin concentration increased significantly ( $p < 0.05$ ) after Run-1 until 90 min during the rehydration phase in H and HS.

Plasma insulin concentration reduced from 90 min until the end of this phase. The changes in plasma insulin in W were not as obvious as in H and HS. There were statistically significant ( $p < 0.05$ ) higher levels of plasma insulin in H and HS than W throughout the rehydration phase. There were no significant differences in cortisol concentration at any time point between all the three trials. Plasma cortisol concentration showed the trend of increase from 0 min until 60 min during Run-1 and subsequently reduced until the end of the rehydration phase.

**Discussion**

The results of the study indicated that consumption of Acacia honey drink and sodium-enriched Acacia honey drink have potential in preventing the athletes from heat stress, dehydration, hypoglycemia and imbalance of fluid in the body. This is based on the observation

that there were higher levels of plasma glucose, plasma insulin, serum osmolality and urine osmolality in both Acacia honey drink and sodium-enriched Acacia honey drink compared to plain water.

In terms of glucose level, the present study found that blood glucose dropped and no significant difference was observed in plasma glucose between the W, H and HS trials after Run-1. During the rehydration phase, plasma glucose in H and HS increased significantly as fast as 30 min from resting value and reduced to a normal level at the end of the rehydration phase. The plasma glucose level in the W trial was lower than the resting value throughout the rehydration phase. These observations imply that honey could increase plasma glucose, but not plain water. The CHO contained in Acacia honey drink with 31.2% of fructose, 22.9% of glucose, and 9.9% of sucrose may have played its role for increasing plasma glucose level, especially during the initial stage of rehydration phase. According to Jentjens and Jeukendrup (2003), the rapid phase of muscle glycogen synthesis is characterised by an exercise-induced translocation of glucose transporter carrier protein-4 to the cell surface, leading to increased permeability of muscle membrane to glucose. This is also related to the functions



of gastric emptying and intestinal absorption rates, as well as the insulinogenic potential of the CHO (Ormsbee *et al.*, 2014). A higher level of glucose potentially stimulates the homeostasis process (Gropper & Smith, 2012) and brings the glucose level to a normal level after two hours.

Regarding blood insulin, no significant changes were observed in serum insulin in W trial during the rehydration phase implying that W did not affect serum insulin. In the present study, the Acacia honey used had shown its potential to elicit a higher level of serum insulin concentration generally compared to W. It is speculated that the compositions of fructose, glucose, and sucrose contained in Acacia honey are appropriate for maintaining a high level of blood glucose and subsequently high level of insulin level during rehydration phase in H trial. A previous study was done by Judelson *et al.* (2008) also found a significantly higher level of serum insulin concentration during the first stage of the rehydration phase to match the rise of glucose level in the blood. A higher level of glucose potentially stimulates glycogenesis activity for the homeostasis process (Gropper & Smith, 2012). Insulin level increased and then decreased generally by time in the rehydration phase in the H trial. It was mentioned in Burke *et al.* (2016) that the rate of muscle glycogen storage may be influenced by muscle glucose uptake and insulin sensitivity. The increased serum insulin level may contribute to the transport of CHO to the muscle for replenishing muscle glycogen at the early stage of the rehydration phase. Reduction of insulin level at the later stage of the rehydration phase may ensure the maintenance of the high level of plasma glucose, by storing blood glucose as an energy booster. Cortisol is an indicator of stress. Cortisol level increased at the end of Run-1 for all three trials after 60 min treadmill running in the heat, and reflecting that exercise may have served as a type of stress.

James *et al.* (2015) suggested that electrolyte restriction might have contributed in reducing exercise capacity in the heat. The moderate amount of sodium, i.e. 50 mmol/L in 150%

bolus was sufficient to raise the plasma volume compared to 23 and 61 mmol/L (Shirreffs *et al.*, 1996). In the study, plasma volume decreased significantly during the running phase in all the trials. After the ingestion of W, H, and HS plasma volumes were significantly increased in all three trials. These results imply that W, H, and HS were equally effective for restoring plasma volume after exercise-induced dehydration. Plasma volume change was calculated by using hematocrit values. In fact, hemoglobin can also be used for calculating plasma volume change. Unfortunately, hemoglobin analysis was not performed and it was considered a limitation of this study.

Regarding plasma osmolality, it was observed that H and HS drinks ingestion elicited greater values of serum osmolality compared to W during the rehydration phase, implying that both honey drink without additional sodium and honey drink with additional sodium could maintain serum osmolality better than plain water. Evans *et al.* (2000) and Hoffman & Stuempfle (2015) mentioned that fluid replacement with the addition of sodium to a rehydration solution is beneficial for the maintenance of fluid balance due to its effects on extracellular fluid osmolality and volume. The proper amount of sodium helped the participants avoid losing a high amount of water after ingestion.

Acacia honey contains 130 mg of sodium in one liter of honey. An additional of 2.9g/L (50 mmol/L) of sodium added in one litre of honey in HS did not provide much difference in serum osmolality compared to honey drink without sodium in the present study. The results revealed that honey drink with 130 mg of sodium was sufficient to produce similar hydration conditions as a sodium-enriched drink to promote osmotic stimulus for absorption (Wilson & Temple, 2003).

In the study, it was found that urine volume decreased and then increased over time in W, H, and HS trials and the highest urine volume was measured in W trial compared to at the end of Run-1. It showed that H and HS caused higher water retention in the body than W. W trial

displayed the largest body weight difference ( $-0.25 \pm 0.2\text{kg}$ ) between pre-body weight and rehydrated body weight even though all the participants consumed a similar amount of drinks during rehydration. It is speculated that the participants might have lost more water through urine with plain water ingestion. Baker & Jeukendrup (2011) mentioned that the ingestion of plain water can enhance the urine output and cause a reduction in the drive to drink. The absence of sodium in the plain water will also dilute sodium content in the body and subsequently increase urine osmolality due to kidney clearance mechanisms (Popli *et al.*, 2014). This phenomenon was supported by a lower level of ( $p < 0.05$ ) urine osmolality during W trial at the end of the rehydration period. The higher level of urine osmolality observed with HS ( $419.0 \pm 358.6\text{mOsm/kg}$ ) compared to H ( $249.5 \pm 301.9\text{mOsm/kg}$ ) and W trial ( $110.1 \pm 100.3\text{mOsm/kg}$ ) may be due to the beneficial effect of sodium contained in the honey drink for conserving body water.

### Conclusion

Rehydration with Acacia honey and sodium-enriched Acacia honey drink elicited greater beneficial effects on physiological parameters especially blood glucose, insulin and osmolality, and urine osmolality compared to plain water in the heat. Thus, both these drinks can be recommended to be used as an ergogenic aid for rehydration purposes in athletes who train and compete in the hot and humid environment.

### Acknowledgments

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## DAILY ACTIVITY BUDGET OF BANDED LANGUR (*Presbytis femoralis*) IN MALAYSIA

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**Abstract:** Banded langur (*Presbytis femoralis*) is an endangered leaf-eating colobine, found in Johor and Pahang in Malaysia. However, with less than 500 individuals reported to be surviving in Johor, their behaviour and ecology remain unknown among primatologists. This study provides the first systematic data on the daily activity budget of the species in Malaysia. Scan sampling technique was used to observe and record *P. femoralis* behaviour with 10 min interval starting from February 2018 to November 2018. The results are based on 186 h and 20 min of direct observation in the wild. The animals spent most of the time for resting ( $43 \pm 13\%$ ) followed by moving ( $26 \pm 9\%$ ), feeding ( $26 \pm 7\%$ ), social activities ( $4 \pm 3\%$ ), and others ( $1 \pm 0\%$ ). Seasonality significantly influences the activity budget of the animals resulting in increased resting and moving in the non-fruiting season. Feeding activities decreased in the non-fruiting season compared with the fruiting season, whereas social activities remained the same. We concluded that the daily activity budget of *P. femoralis* in this study portrays comparable behavior to other langurs in Malaysia that would help in conservation and management of the species in terms of understanding temporal and spatial requirements of *P. femoralis* in a highly fragmented habitat.

Keywords: Colobine, behaviour, conservation.

### Introduction

*Presbytis femoralis* is an endangered Colobine (Primate) in Johor and can be found ranging in the southern part of Pahang and small population in Singapore (Md-Zain, 2004, Abdul-Latiff *et al.*, 2019a). The population has been reported recently with fewer than 500 individuals in selected fragmented areas in Johor (Md-Zain *et al.*, 2008; Vun *et al.*, 2011; Abdul-Latiff *et al.*, 2019a; Najmuddin *et al.*, 2020b). Abdul-Latiff *et al.* (2019a) recognizes the species as Schlegel's banded langur, *Presbytis neglectus*, based on molecular systematic approach. Having in mind the confusing and contradictory taxonomy, systematic relationships of *P. femoralis femoralis*, *P. femoralis percura* and *P. femoralis robinsoni*, Abdul-Latiff *et al.* (2019a) hypothesised that banded langur does not fit in the same species classification as *P. f. robinsoni*

and *P. f. percura* as proposed by Groves (2001). Absence of comprehensive and reliable data for both *P. f. robinsoni* and *P. f. percura* previously has restricted the distinction of both species at species level from *P. f. femoralis*. But with recent findings on the recognition of *P. robinsoni* as distinct species (Md-Zain *et al.*, 2019b) and recognition of *P. percura* by Ang *et al.* (2020) as hypothesised by Abdul-Latiff *et al.* (2019a), the classification of *P. femoralis* for banded langur is accurate and no longer confusing for this species groups.

*P. femoralis* is physically slim and slender, covered in black fur at dorsal area and white patches at ventral area down to thigh with no white patches found at the tail area (Groves, 2001). Although normally found covered in black fur, recent discovery reported two brown morph individuals of *P. femoralis* found in Kota



Tinggi (Najmuddin *et al.*, 2020a). Generally, *P. femoralis* are herbivores but also consume fruits and seeds as well (Caton, 1990; Nijboer, 2006; Kirkpatrick, 2017). Based on preliminary study on the *P. femoralis*, it can forage up to 27 species of plants from 17 families in severely fragmented habitat in Johor (Najmuddin *et al.*, 2019a). Abdul-Latiff *et al.* (2019b) in their preliminary study using *ad libitum* observation method had found the *P. femoralis* spending 36.85% of their activity budget resting, followed by moving (35.65%) and feeding (21.79%) (Abdul-Latiff *et al.*, 2019b; 2019c). However, the issues facing banded langur are the rapidly decreasing population largely because of the threat of habitat fragmentation, land use change, habitat degradation, natural predator and also exploitation as bushmeat (Abdul-Latiff *et al.*, 2019a; Md-Zain *et al.*, 2019a; Najmuddin *et al.*, 2019b). On top of these threats, much is unknown about *P. femoralis* in terms of its behaviour and ecology. Further information such as long-term behavioural data on daily activities, feeding ecology, and population assessment is considered the fundamental knowledge needed for the conservation and management purposes of this species.

Daily activity budget is the study of behaviour on the activities within one complete day (Rizzuto *et al.*, 2017). The daily activity budget can help conservation efforts by giving an insight of temporal and spatial distribution of resources necessary for the animal to survive under threat of habitat loss and degradation (McCain & King, 2014). The method for recording daily activities was established by Altman (1974) for studying animal behaviour and had been followed systematically for many animal behavioural studies (Altman, 1974; Matsuda *et al.*, 2009; Long *et al.* 2010; Ruslin *et al.*, 2014; Sha *et al.*, 2018; Ruslin *et al.*, 2019). The basic daily activities recorded are usually clustered into resting, feeding, moving, and others (Ruslin *et al.*, 2014). Other behaviours are also recorded such as grooming, playing, vocalisation, mating, and fighting (Hambali *et al.*, 2012; Siti-Kauthar *et al.*, 2019). The importance of knowing the

*P. femoralis* behaviour is to assess population viability, dispersal and colonisation movement, human-primate conflict, and corridor uses (Reed, 2002; Abdul-Latiff *et al.*, 2017a, 2017b). The knowledge can be further applied for translocation and reintroduction in conservation (Reed, 2002). Niko Tinbergen, a pioneer ethologist also proposed that the essences of behavioural study were to answer the four problems: causation, ontogeny, function, and evolution (Tinbergen, 1963).

The daily activity budget of colobines varies between species and habitat. Whether in wildlife reserve, national park, neighbouring human settlement, or totally disturbed habitat, colobines can be found living in that area and certainly allocate their budgets for daily activities differently. In Vietnam, an insular residence of Cat Ba Island National Park, the Cat Ba langur (*Trachypithecus poliocephalus poliocephalus*) spent 66% of its time resting, 11% moving, 15% foraging, and 8% for social activities (Schneider *et al.*, 2010). Study on maroon langur, *Presbytis rubicunda* in intact forest in Sabangau, Kalimantan, Indonesia, showed annual activity budget comprised 48% resting, 29.3% feeding, 14.2% travelling, and 0.4% social behaviours (Smith *et al.*, 2013). Mentawai islands sympatric, endemic colobines, *Presbytis potenziani* and *Simias concolor* were studied in 2012 and showed the domination of resting (45.7 and 49.8 events/h, respectively) behaviour followed by feeding (31.8 and 27.7 events/h, respectively), traveling (6.2 and 5.6 events/h, respectively), and other social behaviour (0.6 and 2.1 events/h, respectively) (Hadi *et al.*, 2012). Thorough study on *Nasalis larvatus* in riverine forest of Kinabatangan, Sabah, Malaysia, showed that this odd-nosed colobine spent 76.5% of daily activity budget for resting, 19.5% for feeding, and 3.5% for moving (Matsuda *et al.*, 2009). The result correlates with the large menu of *N. larvatus* of 188 species of plants in their diets that take time for fermentation and digestion (Matsuda *et al.*, 2009).

Disturbed habitats such as urban landscape neighbouring with natural habitat do have

effects on the primates. Cercopithecine long-tailed macaque, *Macaca fascicularis* does alter its behaviour to disturbed habitat in Universiti Kebangsaan Malaysia, Bangi, Malaysia, but less likely for sympatric dusky leaf monkey, *Trachypithecus obscurus* (Ruslin et al., 2014). It was found that the *M. fascicularis* spent longer time feeding and moving than resting and other activities. However, *T. obscurus* spent much time in feeding and resting than moving. The leaf monkey was seen to fully utilise the natural habitat rather than long-tailed macaques, which forage in neighbouring residential colleges (Ruslin et al., 2014). A study on the same species, *T. obscurus* in Penang Botanical Garden, a recreational park, resulted on daily activity budget dominated by feeding (40.02%), resting (23.96%), moving (22.51%), autogrooming (6.52%), vocalisation (3.89%), allogrooming (1.33%), allomothering (0.97%), and playing (0.80%) (Md-Zain & Ch'ng, 2011). Most recently published study on *T. obscurus* in Penang Island showed that *T. obscurus* spent their time largely resting (43.5%,  $\pm 3.8\%$ ); a quarter of their time feeding (24.8%,  $\pm 4.8\%$ ) and locomoting (24.4%,  $\pm 2.0\%$ ); and very small proportions of their time on social grooming (3.8%,  $\pm 1.5\%$ ), social playing (2.6%,  $\pm 1.5\%$ ), and foraging (0.9%,  $\pm 0.3\%$ ) (Yap et al., 2019). Another study on urban population of Hanuman langur (*Semnopithecus entellus*) in India shows a majority of the activities is feeding (28.7%) compared with its rural population where moving activity dominates (33.7%) (Khatun et al., 2018). Such studies are important as basal knowledge for any primate species especially those under threat of habitat fragmentation. As of now for *P. femoralis*, unfortunately no systematic observation on its daily activity budget had been done. Thus, the aim for this paper was to describe the first systematic daily activity budget for *P. femoralis* in Malaysia.

### Methodology

This study was conducted in Kota Tinggi, Johor, Malaysia. The study area setting has mangrove forest at river edges, oil palm

plantation, fruit orchard, and abandoned rubber plantation with Malay village houses scattered around the village. The mean maximum and minimum temperature are 32°C and 24°C, respectively (Othman & Amin, 2018). Scan sampling (Altman, 1974) method was used for observation of daily activity budget of *P. femoralis* in the study area. There were two groups found ranging in the village. The group Dara was an all-male band of banded langur, which consisted of four identified members. Another banded langur group was named Bonda consisting of 12 individuals led by one alpha male, seven adults and sub-adult females, and four infants. The dusky leaf monkey group was also detected ranging in sympatry with long-tailed macaque (*Macaca fascicularis*) in the area. The observation focused on four individuals in all-male group Dara in the village that begun in February 2018 until November 2018. Observation started from 7:00 am and ended at 7:00 pm every sampling day. The sampling days for each month were fixed for 15 days.

Data for daily activity were recorded with interval of 10 min during observation, classified as feeding, resting, moving, socialising, and others. Feeding category is defined by foraging, manipulating, and ingesting the food material. Resting category is defined by inactive movement from a single place such as sleeping, sitting, and resting literally (Fruth & McGrew, 1998). Moving category is defined by the movement from a single place to another location by any means such as jumping, crawling, walking, or climbing (Md-Zain et al. 2019a). Social activities such as vocalisation, playing, or mating are categorised under social category. Other than those mentioned, activities are being grouped in another category (Matsuda et al., 2009; Khatun et al., 2018). Daily activity budget was taken instantaneously by scan sampling (Altman, 1974).

Phenological record was based on phenological study by Sha et al. (2018) in Upper Seletar Reservoir, Singapore. Their study site is approximately 30 km from Kampung Johor



Lama (Sha *et al.*, 2018). From the study, three types of forest were assessed for phenological study; the one similar to our study site is short secondary forest. Thus, we referred to the fruiting season in the forest. We allocated January, February, March June, July, and August as the fruiting season, whereas September, October, November, December, April, and May as the non-fruiting season.

Budgets for each of the activities (moving, feeding, resting, and social) were calculated by obtaining the sum of the activity of each hour of observation (Long *et al.*, 2010). Shapiro–Wilk test was used to test for data normality and advanced with Friedman test (IBM SPSS 22) (Allen *et al.*, 2014) to find differences between the means of each activity against hours and months (Schneider *et al.*, 2010). Data for other activities were excluded from analysis because of very small percentage of less than 1%. All datasets were averaged by converting the total frequencies into percentage for further analysis. For analysis between seasons, we used Shapiro–Wilk test to test for normality. Then, we used independent t-test to see the significance between seasons as the data were determined to be normally distributed.

## Results

### Activity budget

The total sampling hours was 1236 h, across 9 months of sampling. The total observation hours were 186 h and 20 min with mean hours per month at 20 h 42 min and 13 s. The activity budget for the five major activities is shown in Figure 1.

There was a statistical difference between the time budgets for each different activity—feeding, resting, travelling, and socialising based on the Friedman test ( $X^2 = 30.581$ ,  $df = 3$ ,  $p < 0.0001$ ). Based on Figure 1, resting activity dominates the daily activity budget of banded langurs in Kampung Johor Lama by  $43 \pm 13\%$  followed by moving ( $26 \pm 9\%$ ), feeding ( $26 \pm 7\%$ ), social ( $4 \pm 3\%$ ), and others ( $1 \pm 0\%$ ). Box plot graph was developed in Figure 2 to

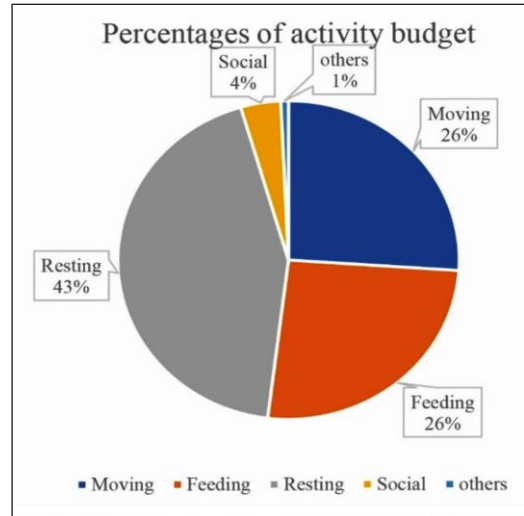


Figure 1: The overall activity budget of *P. femoralis*

evaluate the data distribution of each activity. The social activity was combined with others as the data was very small in percentages. Figure 3 shows the trend of each activity throughout the day with moving activity trend is fairly uniform during the day and decreased drastically toward mid-day between 12:00 p.m to 2:00 p.m and then increased back toward evening. Feeding activities are rather in uniform trend throughout the entire day with peaks in the morning and evening. The resting activities remained high in percentages with increasing trend starting from 9:00 a.m and reached its peak at 2:00 p.m and decreased toward evening at the lowest peak around 6:00 p.m. Social activities remained the lowest in percentages throughout the day and had quite a uniform trend.

### Variation of Activities between Seasons

Both datasets of fruiting and non-fruiting seasons are normally distributed as the  $p$ -value more than 0.05 ( $df = 8$ , fruiting season,  $\alpha \geq 0.05$ , non-fruiting season,  $\alpha \geq 0.05$ ). The result from independent t-test accepted the alternative hypothesis where the difference between fruiting season and non-fruiting seasons is statistically significant ( $F = 7.774$ ,  $p < 0.05$ ). The first comparison between seasons can be referred to in Figure 4 (a) for resting behaviour. Resting

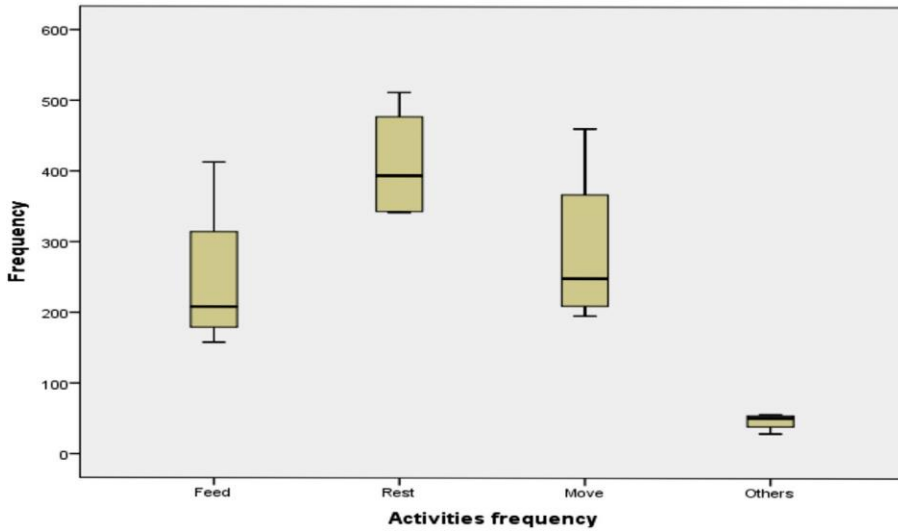


Figure 2: Box plot of the distribution of data for each activity

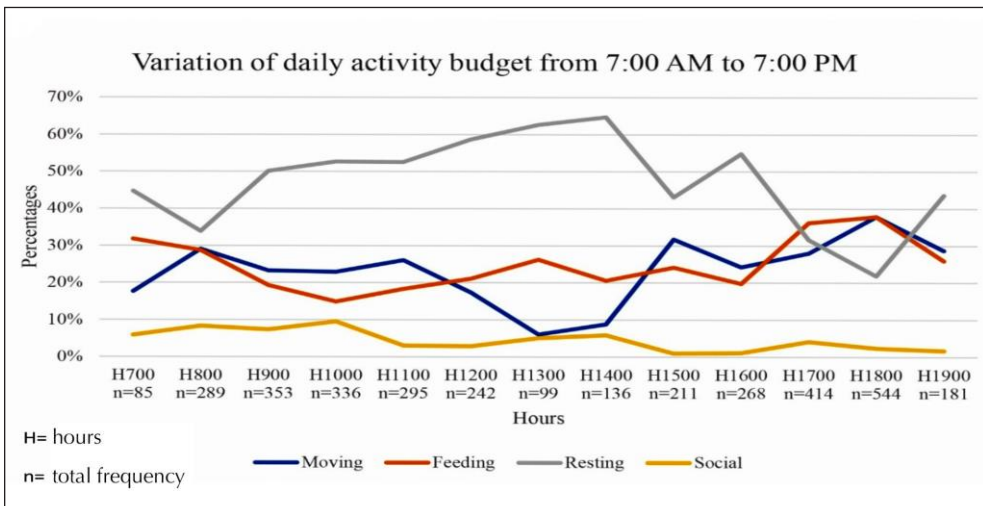


Figure 3: Variation of activity percentages over hours

behaviour shows uneven trends throughout the day for the non-fruiting season as the range varied from 21% to 81% as compared with the fruiting season with range varied from 19% to 65%. Three peaks detected for resting hours in the non-fruiting season, which were at 9:00 a.m, 1:00 a.m and 7:00 p.m, whereas during the fruiting season, only a single peak was detected at 2:00 p.m. Overall, banded langur spent less time resting in the fruiting season ( $42 \pm 13\%$ ) than in the non-fruiting season ( $47 \pm 19\%$ ).

Based on Figure 4 (b), the trend of moving activities in the fruiting season was more even throughout the day, as compared with that in the non-fruiting season with several extremities at 1:00 p.m and 6:00 p.m. The range for the moving budget in fruiting season was 7% to 37%, compared to non-fruiting season which was from 0% to 48% showing more evenness of moving activities in the fruiting season. Overall, moving activities during the fruiting season ( $25 \pm 9\%$ ) was less than that for the non-fruiting season ( $28 \pm 15\%$ ).

Feeding activities during the fruiting season was comparable with the non-fruiting season. The range of percentages of 15% to 44% for the fruiting season was compared with 67% to 11% for the non-fruiting season as can be seen in Figure 4 (c). The non-fruiting season had one extreme value at 7:00 a.m of 67% because of the low quality of food needed to be ingested early in the day. However, the highest percentage of feeding for the fruiting season (44%) was at 6:00 p.m, perhaps for energy restoration before resting in the night. *P. femoralis* spent more time feeding in the fruiting season ( $27 \pm 8\%$ ) than in the non-fruiting season ( $20 \pm 15\%$ ).

Social activities remained small in percentage compared with other major activities (moving, feeding, and resting) as it only ranged from 1% to 11% for the fruiting season and 0% to 11% for the non-fruiting season. The trend of social activities of *P. femoralis* in both seasons is similarly even with peaks in the morning between 8:00 a.m to 10:00 a.m at 11% as can be seen in Figure 4 (d). The total overall activity percentage of social activities was equal for the fruiting season ( $5 \pm 3\%$ ) and the non-fruiting season ( $5 \pm 4\%$ ).

**Variation of Activities between Months**

Monthly variations in time budgets for different activities are presented in Figure 5. Budgets for major activities, such as feeding, resting, traveling, and social activities varied significantly between months ( $\chi^2 = 13.584$ ,  $df = 3, p < 0.05$ ). The moving and resting activities trend throughout the months of observation are somehow unique to be explained. This can largely be attributed to difficulties in sighting of the population especially in February, April and May 2018. In February, the resting activity dominated the activity budget by 67% then dropped down to 13% and continued to rise again in July 2018 (45%) and ended with peak on November 2018 (69%). Conversely, the activity budget for moving was low in February 2018 (0%) due to low sighting of the population (Figure 5) then rose and reached peak on May 2018 (73%), after that the trend decreased month by month until November 2018 (14%). For feeding activity, the trend is nearly even with a range from 9% to 38% and social activities are more even with only peak in February 2018 and decreased percentages month by month to finally reach 3% in November 2018.

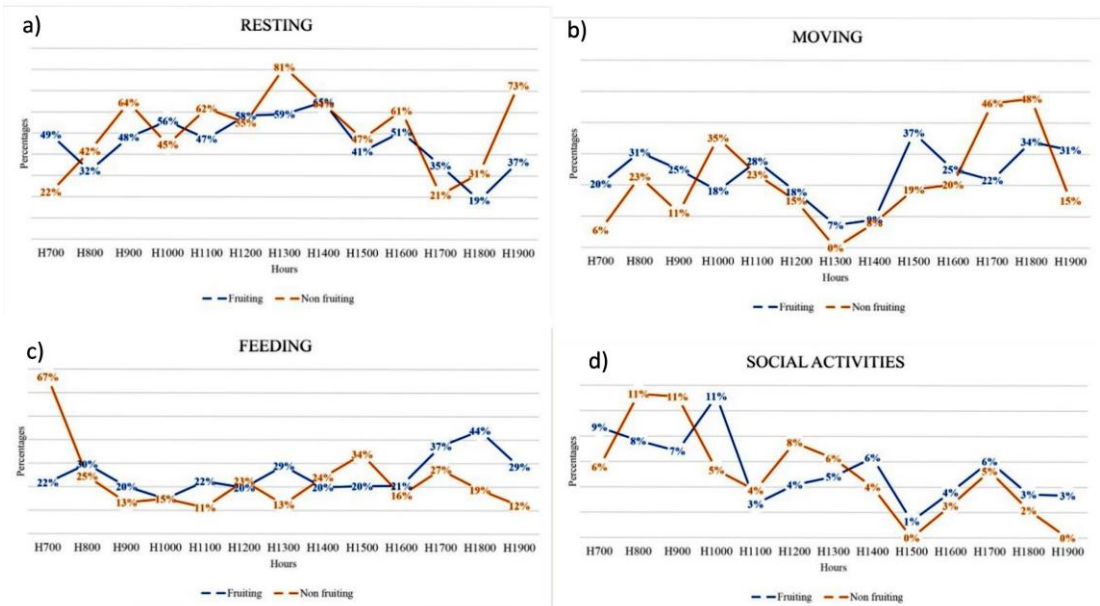


Figure 4: Seasonal difference of daily activities in fruiting and non-fruiting seasons (H=hours)

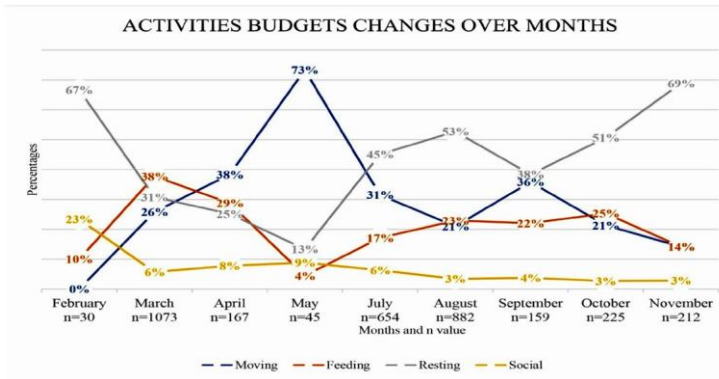


Figure 5: Monthly differences of daily activities from February 2018 to November 2018

**Discussion**

Based on our results of daily activity budget, resting time for *P. femoralis* dominated the daily activities budget (43 ± 13%). This proportion was also shown by other colobines such as *P. rubicunda* (48%), *P. potenziani* (45.7 events/h), *Pygathrix cinirea* (37%), *S. concolor* (49.8 events/h), and *N. larvatus* (76.5%) based on Table 1 (Matsuda et al., 2009; Long et al., 2010; Hadi et al., 2012; Smith et al., 2013). However, there are several species of colobines preferably different in terms of resting time allocation such as *R. beiti* in China (28.5%), *T. obscurus* in Penang (23.96%), and *T. obscurus* in Universiti Kebangsaan Malaysia (UKM) (38.1%), ranking as the second largest budget of the daily activities (Grueter et al., 2013; Md-Zain & Ch’ng, 2011; Ruslin et al., 2014). Resting time was hypothesised to be associated with the herbivory diet of langurs as they have tripartite stomach (Caton, 1999; Long et al., 2010). Thus, long resting time is associated with the fermentation of plant material in colobines’ stomach even to an extent of 40 hours of particle mean retention time (Nijboer et al., 2007; Nijboer, 2006). However, Dasilva (1993) argued that diet is not directly related to resting time but is more closely related to weather condition. On top of the factors listed, other factors such as gut size, food passage rate, home range area, and the cost of locomotion are related to resting time and development of optimal foraging strategy (Garber, 1987).

Feeding is the most important activity in order for an animal to survive. Our results on feeding and moving behaviours show the same proportion, which is 26%. Feeding activity is the second biggest proportion in other studies as well such as in *N. larvatus*, *P. potenziani*, *P. rubicunda*, *S. entellus ajax*, *S. concolor*, and *T. p. poliocephalus* (Matsuda et al., 2009; Minhas et al., 2010; Schneider et al., 2010; Hadi et al., 2012; Smiths et al., 2013). In contrast, other studies had found feeding to be the majority of the daily activity budget, as noted by Grueter et al. (2013) for *R. beiti*, Md-Zain & Ch’ng, (2011) and Ruslin et al., (2014) for *T. obscurus*. Both studies by Md-Zain & Ch’ng (2011) and Ruslin et al. (2014) had reported that dusky leaf monkeys (*T. obscurus*) in similar habitat allocate feeding behaviour as the majority of daily activities budget. Md-Zain & Ch’ng (2011) explained that the spike of feeding behaviour was in December where young shoots began to sprout. Ruslin et al. (2014) explained that the large percentage of time that *T. obscurus* spent on feeding was during the evening before dusk, which is the same as in our study (Figure 3). It is perhaps the degraded habitat of Kota Tinggi (this study), Penang Botanical Garden (Md-Zain & Ch’ng, 2011) and UKM (Ruslin et al., 2014) had forced langurs to forage in habitat with the presence of humans. Thus, feeding activity dominated their daily activity budget on feeding and no longer felt threatened by human presence. Since human settlement was also planted with fruiting trees, it might have attracted the langurs to forage near human settlement (Md-Zain & Ch’ng, 2011).

Table 1: Comparison of daily activities budget across Colobines

No.	Species	Location	Type of habitat	Activities budget				Reference
				Resting	Feeding	Moving	Social/ others	
1	<i>Nasalis larvatus</i>	Sabah, Malaysia	Natural riverine forest	76.5%	19.5%	3.5%	<1%	Matsuda <i>et al.</i> , 2009
2	<i>P. femoralis</i>	Johor, Malaysia	Disturbed secondary forest	43%	26 %	26 %	5 %	This study
3	<i>P. rubicunda</i>	Kalimantan, Indonesia	Lowland intact rainforest	48%	29.3%	14%	0.4 %	Smith <i>et al.</i> , 2013
4	<i>P. potenziani</i>	Mentawai island, Indonesia	Undisturbed mixed forest	45.7 events/h	31.8 events/h	6.2 events/h	0.6 events/h	Hadi <i>et al.</i> , 2012
5	<i>P. cinerea</i>	Kon Ka Kinh National Park, Vietnam	Forest Reserve	37.0%	11.9%	25.8%	25.1%	Long <i>et al.</i> , 2010
6	<i>R. bieti</i>	Samage Forest, China	Sub-tropical forest reserve	28.5 %	38.5 %	19.1%	13.9%	Grueter <i>et al.</i> , 2013
7	<i>S. e. ajax</i>	Machiara National Park, Pakistan	Temperate Himalayan forest, livestock	43.83%	31.71%	12.43 %	12.03 %	Minhas <i>et al.</i> , 2010; Dar <i>et al.</i> , 2012
8	<i>S. concolor</i>	Mentawai island, Indonesia	Undisturbed mixed forest	49.8 events/h	27.7 events/h	5.6 events/h	2.1 events/h	Hadi <i>et al.</i> , 2012
9	<i>T. obscurus</i>	Penang, Malaysia	Disturbed forest reserve	23.96%	40.02%	22.51%	13.51%	Md-Zain & Ch'ng, 2011
10	<i>T. obscurus</i>	UKM, Malaysia	Disturbed forest reserve	38.31%	40.81%	19.19%	1.68%	Ruslin <i>et al.</i> , 2014
11	<i>T. p. poliocephalus</i>	Cat Ba Island, Vietnam	Natural island, national park	66%	15%	11%	8%	Schneider <i>et al.</i> , 2010

Moving activities account for 26% of the daily activity budget and are nearly close as the percentage in the study on *P. cinerea* and *T. obscurus*, which are 25.8% and 22.51%, respectively (Long et al., 2010; Md-Zain & Ch'ng, 2011). Moving activities are related to multiple factors such as digestive physiology, ranging area, disturbance, threats, food abundance, weather, and population dynamics. Semi-habituated *T. obscurus* in Penang do not bother with human presence in the recreational area and thus can move freely (Md-Zain & Ch'ng, 2011). However, *N. larvatus* is found to be the least moving (3.5%) in Table 1 and seems to be related to its great resting time and the harem group comparably with our study where the focal group Dara is all-male band (Matsuda et al., 2009).

Social activities score the least in the daily activity budget of *P. femoralis* (5%). They are adult all-male band thus the percentage seems to be similar in pattern as in the other studies. Though *P. femoralis* are ranging and moving in a group, social activities were very few to be recorded compared with other activities. One extreme percentage was shown by *P. cinerea*, where socialising made up of 25.1% of their daily activity budget (Long et al., 2010). *P. cinerea* in the study consist of a number of infants and juveniles where they mostly displayed playing, scrambling, and calling each other when the adults were feeding (Long et al., 2010). *P. femoralis* in our study also display playing behaviour between adult males and sympatrically ranging *M. fascicularis* based on our observation.

The differences of daily activity budget of *P. femoralis* in this study did not vary much between seasons. Based on the result, during the fruiting season their activities comprised moving (25%), feeding (27%), resting (42%), and socialising (5%), whereas activities during the non-fruiting season comprised moving (28%), feeding (20%), resting (47%), and socialising (5%). Feeding behaviour of *P. femoralis* did reduce in the non-fruiting season maybe because of the availability of fruits in the ranging area,

although this was statistically insignificant. The study area has a fruit orchard planted by villagers that provided high-calorie fruits such as durian (*Durio zibenithus*), rambutan (*Nephelium lappaceum*), banana (*Musa acuminata x balbisiana*), jackfruit (*Artocarpus heterophyllus*), and mango (*Mangifera indica*). On top of that, two top commodity plants of Malaysia, which are rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*), were also available in the study area and were consumed by *P. femoralis*.

Fruits are made up of simple sugars and have readily available nutrients (Harahap et al., 2012), thus it can reduce the resting activity for digestion in the fruiting season (42%) compared with the non-fruiting season (47%). However, the fruit eating activities did not vary significantly for the case of *P. femoralis* in Kg. Johor Lama. Based on observations, there are several evergreen fruiting trees such as oil palm, rubber, and cempedak trees (*Artocarpus integer*) that offer fruits for *P. femoralis*. Although in non-fruiting seasons, *P. femoralis* are still able to consume fruits from evergreen fruiting trees as fallback food. Fallback foods are the resource of relatively low-preference foods that are used seasonally when preferred foods are unavailable (Marshall & Wrangham, 2007). The behaviour of relying on fallback foods was also exhibited by other species of colobine monkeys. Maroon langur (*P. rubicunda*), show the dependence on young leaves of *Spatholobus macropterus* (liana, Leguminosae) as fallback foods when the preferred foods are unavailable (Hanya & Bernard, 2012). *P. femoralis* were recorded to consume evergreen fruiting trees such as rubber fruits (*H. brasiliensis*), oil palm fruits (*E. guineensis*), and banana fruits (*M. acuminata x balbisiana*) in the non-fruiting season. The non-fruiting season also indicated a higher percentage of moving to rationalise the need of travelling to search for high-calorie food. In conclusion, *P. femoralis* can adapt well to food availability to optimise their foraging strategy.

### **Conservation and Human–Langur Conflict of *P. femoralis***

Comparing the data gained in this study with other langurs ranging in disturbed habitat, *P. femoralis* show that their daily activity budget was different from *T. obscurus* in Penang and UKM, Malaysia. Both cases show that feeding behaviour dominated the daily activity budget compared with *P. femoralis* in our study. *P. femoralis* showed resting activity budget as the main activity similar to *N. larvatus* in Sabah that ranged in natural riverine forest (Matsuda *et al.*, 2009). This may indicate that *P. femoralis* has totally habituated with humans in the area as they behave normally like other colobines that lived in natural forest and intact forest (Schneider *et al.*, 2010; Smith *et al.*, 2013).

In contrast, *P. femoralis* did encounter conflicts with humans as they ranged inside the village and consumed fruits from the village orchard based on our observation on the field. For example, *P. femoralis* was found to consume mango (*M. indica*) and banana (*M. acuminata x balbisiana*). As a result of this, we recorded a villager who aimed a slingshot and clapping hands to deter the *P. femoralis*, signifying it as pest. Pest behaviour may be directly related to the shrinking habitat size and conversion of forest into agriculture land such as oil palm plantation. Other instances such as human settlements, forest clearance, and human–primate conflicts are known as threats for the conservation of the species (Nijman *et al.*, 2008). However, *P. femoralis* was found consuming an invasive species *Mikania micrantha*, that usually becomes a problem in disturbed habitat as its rapid spread becomes threats to both natural and agricultural environments, kills or reduces growth of preferred species, severely impacts biodiversity and agriculture production (Day *et al.*, 2016). Another colobine monkey, capped langur (*Trachypithecus pileatus*) was also recorded to have largely consumed *M. micrantha* (11.2%) from overall 43 species during winter in India (Solanki *et al.*, 2008). Further studies may prove that the ecological function of *P. femoralis* in disturbed habitat is to control invasive species

and balance out the notion of *P. femoralis* as solely pest. Opportunistic pest behaviour of the banded langur seen in Kg. Johor Lama is not naturally ignited but a behavioural drift due to multiple ecological and behavioural factors as for other colobines (Hill & Wallace, 2012; Hill, 2017).

### **Conclusion**

This study provides first systematic record of daily activity budget for *P. femoralis* in Malaysia, and based on their activity pattern, it was found to be fairly similar to other colobines. The daily activity budget displayed by *P. femoralis* gave an overview of population viability, which then can be applied into conservation and management effort. Further study should be focused on ranging behaviour, canopy use, terrestrial behaviour, and population dynamics to truly understand the behaviour of *P. femoralis*.

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## NEAREST GREEDY ALGORITHM FOR SOLVING A SINGLE LANDFILL SITE SELECTION WITH RESOURCE REQUIREMENTS

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**Abstract:** Landfill site selection has appeared to be an important waste management issue for future landfill planning. The selection of suitable landfill sites involves several alternative sites, along with evaluation criteria. Previously, most studies solved the landfill site selection problem by using the geographic information systems (GIS) and the multiple criteria decision making (MCDM) methods. GIS is used to identify suitable sites for a new landfill, while MCDM is used to rank the candidate sites based on the score calculated for each site. With that this paper presents a new approach that ranks the related candidate sites. These candidate sites were ranked based on several vital resource requirements, such as total travel distance to transport collected waste to the landfill, number of vehicles/drivers required for the collection and total working hours of drivers affect the operating cost of the selected landfill. To be precise, all requirements as described above have been provided when a particular site is selected as the new landfill. These resources are identified by using the heuristic technique, namely nearest greedy. This approach was further tested on a benchmark problem set, namely waste collection vehicle routing problem with time windows. The results serve to aid the waste management team to select the most suitable location for landfill siting, besides listing the influential resource requirements for landfill site selection planning in selecting a new landfill site.

Keywords: Landfill site selection, landfill siting, waste collection benchmark, heuristic, resources.

### Introduction

Rapid population growth, urbanisation development, and fast economic growth have been determined as the common factors that have contributed to the increasing amount of waste generation rates in many nations worldwide. Thus, it is necessary to generate a more effective and efficient method or model to address solid waste management problem. Moreover, a number of approaches are available to manage and dispose solid waste, such as composting (Jara-Samaniego *et al.*, 2017), incineration (Yang *et al.*, 2017), and landfilling (Vosoogh *et al.*, 2017). Regardless of the varied methods available to dispose solid waste, landfilling is still the preferred choice due to its simplicity and low costing, especially in developing countries (Rahmat *et al.*, 2017).

In general, a good landfill site selection plan should be beneficial to both the government and

the community in terms of long-term survival and free from pollutions. Hence, the initial step in the preparation of the plan is determining the most suitable location to establish waste disposal facilities that would not negatively affect the aspects of economy, ecology, and environmental health (Chang *et al.*, 2008). In selecting a new landfill site, all important criteria, including environmental, economic, and social elements, must be considered in the preliminary screening and landfill suitability assessment phase. Nevertheless, the criteria used may differ between research as they rely on the type of landfill (municipal or hazardous), as well as physical and ecological conditions of the research areas (Moghaddas & Namaghi, 2011; Bahrani *et al.*, 2016). In fact, a comprehensive study carried out by Mat *et al.* (2016) reported the varied landfill selection criteria across many nations.

Although prior studies have employed various criteria related to environmental, economic, and social aspects, these studies have failed to investigate the best utilisation of their limited resources in locating a new landfill site, which may cause a problem in the implementation phase. In addition, resource requirements need to be finalised early within a project lifecycle as these demands often surpass initial estimates and incapability's to secure resource commitments, which possess the potential to dampen project efforts (Reel & Systems, 1999; Somers & Nelson, 2001). Furthermore, in landfill selection, resource requirements (e.g. vehicles, drivers, and fuel) that aid the transportation of solid waste from customers to landfill facilities must be defined at the beginning stage and allocated equally to the most suitable landfill facilities. With that, customers can be served efficiently during waste collection. This should enhance the present solid waste management system to be more effective.

On top of that, determination of resource requirements is indeed necessary when planning for landfill selection with limited resources. In such situations, trade of decision must be made regarding which landfill site should be open to receive the available resource. For instance, for the farthest landfill site, more maintenance cost should be allocated due to the long distance covered by the particular vehicle in collecting waste from customers until disposal at the landfill site. Other resources that can be considered are the transportation cost, number of vehicles and drivers as well as drivers' working hours. Therefore, we believe that these resources affect the operating costs of a landfill.

In this paper, a real life waste collection vehicle routing problem with time windows (VRPTW) benchmark problem has been used to test the proposed algorithm. The benchmark problem is based on the solid waste management services in North America, of which nearly 26000 collections are conducted to collect about 80 million tons of garbage a year (Sahoo *et al.*, 2005).

Since there are many criteria that belong to environmental, economic and social groups that

must be weighed in during landfill site selection process, this problem has often been viewed as a multi-criteria decision-making problem (MCDM) (Onut & Soner, 2008). As such, most past research solved landfill site selection problems by using statistical procedures, geographic information systems (GIS), MCDM methods, and fuzzy techniques. For example, Anderson & Greenberg (1982) applied the matrix statistical approach to evaluate land use suitability to locate new hazardous landfill facilities based on water supply, physical, and cultural criteria. Meanwhile, Al-Bakri *et al.* (1988) identified and evaluated a potential landfill site in Shuiba Industrial Area located at Kuwait by using a weighting/scaling scoring system. Nonetheless, the initial combination of GIS and analytical hierarchy process (AHP) was proposed by Siddiqui *et al.* (1996) for landfill selection in Cleveland County found at Oklahoma. Charnpratheep *et al.* (1997) combined the fuzzy set theory (FST) and AHP into a raster-based GIS for preliminary screening of landfill sites in Thailand. Cheng *et al.* (2002) applied the MCDM approach (simple weighted addition (SWA), weighted product (WP) method, TOPSIS, cooperative game theory (CGT), and ELECTRE) to solve issues related to landfill selection in Regina of Saskatchewan Canada.

Additionally, in 2003, similar MCDM approaches were utilised by combining them with inexact mixed integer linear programming (IMILP) methods to detect an optimal landfill site selection and a waste-flow-allocation pattern in Regina (Cheng *et al.*, 2003). On top of that, Şener *et al.* (2006) identified an appropriate landfill in the vicinity of Ankara by using the integration of GIS, simple additive weighting (SAW), and AHP, whereas Gemitzi *et al.* (2007) integrated GIS, fuzzy logic, AHP, and order weighted average (OWA) for municipal landfill selection in Greece. Besides that, Chang *et al.* (2008) combined GIS with fuzzy MCDM for landfill siting in Texas, while Aragonés-Beltrán *et al.* (2010) used the Analytic Network Process (ANP) to identify the best location for landfill siting in Spain. On the other hand, Gorsevski

*et al.* (2012) evaluated landfill suitability in Macedonia by using GIS-based fuzzy MCDM approach, while Arkoc (2014) solved MSW landfill selection at Çorlu District by employing GIS with an overlay analysis. Furthermore, Torabi-Kaveh *et al.* (2016) coupled GIS analysis with a fuzzy AHP to locate a suitable landfill site in Iranshahr County located in Iran. Additionally, more information concerning decision-making techniques in solving landfill site selection problems can be referred to the article published by Mat *et al.* (2017). Table 1 presents a summary of recent studies concerning landfill site selection problems.

With that, this paper presents a landfill site selection problem that emerges when a set of candidate landfill sites are already available and further evaluation is required to select the best site among them. In such a case, it is

common for local authorities to opt for the most economical landfill in terms of operational cost incurred at the time of waste collection from customers until disposal of at the landfill site. Sahoo *et al.* (2005) reported that one-third of waste management revenue is derived from landfill disposal and the remaining waste collection services. Moreover, given that the vast majority of income comes from waste collection services, increment in management level and technical efficiency (routing, dispatching, and maintenance) should be given priority. Hence, the utilisation of available resources can reduce operating costs (Sahoo *et al.*, 2005). Besides, identifying the most suitable location for landfill facilities could also reduce operational cost, as well as routes taken by waste collection vehicles and the number of vehicles needed (Benjamin & Beasley, 2013).

Table 1: Recent works on landfill site selection problem

Author(s)	Descriptions
Vosoogh <i>et al.</i> (2017)	Zoning the pollution potential of the Mashhad aquifer by using modified DRASTIC method and GIS to assess both old and new landfill sites.
Rahmat <i>et al.</i> (2017)	Determined a suitable site to dispose solid waste in Behbahan city in Iran by using a combination of GIS and AHP.
Jamshidi-Zanjani & Rezaei (2017)	Selected a landfill site in Markazi province in at Iran by using different methods, including ANP combined with fuzzy linguistic quantifier, ordered weighted average (OWA), and weighted linear combination (WLC) approaches in GIS.
Chabuk <i>et al.</i> (2017)	Detected the most suitable landfill site by using GIS and two varied methods of MCDM
Al-Ruzouq <i>et al.</i> (2018)	A combination of fuzzy membership and AHP in GIS environment was used for landfill siting in Sharjah city, United Arab Emirates.
Ding <i>et al.</i> (2018)	A selection of Construction and Demolition (C&D) waste landfill sites in Shenzhen, China using GIS and AHP methods presented
Kahraman <i>et al.</i> (2018)	Information axiom into a trapezoidal intuitionistic fuzzy set to overcome doubts among experts in deciding the best location for landfill siting in Istanbul included
Santhosh & Sivakumar Babu (2018)	A landfill site selection process in Bengaluru City in India using integrated AHP with GIS after considering groundwater vulnerability contamination assessment presented. The assessment was solved by using the DRASTIC method.

Thus, in this study, in order to determine resource requirements for selecting good landfill site, the problem is solved as waste collection VRPTW. In constructing vehicle routes, various solution techniques have been successfully applied by previous research, for instances, heuristic approaches (i.e. Molina *et al.*, 2019), exact methods (i.e. Lysgaard *et al.*, 2004), and technology applications (i.e. Chaudhary *et al.*, 2019). Of all these, heuristic technique is the most appropriate technique for finding solutions involving real-world applications (Louati & Chabchoub, 2019). The greedy algorithm is one of the heuristics approaches which is often used (Karabulut & Tasgetiren, 2014; Delgado-Antequera *et al.*, 2019) in generating initial solution. Therefore, in this study, the nearest greedy (NG) algorithm is used for analysing resources such as total travel distance to transport collected waste to the landfill, number of drivers required for the collection and total working hours of drivers. All these resources affect waste management operating cost. With that, in this paper, a single landfill site selection problem by using NG algorithm had been investigated to reduce the operating costs incurred during the waste collection process.

**Materials and Methods**

This section presents the real-life waste collection VRPTW benchmark problem sets

and new approach to rank the candidate landfill sites used in this paper.

**Benchmark dataset**

This paper investigated the waste collection vehicle routing problem with time windows (VRPTW) benchmark problem employed to test the proposed landfill site selection model with resource requirements embedded into the model. The benchmark problem was introduced by Kim *et al.* (2006). The problem consisted of varying numbers of customers, landfill sites, vehicle capacity, and route capacity per day. The characteristics of each dataset are displayed in Table 2.

The first column of Table 2 lists the name of all datasets to represent the total number of nodes (i.e. depot, customers, and landfill site) involved in each dataset. Figure 1 depicts an example of dataset 102 (i.e. a total of 102 nodes) which comprised of 99 customers, 2 landfill sites, and 1 depot. In this study, the following scenario is illustrated where the waste collection process starts with an empty vehicle from the depot, collecting waste from one location (termed as customer) and unloaded the accumulated waste at the landfill. Then, the vehicle will leave the landfill and collect more waste from other customers' locations until no waste is found to be collected and then return to the depot with an empty capacity. The number

Table 2: Characteristics of Waste Collection VRPTW benchmark problem

Dataset / number of nodes	Number of customers	Number of landfills sites	Vehicle capacity (cubic yards)
102	99	2	280
335	330	4	243
804	784	19	280
1051	1048	2	200
1351	1347	3	255
1599	1596	3	280
1932	1927	4	462
2100	2092	7	462

of landfill sites displayed in the third column of Table 2 is considered as the potential candidate landfill sites. For instance, dataset 102 consists of 2 potential landfill sites and the vehicle capacity is limited to 280 yards. Besides, for all datasets, the maximum number of customers served by each vehicle is 500 on a daily basis. Meanwhile, the duration of lunch break for drivers is an hour. Other than that, the vehicle travels in static speed, which is 40 miles per hour (mph). Furthermore, the coordinate of each node (depot/customers/landfill sites) provided in the dataset is in feet.

### The New Approach

The new approach proposed in this paper is projected to solve single landfill site selection problem, as illustrated in Figure 2. In this research, the ranking process starts by generating the distance and travel time matrix ( $n \times n$ ) for

each dataset, where  $n$  is the total number of nodes (depot/landfill site/customer). The number of matrices constructed depends on the number of landfill site. For example, dataset 102 has two candidate landfill sites. Thus, the nearest greedy (NG) technique adopted from (Mat *et al.*, 2017; Mat *et al.*, 2018) was executed twice with varied distance and travel time at each execution. In the first run, distance and travel time between the nodes were used based on the coordinate of candidate landfill 1. Next, in the second run, distance and travel time between the nodes had been based on the coordinate of candidate landfill 2. The total distance travelled, and the numbers of constructed routes were then calculated for each solution. After that, the solutions obtained were sorted in ascending order based on the total distance travelled. Lastly, the rank of the solutions is displayed, where the lowest distance is regarded as the best solution.

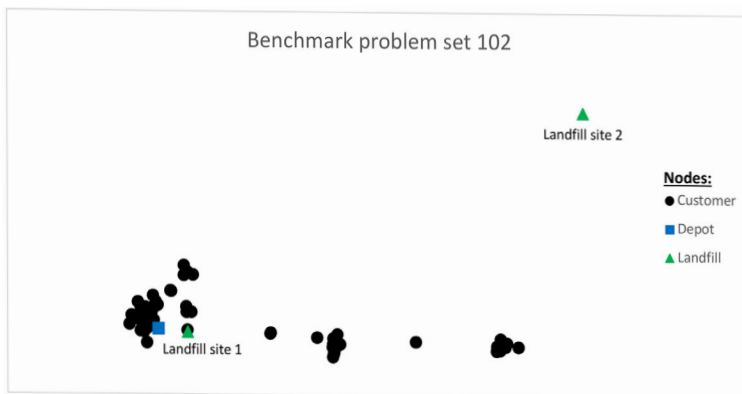


Figure 1: Location of nodes for dataset 102

```

Calculate the total number of nodes,  $n$ .
Create a 2-dimensional distance matrix of  $n \times n$ .
Create a 2-dimensional travel time matrix of  $n \times n$ .

FOR  $i = 1$ : number of candidate landfill sites
Construct vehicle routes using nearest greedy technique
Calculate total distance travelled
Calculate number of constructed routes
Save solution  $i$ 
END FOR

FOR  $i = 1$ : number of solutions
Sort solution  $i$  into ascending order based on the total distance travelled
END FOR
Display rank of the solutions

```

Figure 2: Pseudo-code of ranking process



Basically, the NG technique selected the closest customer from the present node to be served based on a set of problem constraints, as listed in the following:

- Maximum number of customers served per day
- Route capacity per day
- Driver's rest break
- Vehicle travel speed
- Time windows (depot/customer/landfill site)
- Service time
- Each customer is serviced exactly once
- Each vehicle route starts and ends at the depot
- The amount of waste collected at each customer cannot exceed vehicle capacity
- The vehicle must be emptied at the landfill site before continuing servicing the customer or before returning to the depot (final trip)

Further elaboration pertaining to the technique employed by NG in constructing a vehicle route is illustrated in Figure 3. In addition, this study presents a new set of initial solutions constructed for each vehicle route that must start from the depot. A new vehicle route was constructed by identifying the nearest distance from a set of customers that needs to be scheduled from depot 0. Once *ii* was confirmed, the variables, the total capacity, and the present vehicle capacity were updated. Next, the rest period allocated to the drivers was determined. The drivers were permitted to take a break during their break time. Otherwise, the driver would need to identify the next closest customer *jj* to be serviced from customer *ii*. At the same time, the variables were updated.

Next, the vehicle was checked if it was loaded with waste. If the vehicle was full of load, a candidate landfill site was suggested for disposal of waste. Upon waste disposal, the candidate landfill site was included in the present vehicle route, in which the variables, the

total capacity, and the present vehicle capacity were updated.

After that, the system determined if there was remaining customer(s) that required waste disposal service. Upon opening the time window, the vehicle would have to service the customers. In the absence of customers and after emptying the vehicle, the vehicle would need to return to the depot. Thus, the variables: total vehicle capacity and total customer visited per day, would be updated. However, a new vehicle would be used to collect waste from any remaining customer(s), indicating increment in the number of drivers. The new vehicle would eventually undergo the whole process starting from the initial phase. The whole process would be terminated as soon as all customers have sought the service.

Furthermore, it is worthy to highlight that the whole process was executed *n* times based on the number of candidate landfill sites derived from the dataset. For example, dataset 102 has two possible landfill sites. Thus, it was executed twice to construct two solutions for the dataset. In the first run, all collected waste from the customers was unloaded at landfill site 1, while in the second run; all the waste was unloaded at landfill site 2.

Both solutions (obtained from both runs) provided resource requirements to serve all customers in terms of the total distance travelled and the number of drivers needed. The resource requirements from both solutions were further compared so as to choose the best landfill site for the dataset. The comparisons are discussed in detail in the next subsection.

## Results and Discussion

This paper applied resource requirements to select the best landfill site. The outcome of the total distance travelled and the number of drivers needed had been determined for the waste collection process. As such, the NG technique was coded in C++ and run on a Pentium® Dual-Core CPU T4300 @ 2.10GHz with 3.00 GB memory. Besides, this very approach was tested

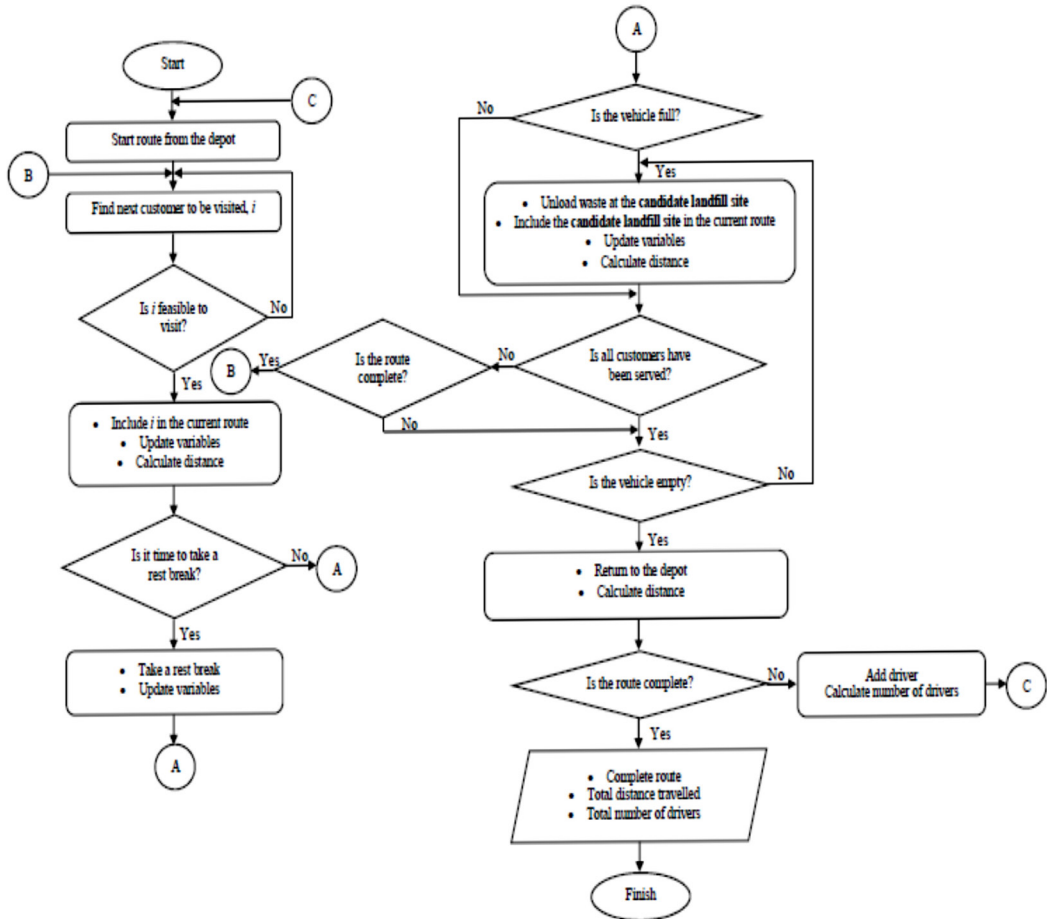


Figure 3: Flow chart of the NG technique to construct vehicle routes

on the same benchmark problem employed by Kim *et al.* (2006) and Benjamin and Beasley (2010, 2013). With that, Table 3 until Table 10 present the resource requirements needed to serve all customers if each candidate site was selected as a landfill site. The third and the fourth columns of the tables display the resource requirements, whereas the last column shows the ranking of the candidate landfill sites.

Table 3 presents the resource requirements that served 99 customers based on two different landfill candidate sites. Based on the solution proposed by NG technique, if site 1 was selected, the waste management team would need to hire three drivers to serve the customers and the total distance travelled by all the drivers would have been 257.21 miles. Meanwhile, if site 2 was selected, they also need to hire the same number

Table 3: Computational results for dataset 102

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
102	1	257.21	3	4	1
	2	701.66	3	8	2

of drivers, but the total distance would have been higher when compared to site 1 (an increment by 172.8%). Average working hour per driver if site 1 was selected is 4 hours. While, average working hour for site 2 is 8 hours, this is due to the location of landfill site 2 which is far from the customers (refer to Figure 1). Moreover, as observed, the waste management team was given two options, either site 1 or site 2. If site 1 was selected, they could save thrice the resources required (i.e., fuel consumption), as compared to site 2, where the distance travelled by all drivers was longer.

Table 4 presents the resource requirements needed to serve 330 customers based on four different landfill candidate sites. Based on the solution proposed by NG technique, site 1 emerged as the best choice, when compared to the rest. The total distance travelled by all drivers was 213.28 miles and average working hour per driver if site 1 were selected is 5 hours. Meanwhile, all candidate landfill sites would require six drivers, the same number.

Table 5 presents that dataset 804 proposed two candidate sites: sites 3 and 9. Both sites would require similar number of resources (6

Table 4: Computational results for dataset 335

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
335	<b>1</b>	<b>213.28</b>	<b>6</b>	<b>5</b>	<b>1</b>
	2	552.35	6	6	2
	3	688.37	6	7	3
	4	865.45	6	7	4

Table 5: Computational results for dataset 804 x

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
804	1	1545.27	7	9	4
	2	2582.25	10	9	14
	<b>3</b>	<b>801.05</b>	<b>6</b>	<b>8</b>	<b>1</b>
	4	1781.39	8	9	6
	5	1987.39	8	9	9
	6	2037.66	8	10	11
	7	2582.25	10	9	14
	<b>8</b>	<b>805.48</b>	<b>5</b>	<b>10</b>	<b>2</b>
	<b>9</b>	<b>801.05</b>	<b>6</b>	<b>8</b>	<b>1</b>
	10	1495.67	7	9	3
	11	1754.50	8	9	5
	12	1818.47	8	9	7
	13	3670.64	11	10	14
	14	2448.19	10	9	13
	15	2007.04	8	10	10
	16	2074.75	8	9	12
	17	1781.39	8	9	6
	18	1866.26	8	9	8
	19	1545.27	7	9	4

drivers, 8 hours working duration per driver in average and a total of 801.05 miles in travel distance). Therefore, the authorities are given two options to choose either site 3 or site 9 as a landfill site. If the authorities faced limited resources, such as drivers, they could choose site 8, which would need only five drivers to serve 784 customers. However, the total travel distance of all drivers was 805.48 miles, indicating an increment by 4.43 miles (0.55%), when compared to sites 3 and 9.

Table 6 presents the resource requirements that would be required to serve 1048 customers based on two candidate sites. Based on the solution proposed by NG technique, both sites would need eighteen drivers to serve the customers, while the lowest total distance travelled by all drivers would have been 3048.53 miles (site 1). If site 2 were selected, the same

number of drivers would be required, but the total distance would escalate, as compared to site 1 (an increment by 1.73%). Average working hour per driver would be 7 hours.

The results depicted in Table 7 shows the resource requirements needed to serve 1347 customers based on three different landfill candidate sites. Based on the solution proposed by NG technique, site 3 appeared to be the most suitable site that gave the lowest total travel distance in serving all the customers. The average working hour per driver for site 3 would be 7 hours. However, all the candidate sites would require the same number of drivers, a total of 8.

Table 8 displays the resource requirements needed to serve 1596 customers based on two different candidate landfill sites. Based on the

Table 6: Computational results for dataset 1051 X

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
1051	<b>1</b>	<b>3048.53</b>	<b>18</b>	<b>7</b>	<b>1</b>
	2	3101.20	18	8	2

Table 7: Computational results for dataset 1351

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
1351	1	1290.81	8	8	2
	2	1382.95	8	8	3
	<b>3</b>	<b>1040.01</b>	<b>8</b>	<b>7</b>	<b>1</b>

Table 8: Computational results for dataset 1599

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
1599	1	3012.37	18	9	2
	<b>2</b>	<b>1847.19</b>	<b>15</b>	<b>10</b>	<b>1</b>

solution proposed by NG technique, if site 2 were selected, the waste management team would need to hire fifteen drivers to serve the customers and the total distance travelled by all drivers would have been 1847.19 miles. Average working hour per driver would be 10 hours for site 2. On the other hand, if site 1 were selected, more drivers and more coverage of distance (an increase of 63.08%) would be needed, when compared to site 2.

The computational results presented in Table 9 show the resource requirements needed to serve 1927 customers based on four different candidate landfill sites. Based on the solution proposed, site 4 provided the lowest distance in serving all the customers. However, the same number of drivers (sixteen) would serve all the customers for each candidate landfill site and the average working hour for each of driver is similar for all sites which is 13 hours.

Lastly, Table 10 demonstrates the resource requirements needed to serve 2092 customers based on seven different candidate landfill sites. Based on the solution proposed by NG technique, site 3 offered a better solution, as compared to the rest. If site 3 were selected, the waste management team would need to hire eighteen drivers to serve all the customers, the total distance travelled of all drivers would have been 2300.23 miles and 10 hours would be the average working hour of all drivers.

**Conclusion**

This paper has introduced a new approach to rank the candidate landfill sites based on resource requirements, such as the total distance travelled and the number of drivers needed. As such, the nearest greedy (NG) technique was used to evaluate both resources. The proposed approach

Table 9: Computational results for dataset 1932

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
1932	1	1431.17	16	13	3
	2	1384.60	16	13	2
	3	1431.89	16	13	4
	<b>4</b>	<b>1368.36</b>	<b>16</b>	<b>13</b>	<b>1</b>

Table 10: Computational results for dataset 2100

Dataset	Landfill ID	Total distance (miles)	Number of drivers	Average working hour per driver	Ranking based on total distance
2100	1	3258.36	20	10	4
	2	5203.36	25	9	7
	<b>3</b>	<b>2300.23</b>	<b>18</b>	<b>10</b>	<b>1</b>
	4	3687.20	21	10	6
	5	3502.47	21	10	5
	6	2949.76	19	10	2
	7	3005.00	19	10	3

was tested on a waste collection vehicle routing problem with time windows (VRPTW) dataset suggested by Kim *et al.* (2006). As a result, the computational findings showed that both resources (travel distance and drivers) greatly influenced the landfill site selection problem. If the number of customers who seek the service is higher, then more resources would need to be allocated. In the near future, the authors would like to consider a multiple landfill site selection in the attempt to devise more reliable solutions.

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## THE DIFFERENTIATION IN WORK ENRICHMENT STRATEGIES AND ORGANIZATIONAL CREATIVITY FUNCTION: A PERSPECTIVE FROM THE LEADERS OF THE MINISTRY OF OIL IN IRAQ

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**Abstract:** This study aimed to investigate the relationship between work enrichment strategies and the success of organisational innovation in the Ministry of Oil in Iraq. The study was conducted at the headquarters of the Iraqi Ministry of Oil in Baghdad and the units of analysis are the leadership of the ministry of directors of 215 people. Questionnaire method was used to collect the data in accordance with the scientific standards approved in previous studies. To verify the validity and the ability to examine the views of the sample, a series of tests were carried out. The Pearson's correlation with F value, R squared and beta ( $\beta$ ) were also used to test the hypothesis. The study revealed that there is a significant effect of the dimensions of enriching the work on organisational innovation. The model of the study showed that there is a correlation between the variables of the study. Meanwhile, the exclusion of the variables of the resources and creativity of the current results is the most powerful model. Therefore, it is advised to pay attention to these two variables in order to make a greater impact on the possibility of developing the innovative process based on the enrichment of labour.

Keywords: Work enrichment, workload requirements, organisational innovation.

### Introduction

Innovation and adoption of a course of action that depends entirely on innovative ideas must be considered if the organisations at different levels of size, productivity and the society that deals with it as an external environment want to continue their work and remain in the labour market and gain competitive advantage with sustainability (Yusoff *et al.*, 2016). This is in accordance with the increase in global competition. In order to pay attention to the importance of innovation for prosperity, it is the duty of the organisations to survive, develop and succeed. Therefore, one of the most important and most influential methods that organisation can use to reach the innovative climate and innovative employee is by enriching the work (Olszak *et al.*, 2018).

Enriching the work implies that making changes to the function of the dimensions of the routine and to ensure that the incumbent has the right and the time in an appropriate field to express

his ideas. This ultimately leads to innovation in production and provides a kind of independence through which the reactions of the customer are known or a person is received in a timely service. The study focuses on two variables from the report which includes five main dimensions: skill diversity, mission identification, mission importance, independence, feedback and the respondent variable (Zocche *et al.*, 2018).

The conceptual framework of this current study on the Iraqi Ministry of Oil is organisational innovation and its seven dimensions: encouragement and motivation, reciprocity, resource adequacy, freedom of action, work challenges, creativity and workload requirements. The most important justification for the application of this concept in this domain as in the Iraqi Ministry of Oil is because of the oil sector for a country like Iraq which depends almost entirely on this sector (Li *et al.*, 2018). For this model to be effective, it must rely on innovation, processes and production.

### **Job Enrichment**

Lyngdoh *et al.*, 2018 carried out a study on the effect of job enrichment schemes on selected construction workers in Nigeria. The aim of the study was to ascertain the impact of job enrichment schemes on workers in the construction industry in Nigeria in order to justify their continued use as catalysts. This study is designed to determine the relative performance of the job enrichment systems used by the selected construction companies in Lagos, Nigeria and the effects of the schemes on the employees of these companies. The targeted community has forty-two project sites and the unit of study was project managers and artisans. The questionnaire was used as a survey tool for data collection. The study concluded that high-performance work enrichment programme lead to increased decision-making, total quality management and training programmes (Castillo-Vergara *et al.*, 2018).

In other words, (Shang *et al.*, 2019) reported on the job enrichment and individual performance among colleges with special reference to a private university. The aim of the study is to determine the relationship between work enrichment and performance of the individuals. The factors of work enrichment (task importance, task identity & skill variety) on individual performance were explored with quantitative research in an educational institution. The probability of stratification of random samples is employed to collect data from colleges at the private university in order to estimate the relationship between the three factors towards individual performance. From the exploratory study, a pilot guide was provided to determine the second factor which contributes more to enhancing the performance of individuals in the educational organisation (Secundo *et al.*, 2019).

Furthermore, (Laguía *et al.*, 2019) studied how job enrichment can improve job satisfaction at Sokoine University of Agriculture in Tanzania. The aim of the study was to ascertain whether the work enrichment improves job satisfaction of academic staff at the University of Suqwen

Agriculture. Also, the study aimed to determine the existence of work enrichment practices for academic staff and explore the effects of enriching work on the employee's mental state among faculty members. The design of case study was adopted with a total sample size of 104 individuals which were selected using judgment sampling techniques. Data was collected through questionnaire, interview and document review. Quantitative data were analysed by the statistical package for social sciences (Guo *et al.*, 2018). The results showed that the functional enrichment exists among the academic staff and has a positive effect on the employees' ways of thinking about their jobs. Similarly, there is a link between the basic functional characteristics such as task diversity, task identity, task importance, independence of tasks which are elements of job enrichment and job satisfaction for workers (Awan *et al.*, 2019).

### **Organisational Creativity**

A study on creativity in smaller organisations conducted by Nayak, 2008 aimed to investigate how different levels of innovation may affect small organisations. This study focused on innovation in terms of levels and what factors affect it in small organisations. When designing the study, a qualitative approach was selected with a case study. Through multiple case studies, experimental data were collected. Three small organisations were investigated from the community of study (Schalock *et al.*, 2018). From the analysis, the study concludes that there is a relationship between regression in organisational structure and individual innovation. It is found also that the loss in the number of staff can be as a result of increased responsibility and more existing employees are self-producers (Lee *et al.*, 2017). In order to overcome constraints, the level of knowledge within the company is critical. If handled correctly, restrictions may also promote individual motivation. Close relationships contribute to a secure climate while it is easy to establish closer relationships in smaller organisations. It was also found that individual motivation among staff was linked to

the innovative work environment (Zhou, 2015; Yusoff *et al.*, 2016).

Moreover, the study was on the understanding of organisational creativity through relationships among cross-level variables and creativity in research and development organisations. The aim of the study was to examine the correlations between four variables (field experience, innovative personality, non-controlling supervision, and organisational learning culture) and to understand how innovation relates to each variable, as well as cross-level. This study focused on examination of the association of organisational innovation with innovative personality, experience in the field, non-controlling supervision and organisational learning culture and the correlations across levels in research and development of the organisations. The study concludes that experience in the field and uncontrolled supervision was found to be positively associated with innovation. The Ministry is has been commissioned tasked with major tasks, the most important of which is financing the rest of the sectors and trying to promote them, which have been given much attention in the oil sector as source of assistance (Joo *et al.*, 2016).

This research aimed to review the previous cognitive efforts and the scientific literature to increase the verification and clarification of the nature of these variables, this study focused on the concept of enriching the work and its contribution to the success of organisational innovation. Then, using the quantitative approach, this study verified this logical relationship between the two variables proved by those cognitive efforts. Additionally, this study is divided into related parts: the first part reviewed the previous cognitive efforts of the variables; the second part reviewed the scientific literature; and the third part highlighted the research methodology, the population of the study, the scale used and the statistical techniques.

## **Methodology**

The exploratory approach to the views of leaders and managers at the headquarters of the Iraqi Oil Ministry in Baghdad is the scientific method used in this study. The method is explored to know their views and make estimation based on the scale of the study. An analytical method is also used to interpret the data collected and then analysed by various statistical means after being proven of its credibility and reliability on the interpretation of the relations between the variables of the study to reach the final outcome. The final result reflects the effects on the field of research and on the interest of academics and researchers. The main hypothesis of the study is that “there is a significant correlation between the dimensions of work enrichment (measured by: skill diversity, task assignment, task importance, independence, feedback) and organisational innovation (measured by: encouragement, motivation, reciprocity, resource adequacy, workload requirements).

## **Data Collection**

The questionnaire includes a set of section pertaining to the personal, scientific and functional data of the sample. From the questionnaire, the third section was allocated to the main research variables (work enrichment) as an independent variable and its dimensions (skill diversity, task assignment, task importance, independence, feedback). The dimensions of organisational innovation, according to the ESBRA (2015), are encouragement, motivation, reciprocity, resource adequacy, freedom of action, work challenges, creativity and workload requirements.

## **Population of the Study and Research Sample**

The study was carried out at the headquarters of the Iraqi Ministry of Oil in Baghdad. The study was based on a community of ministry leaders who held positions of responsibility. The study was conducted on a sample of 215 officials who are among the general managers. The percentage of agents of general managers is 3.3% while that of managers’ assistants is 4%, managers made

up 55% and 25.6% was for public officials. The number of male is 152 which accounts for 70.7% while the remaining 29.3% is for female. This is a significant proportion. The Ministry's diversity was calculated. The percentage of the diploma certificate holders was 11.4% and that of the bachelor degree holders was 69.3%.

The percentage of holders of the higher diploma certificate was 3.3% and that of the master's degree was 10.2%. The percentage of the holders of the bachelor's degrees was higher than the rest of other qualifications and the percentage of higher degrees was fairly good. The age groups were divided by 5% of the category (under 25 years), 23.7% (31-35 age group), 15.3% only (36-40 age group), 15.8% (41-45 age group), 11.6% (46- 50 age group), 9.8% (51-55 age group) and 16.3% for 56 and above age group. The result of the proportion is also good and the calculation for the Ministry in that, most of the leaders are holders of a bachelor's degree and are within the young age group due to the decline of the last proportion. The experience is due to the system of public service and the age of retirement specified at the age of 63. Finally, the youth group is the largest within the sample.

## Results and Discussion

This part of the study shows the results of the statistical and quantitative analyses of the data collected by the survey tool from the research sample which are the leaders and directors of the Ministry of Oil headquarters. The results will be reviewed in the form of paragraphs. The first paragraph is devoted to describing and diagnosing research variables through statistical tools (weighted mean, standard deviation, coefficient of variance) and the relative importance of the paragraphs and distances. It covers the limits of the answers to the sample within the Likert scale. The second section is allocated to the tests of correlation between the main variables of the study and its dimensions using Pearson Correlation test. The last paragraph is assigned to test for  $p$  value. This analysis was carried out after confirming

the validity of the scale and statistics through several tests that confirm the distribution of the data. The researcher has the confidence to use the standards and reassurance of the results extracted due to the normal distribution and tests that confirm the stability of the scale.

### *Descriptive Statistics*

In this part of the study, the results of the description and diagnosis of the variables of the research will be discussed independently of the variables of work enrichment strategies and organisational innovation as follows:

### *Descriptive Statistics of Job Enrichment*

The dimensions and paragraphs of the independent variable (work enrichment) and the statistical tools used to analyse the results are shown in Table 1. From the statistical results, it is revealed that the independent variable obtained a mean of 3.53 which is higher than the arithmetic mean of 3 and a standard deviation of 0.99. Also, there are independent statistics for each of the five dimensions. A mean of 3.89 is obtained after determining the task which is higher than the arithmetic mean with a standard deviation of 0.88. This is a good result that indicates the sample agreement on accuracy of the result and the generalisation. The value of coefficient of variance of 0.21 gave it the first place among the five dimensions of relative importance.

The study found that all values exceeded the mean arithmetic mean when observing the computational and standard deviations of the paragraphs after determining the task which reflects the importance of the medium of the sample of these paragraphs. In order to achieve the ministry's interest, the result indicates constructive cooperation and communication in an easy way within the ministry. A mean of 3.26 was obtained after the significance of the task and a standard deviation of 1.01 reflects the sample agreement on the answer and a coefficient of variance of 0.26 as shown in Table 1. In the same way, this study found that the coefficient of variation is very close to the dimensions. The

Table 1: Description and diagnosis of subdivisions and paragraphs of job enrichment

Descriptive Statistics		Values	Coefficient variation	Std. Deviation	Mean
1	The Ministry provides a variety of work experiences	0.78	0.22	0.83	3.74
2	The Ministry provides training programmes to learn new skills and allows the use of many new technologies.	0.78	0.22	0.83	3.83
3	The Ministry grants various powers and the possibility of changing tasks	0.75	0.25	0.86	3.38
Total		0.77	0.23	0.84	3.65
4	Tasks are arranged regularly to provide good cooperation within the Ministry	0.77	0.23	0.84	3.72
5	There is good communication and communication between presidents and subordinates within the Ministry	0.77	0.23	0.90	3.83
6	Working in the Ministry is a good opportunity that gives me a sense of importance.	0.82	0.18	0.73	4.11
Total		0.79	0.21	0.82	3.89
7	The success of the Ministry's work depends on the individual performance of the tasks.	0.57	0.43	1.22	2.84
8	The function of the staff affects the organisational decisions in the Ministry.	0.73	0.27	0.92	3.44
9	The functions within the Ministry are intellectually stimulating and give a sense of accomplishment.	0.74	0.26	0.90	3.50
Total		0.69	0.31	1.01	3.26
10	The employee performs the duties independently and independently of the direct supervisor.	0.57	0.43	1.10	2.56
11	Staff have the freedom to choose the way they see fit.	0.64	0.36	1.07	3.00
12	Direct officials give subordinates the freedom to arrange work.	0.71	0.29	1.02	3.48
13	The functions of the Ministry include a great deal of responsibility	0.83	0.17	0.70	4.09
Total		0.70	0.30	0.97	3.28
14	The Ministry attaches great importance to feedback	0.75	0.25	0.87	3.55
15	Employees receive information about performance directly from work.	0.24	0.76	2.81	3.71
16	The Ministry is always working to obtain regular updates on job performance.	0.77	0.23	0.83	3.56
17	Leaders within the ministry recognize the satisfaction of the supervisor while doing the work.	0.78	0.22	0.77	3.51
Total		0.63	0.37	1.32	3.58
Independent dimension results		0.72	0.28	0.99	3.53

fourth analysis is on the relative importance. The arithmetic mean reflects the importance of this dimension in the research sample. They are very much in agreement with the importance of the jobs they perform and their impact on the work of the other employees.

In the case of diversity of skills, the study seeks to examine and measure the diversity of skills among workers. This dimension obtained a weighted mean of 3.65 which indicates a good mean and a standard deviation of 0.82 which reflects the agreement of the sample on this answer and the value of the coefficient of variance of 0.21 gave this dimension to be ranked second relative importance. These results reflect a good agreement among the leaders of the research sample on the importance of skill diversity among subordinates. The fourth dimension which is the independence reflects the extent of the possibility of workers to complete their work freely and independently of the direct charge. This dimension obtained a weighted mean of 3.28, which is higher than the arithmetic mean and a good standard deviation of 0.97 reflects a large agreement in the sample.

The coefficient of variance of the dimension is 0.30 which made this dimension in the fourth ranking between the dimensions of enrichment work. The result reflects the good situation among the leaders of the targeted population in dealing with subordinates as individuals and not just members of the group. It also helped them to develop their strengths through the allocation of time to train them and teach them while each person has the capabilities and aspirations which are different from other colleagues. Regarding

the fifth dimension, the feedback reflects the extent to which the employees' reactions and expectations were obtained. This dimension has a weighted mean of 3.58, which is higher than the arithmetic mean and has a standard deviation of 1.32. The result indicates a large agreement in the sample for the dimension with value 0.37. The Table 1 shows the statistics for all paragraphs on the enrichment of the work.

### *Descriptive Statistics of Organisational Creativity*

The descriptive statistics of the variable, organisational creativity is presented in Table 2. This variable obtained a weighted mean of 3.64 which is higher than the arithmetic mean and with a standard deviation of 0.86. The result reflects the severity of the sample responses on this variable. The variable is measured with 30 items which were distributed to seven main dimensions. The first dimension was encouragement and motivation with a weighted mean of 3.65 and a standard deviation of 0.89 and a coefficient of variance of 0.25. It gives this dimension a fourth relative importance between the dimensions. The result indicates that there is a good response in the sample of the research on this dimension and there exists the importance of leaders to pursue the achievement of the goals. The post-reciprocity has reached the weighted mean of 3.81 as shown in the Table 2 and a good standard deviation of 0.81 and the coefficient of variance of 0.21. This gave a second order ranking for this paragraph, reflecting the existence of challenges in work and sample agreement.

Table 2: Description and diagnosis of subdivisions and paragraphs of organisational creativity

	<b>Descriptive Statistics</b>	<b>Values</b>	<b>Coefficient variation</b>	<b>S.D</b>	<b>Mean</b>
1	The active flow of ideas is encouraged. The good employee is known through their innovation contributions	0.77	0.23	0.87	3.81
2	Failure is permitted if the employee does his best	0.70	0.30	1.02	3.35
3	Senior management appreciates creative ideas and recognises innovative works.	0.75	0.25	0.92	3.67
4	There is a great deal of exchange of ideas being done daily because the tasks of action stimulate this exchange	0.76	0.24	0.86	3.63
5	Staff participate in discussions on any new work or design. There is encouragement for continuous professional development through learning.	0.79	0.21	0.81	3.78
	<b>Total</b>	<b>0.75</b>	<b>0.25</b>	<b>0.89</b>	<b>3.65</b>
6	Team members support each other at work and in the face of work and crisis problems.	0.80	0.20	0.78	3.90
7	Staff challenge each other's ideas constructively.	0.76	0.24	0.84	3.51
8	There is a great commitment to work within the Ministry	0.80	0.20	0.79	3.89
9	Interpersonal work is coordinated in our department's task force with members of other sections of the Ministry.	0.80	0.20	0.78	3.94
10	The team complements the work already begun by others in the Ministry.	0.78	0.22	0.86	3.82
	<b>Total</b>	<b>0.79</b>	<b>0.21</b>	<b>0.81</b>	<b>3.81</b>
11	There are sufficient resources within the organisation and suitable for project completion	0.73	0.27	0.92	3.45
12	Project budgets are generally adequate.	0.70	0.30	0.91	3.07
13	The information collected in project research makes projects more creative.	0.76	0.24	0.83	3.44
	<b>Total</b>	<b>0.73</b>	<b>0.27</b>	<b>0.89</b>	<b>3.32</b>
14	Staff shall determine the appropriate methods and procedures for the completion of their work.	0.71	0.29	1.01	3.43
15	Management determines how staff will perform work tasks and how best to implement them	0.81	0.19	0.75	3.84
16	Employees enjoy planning their own business freely.	0.74	0.26	0.93	3.53
	<b>Total</b>	<b>0.75</b>	<b>0.25</b>	<b>0.89</b>	<b>3.60</b>
17	Daily tasks are a challenge for the Ministry and the staff to the importance of these tasks	0.81	0.19	0.72	3.87
18	Staff is challenging the projects currently in the Ministry.	0.77	0.23	0.80	3.55
19	Working in this Ministry is important and meaningful to employees.	0.85	0.15	0.63	4.16

20	The Ministry confirms the completion of things in the way they were always done.	0.78	0.22	0.83	3.72
21	There is intense competition within the Ministry to prove existence and efficiency	0.78	0.22	0.84	3.85
<b>Total</b>		0.80	0.20	0.76	3.83
22	The functions of the Ministry require innovative employees because we produce innovative projects.	0.79	0.21	0.86	3.99
23	At the Ministry of Oil employees are encouraged to take the risk of being innovative	0.75	0.25	0.88	3.53
24	Many businesses within the Ministry require individual innovation.	0.75	0.25	0.89	3.59
25	There is a dispersion in the daily work of the employee that prevents innovation	0.73	0.27	0.91	3.39
26	Operational procedures and structures facilitate innovative processes	0.72	0.28	0.95	3.42
<b>Total</b>		0.75	0.25	0.90	3.58
27	Employees have time to do their work	0.80	0.20	0.79	3.95
28	Team members leave work as if they have not completed everything that can be done.	0.80	0.20	0.75	3.76
29	Stress does not affect the prioritization of tasks	0.69	0.31	1.04	3.40
30	People in this ministry have sufficient time to implement best practices when they do their work.	0.76	0.24	0.88	3.63
<b>Total</b>		0.76	0.24	0.87	3.68
	<b>Variable results</b>	0.76	0.24	0.86	3.64

The third dimension is the adequacy of the resources. The weighted mean was 3.32 and the value of the standard deviation is 0.89 and the coefficient of variance was 0.27. This result shows that this dimension in terms of the importance is the last dimension among the dimensions of this variable. The freedom of work is the third dimension with weighted mean of 3.60 and a standard deviation of 0.89 and the coefficient of variance of 0.25. This gave it a relative importance in the fifth degree between the dimensions of this variable, which in turn reflects the interaction of the sample of the research.

The fifth dimension is the challenges of work which have weighted median value of 3.83. This good mathematical mean shows the sample agreement on the above paragraphs and standard deviations of 0.76 while the coefficient of variance of 0.20. This result gave this dimension the first place among other dimensions and it confirms the agreement of the sample by trying to emphasise things agreed upon in enriching the

work rather than the things that differ from them. For the sixth dimension, creativity, it obtained a balanced of 3.58 and a standard deviation of 0.90 and a coefficient of variance 0.25. This gives this dimension the position of sixth among other dimensions. Similarly, a weighted mean of 3.68 and a standard deviation of 0.87 and a coefficient of variance of 0.24 are realized for the seventh dimension of the workload requirements. This gives the dimension the seventh rank among other dimensions.

### **Correlation Analysis**

The study must test the correlations between the independent variable and the variant of Pearson Correlation before entering into the hypothesis test as shown in Table 3. Thus, there is a significant and positive correlation between the leadership of enrichment work and organisational innovation. The value of correlation is 0.732 \*\* with a significant level of 0.01. It indicates very large approaching (+1) and the value of Significance of 0.000 which



Table (3) the correlation matrix between the variables of the study

Correlations	Work Challenges						Organisational creativity
	Encouragement and Motivation	Transaction	Adequate Resources	Freedom of work	Innovation	Workload requirements	
Skill variety	Pearson Correlation	0.461**	0.320**	0.342**	0.312**	0.387**	0.351**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	215	215	215	215	215	215
Task identity	Pearson Correlation	0.532**	0.245**	0.348**	0.373**	0.455**	0.295**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	215	215	215	215	215	215
Task significance	Pearson Correlation	0.341**	0.286**	0.355**	0.322**	0.422**	0.163*
	Sig. (2-tailed)	0	0	0	0	0	0.017
	N	215	215	215	215	215	215
Autonomy	Pearson Correlation	0.367**	0.303**	0.510**	0.406**	0.330**	0.280**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	215	215	215	215	215	215
Feedback	Pearson Correlation	0.647**	0.411**	0.476**	0.432**	0.490**	0.344**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	215	215	215	215	215	215
Job Enrichment	Pearson Correlation	0.646**	0.411**	0.557**	0.506**	0.554**	0.395**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	215	215	215	215	215	215

means that the calculated value of  $t$  is greater than the scale.

The study found that all these correlations are positive at a significant level of 0.01 when reviewing the correlation values of the five work spans with the variable, organisational innovation. All the significant levels are less than 0.05; thus, the calculated  $t$  values are greater than the scale of the work's richness and its dimensions with the organisational innovation. Therefore, the study proceeds to the second step in testing for the hypothesis.

### Conclusion

It is clear that organisational innovation is one of the best ways to obtain competitive advantage and stay in the labour market. Similarly, it helps to focus on enriching work as a measure to improve the quality of work and eliminate boredom where an excessive routine has become a necessity to achieve the greatest impact on subordinates. For the purpose of achieving the objectives of this study, the empirical results reveal that there is a great interest in the sample of the research under the research variables. The main hypothesis is confirmed and the initial impressions obtained by the researchers from the preliminary interviews revealed the existence of the problem. Also, the current model emphasised the existence of the correlation between the variables of research. Nevertheless, the exclusion of the variables of resource adequacy and creativity from the current results makes it a powerful model. Finally, these two models should be focused on by the research sample and attention should be paid to them.

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## **IMPLEMENTATION OF ENTREPRENEURSHIP, BUYING AND SELLING ACTIVITIES IN MATHEMATICS LEARNING TO PROMOTE STUDENTS INTERACTION AND METACOGNITIVE REGULATION SKILLS**

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**Abstract:** Metacognitive regulation skills and interaction are interrelated elements in mathematics learning to enhance the engagement and focus of the students. Interactions will affect the development of metacognitive regulation skills. Metacognitive regulation skills will ensure students' mathematics problem solving is well managed to provide an accurate solution. One of the factors contributing to weak mastery of mathematics among students is learning activities do not ensure optimal interaction. Therefore, initiatives need to be implemented to address the problems. So, the present study will propose, summarise and discuss the implementation of entrepreneurship, buying and selling as an activity that can encourage students to interact and develop as well as to train their metacognitive regulation skills. Articles around 2009 and up to date have been explored based on approaches, methods, techniques, and practices of entrepreneurship learning strategies implemented. A total of 8 articles were selected through a search of databases such as Google Scholar, Researchgate, ERIC, SpringerLink, Elsevier and more. Systematic reviews and discussions through previous research show that the effectiveness of the implementation of buying and selling activities in mathematics learning is creating interaction and leading to increased student metacognitive regulation skills.

Keywords: Metacognitive regulation, interaction, entrepreneurship, buying selling, mathematical learning.

### **Introduction**

Mathematics learning is a process for changing the coordination of thought, which is to explain something abstract and to link numbers, symbols, shapes, patterns and so on to form a real concept. Chris (2015) stated that mathematical learning is not only focused on telling but also requires strengthening to enhance individual intellectual credibility. Therefore, the teacher needs to change the learning approach from conventional methods as a presenter to learning agents who are seen to be more widespread for providers, drivers, facilitators and coordinators to learn. Learning materials are not entirely on the teacher, but students are also learning resources for other students (Pokhrel, 2018). This learning transformation requires teachers to manage to learn more effectively. Students should also become managers of self-study more systematically and efficiently.

To improve learning management efficiency, metacognitive regulation is a positive indicator that will ensure students become active during the learning process. Metacognitive regulation is a component of metacognition that is according to Schraw and Moshman (1995) the ability of the individual to regulate their cognition by controlling, monitoring and acting systematically. Subcomponents in metacognitive regulation are constructs that demonstrate the process of new knowledge development (Schraw & Moshman, 1995; Hasbullah, 2015). Through planning constructs, students will set learning goals, set up the way how to achieve the goals and know the previous knowledge to be used (Moos & Ringdal, 2012). Construct monitoring will ensure that students are always aware of the level of understanding, strategies used, reducing mistakes, confirming the knowledge to be developed is the right concept (Stephanou & Mpiontini, 2017).

Moreover, the evaluation construct will help students build confidence with new knowledge, test the effectiveness of the strategies used and evaluate the strength of knowledge (Schraw & Moshman, 1995). Cognitive management skills are seen as meaningful in individual learning so that mathematics learning is closer to the ability of cognitive and metacognitive setup and their coordination (Su *et al.*, 2016).

Accordingly, mathematics learning should be a focus on the development of metacognitive regulation to enhance student performance. A low level of student mastery in mathematical concepts is not a new issue, but it still cannot be solved although it has been done in various ways. Most factors are learning activities conducted in the classroom (Willis, 2010). Therefore, the researcher proposes a learning activity to ensure mathematics learning is more fun and can develop metacognitive regulation skills in line with the desire to improve student achievement. In this regard, to strengthen cognitive development, learning must be conducted as a cognitive activity, which is a mind-challenging activity to ensure students' metacognition fully in function (Du Toit & Kotze, 2009).

Besides that, to achieve the purpose of learning activities that can develop metacognitive regulation is through interactive activities. Active involvement and effective interaction should be examined in selecting the activity. This is because according to Smith & Mancy (2018), during actual learning student interaction will lead to metacognitive discussion. Metacognitive elements will be the main focus when interacting with a peer during learning. Hence, there is a need for further studies that examine learning activities that can encourage students to metacognitive regulation skills and interactions. When the interaction is well-executed, it will produce effective learning. Dagarin (2005) and Jose (2016) stated that interactions can occur between students with teachers, students with students, students with materials and can also be between students with themselves. Specifically, student interaction with self is individual in nature leading to

the formation of self-regulation and this will encourage the learning process. According to Schraw and Moshman (1995), if the situation was forced to act in designing, monitoring and evaluating learning, then the metacognitive regulation development had improved. In the context of the success of mathematical learning, the interaction will ensure that students can express ideas using numbers, symbols, diagrams and so on in all forms of oral, written or visual (Mary, 2017; NCTM, 2000).

In this context, the researcher proposes a learning activity that can ensure optimum interaction that involves the implementation of entrepreneurial activities in buying and selling. Studies conducted by Palmer and Johansson (2018), Shanklin & Ehlen (2017), Noor Izzuddin *et al.*, (2014), Ishak *et al.*, (2018), Rayung and Ambatong (2018), Almahry *et al.*, (2018) and Rahmawati (2017) have shown that buying and selling activities can increase focus, active involvement and ability to master the contents of the lesson. According to Palmer and Johansson (2018), entrepreneurship competence will create mathematical competencies leading to thinking skills. Therefore, buying and selling can be a platform to ensure interaction. According to Mantell *et al.*, (2002) and Goh (2010), buying and selling activity is favourable to children and it is a cognitive need and the ability to coordinate problem-solving among children when selling and buying is made into a learning game. Buying and selling is the basic experience that all individuals have. Poh (2000) said that, according to contextual theory, learning will be easier than the experience and knowledge framework that exists in the minds of individuals. In this regard, Schraw and Moshman (1995) and, Nelson and Narens (1990) argued that each individual has the metacognitive experience that will be the basis for constructing a piece of new knowledge. This metacognitive experience will be easier to regulate when there is positive motivation through effective interaction.

### Conceptual Framework of Entrepreneurship, Buying and Selling Activities (EBSA)

The study was aimed at discussing the effectiveness of learning activities through the implementation of entrepreneurship, buying and selling activities (EBSA). Based on the Constructivist Theory, Vygotsky's Social Development Theory and Metacognitive Theory, a learning activity, students' interaction, and metacognitive regulation skills that will be constructed are seen to influence students' learning and their mastery. From constructivism beliefs, learning is one of the processes that students modified their previous skills, experience, and knowledge in order to construct and understand the new concept. Interactions, mediations, and scaffolding become the important elements in Vygotsky's Theory as a social connector to develop the potential and ability of the student in learning. Besides, Metacognitive Theory proposed metacognitive learning strategies to optimise the awareness, regulation, and experience of students in

cognitive aspects during the learning process. A conceptual framework was developed to see the relationship between the EBSA as a learning activity, students' interaction and metacognitive regulation skills that will be the variables in this study. According to Sethughes (2013), the basis of buying and selling must include the aspects of place, product, price, and promotion. Next, Rahmawati (2017) explained the five components in the buying and selling game based on marketing activities as i) the role of the student as either the seller or the buyer, ii) the game instructions or the way of how to operate, iii) the product, iv) the process of trading activities and v) discussions. Therefore, the review summarises the construct as a phase in trading activity.

According to Vygotsky's Theory, learning will occur when there is an interaction between students (McLeod, 2018). When interacting, students will develop the individual potential to enhance understanding of the lesson's contents. Through this activity, the students, especially

Table 1: Implementation of trading activity phases and relating it o the learning dimensions

Phases	Implementation of entrepreneurship, buying and selling activities (EBSA)	Learning Dimensions
<u>Place</u> -Buyer and seller -Instructions	i. Buying and selling goals ii. Determining of roles of buyer or seller iii. Organising/conducting the activity or instruction	i. Learning objectives ii. Students' role in learning iii. Rules or learning activities are conducted
<u>Product</u> -Preparing the product -preparing the presentation needs	i. Sale product ii. Buyers' needs	i. Learning matters or resources ii. Presentation materials iii. Mathematics problem-solving strategies
<u>Price</u> -Set the price	i. Sale price	i. Learning motivation ii. Question levels/tasks
<u>Promotion</u> -Trading activities	i. Buying and selling process	i. Discussion/presentation ii. Interaction

Source: Sethughes (2013) and Rahmawati (2017)

in the process of selling and buying products, will apply the concept of Zone of Proximal Development (ZPD) and More Knowledgeable Other (MKO). There will be a mentoring, tutoring and guiding process. Therefore, buying and selling are scaffolds for interactions and this is in line with the concept of scaffolding based on Vygotsky’s Theory (McLeod, 2018). According to the Constructivist Theory, the actual learning experience will ensure that students learn. This is because minds-on and hands-on appreciation will occur and contribute to meaningful learning (Nik Pa, 1999; Poh, 2000).

Through the four phases in trading activities, students will develop metacognitive regulation skills. For example in a place phase, students will plan learning requirements in the role played by either the seller or the buyer. During the course of the product phase, price and promotion will increase students’ ability to monitor and evaluate learning through interaction with other students during activities. Students will check the level of understanding and evaluate the learning strategies implemented. This illustrates the role of metacognitive regulation skills in driving learning (Schraw & Moshman, 1995; Du Toit & Kotze, 1999). At the same time it improves the thinking skills and mathematics problem-solving skills.

Metacognitive Theory illustrates how restructured knowledge is got through metacognitive relationships and self-regulated processes (Schraw & Moshman,

1995). Metacognitive experts have explained how metacognitive components consist of metacognitive knowledge and metacognitive regulation action affecting individuals as well as learning actions in order to master the subject matter (Menz & Cindy Xin, 2016; Pantiwati & Husamah, 2017). In the process of the students are made aware of their abilities and effectively manage the metacognitive aspect of learning that can increase mastery (Cera *et al.*, 2013). An active learning environment that optimises interaction will create learning scenarios through metacognitive development and increase self-determination and self-belief of students. The combined results of Constructivist, Vygotsky’s and Metacognitive theories will contribute to the achievement of learning objectives and student performance.

**Methodology**

The purpose of this present study is to examine the implementation of entrepreneurship, buying and selling activities in mathematics learning which can influence the students’ interaction and metacognitive regulation skills that will enhance student engagement, performance, and achievement. Hence, the research questions are being developed to achieve the objectives of this review. The research questions are i.e. how do EBSA in mathematics learning create student’s interaction and develop metacognitive regulation skills? What is the impact of EBSA on student mathematics learning?

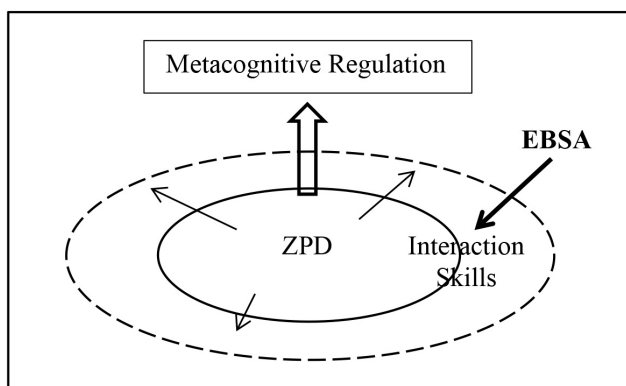


Figure 1: The Conceptual of Mathematics Learning of EBSA

Furthermore, searching for articles and journals that lead to applications of entrepreneurship education and learning, buying and selling activities, student interactions, metacognition regulation or a combination of these keywords is initiated through databases such as Google Scholar, Researchgate, ERIC, SpringerLink, Elsevier, and some other databases. Journals or articles related to the area of study are selected by first looking at the abstract and if related, the journal contents are viewed more specifically. Literature,

data, findings, results, and discussion will be fully referred to. The searching process is the implementation of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) proposed by Moher et al (2009). Eight articles were selected after going through the steps of *Identification, Screening, Eligibility* and *Included*. The following table shows the implementation of entrepreneurial skills, buying and selling activities conducted by some researchers in the context of learning.

Table 2: Analysis of Implementation of Buying, Selling and Entrepreneurship Activities in Learning

Author(s)	Research Objective(s)	Learning aspects discussed through activities	Impact on the students
Hanna Palmer & Maria Johansson (2018)  Combining Entrepreneurship and Mathematics In Primary School-What Happens? <i>Journal Education Inquiry</i> , 9(4)	To explore what happens when entrepreneurship is integrated into mathematics lessons	<ul style="list-style-type: none"> <li>i. Discuss the potential of combining the teaching of entrepreneurial and mathematical competencies in schools</li> <li>ii. Implement the entrepreneurship principles to solve mathematics problems in learning i.e creativity, ability to take responsibility, having courage, and ability to take initiative</li> </ul>	<ul style="list-style-type: none"> <li>i. Increase mathematical competencies</li> <li>ii. Train the strategies of problem solving</li> <li>iii. Increase critical thinking</li> </ul>
Eka Rahmawati (2017)  The influence of buying-selling Equipment on Learning Math Results About Money Class I in Basic School (Experimental Research in The Low Class). <i>Published Version Thesis Online. Universitas Negeri Jakarta.</i>	To determine the difference of mathematics learning outcome of money between students who follow the learning with the activities of buying and selling games and students who follow the learning conventionally	<ul style="list-style-type: none"> <li>i. Implement of buying and selling activities during mathematics learning</li> <li>ii. Create the principle of buying and selling activity i.e targets, student role plays, product, buying and selling process, discussion setting</li> </ul>	<ul style="list-style-type: none"> <li>i. Impact on the students' performance</li> <li>ii. Increase students' problem-solving skills</li> </ul>



<p>Fatima Fouad Almahry, Adel M. Sarea &amp; Allam M. Hamdan (2018)</p> <p>A Review Paper on Entrepreneurship Education and Entrepreneurs' Skills. <i>Journal of Entrepreneurship Education</i>, 21(25).</p>	<p>To demonstrate the theoretical relationship between Entrepreneurship Education (EE) and Entrepreneurs' Skills (ES)</p>	<p>i. Review of the skills and how the skills correlated</p> <p>ii. Discuss the impacts of the level of several skills of entrepreneurs which are technical skills, business management skills and personal entrepreneurial skills to the formal educational setting</p>	<p>i. An exercise in decision making and setting goals</p>
<p>Khar Kheng Yeoh (2017).</p> <p>Entrepreneurship Students Distilled Their Learning Experience Through Reflective Learning Log. <i>Journal of Research in Innovative Teaching &amp; Learning</i>, 10(2), 126-142</p>	<p>To analyse written reflections through learning log among students</p>	<p>i. Discuss how writing the reflection affects the learning experience</p> <p>ii. The result showed the treatment group did better in critical thinking and a higher level of reasoning ability than the control group.</p> <p>iii. The impact of reflection on learning performance and self-management</p>	<p>i. Increase critical thinking</p> <p>ii. Impact on the reasoning ability</p>
<p>Mario Franco &amp; Heiko Haase (2009)</p> <p>Entrepreneurship: An Organisational Learning Approach. <i>Journal of Small Business and Enterprise Development</i>, 16(4), 628-641</p>	<p>i. To shed new light on the interface between learning and entrepreneurship.</p> <p>ii. To show how entrepreneurship can be studied as a never-ending, dynamic learning process.</p>	<p>i. Describe learning as a crucial factor in entrepreneurial activity.</p> <p>ii. Discuss a new definition of the entrepreneur (entrepreneur as a learner) and a conceptual model of entrepreneurial learning theory is synthesised.</p> <p>iii. Setting goal, act to the goal, management, and ability to evaluate the strategies</p>	<p>i. To practice the skills</p> <p>ii. Increase students reasoning and critical thinking</p>
<p>Sanchez-Garcia &amp; Jose Carlos (2011)</p> <p>University Training for Entrepreneurial Competencies: Its Impact on Intention of Venture Creation <i>International Entrepreneurship and Management Journal</i>, 7(2), 239-254.</p>	<p>To test the effect of entrepreneurship education programmes on the entrepreneurial competencies</p>	<p>i. Discuss the impact of entrepreneurship activities on students' learning</p> <p>ii. Responsibility for the learning process</p>	<p>i. Increase entrepreneurial competencies</p> <p>ii. Impact on the intention of students</p>

<p>Martha Christianti, Nur Cholimah, &amp; Bambang Suprayitno (2015)</p> <p>Development of Entrepreneurship Learning Model for Early Childhood. <i>Asia Pacific Journal of Multidisciplinary Research</i>, 3(3)</p>	<p>i. To explore how learning entrepreneurship was done in early childhood</p> <p>ii. To know whether parents, teachers, and principals support entrepreneurship learning</p> <p>iii. To identify what kind of values of entrepreneurship can be developed for early childhood</p>	<p>i. Applied entrepreneurship learning model and studied the effectiveness of</p> <p>ii. Activities ensure that students are controlling their own destiny, maximising self-potential, planning orientation, increasing continuously quality work, and having the willingness to grab opportunities</p> <p>iii. During activities, students have strategic time management and become innovative</p>	<p>i. Develop self-confidence</p> <p>ii. Become creative and innovative</p>
<p>Mohd Nasir Rayong &amp; Abdul Said Ambotang (2016)</p> <p>Relationship Between Entrepreneurship Skill, Management Skill and Life-Long Learning Towards Critical Thinking Skill Among Form 6 Students <i>Jurnal Kinabalu</i>.</p>	<p>To determine the direct and indirect relationship of the factors of imagination, self-motivation and the imagination capability towards thinking skills among Form Six students</p>	<p>i. Discuss the influence of entrepreneurship skill on the students thinking skill</p> <p>ii. Awareness of the learning process</p> <p>iii. Choose the right strategies to solve the problem</p>	<p>i. Practice critical thinking</p> <p>ii. Develop thinking and management skills</p> <p>iii. Impact on the student s' self-determination and self-management</p>

It can be concluded that in the course of conducting EBSA activities, the skills in managing the sale and entrepreneurship will be practiced. Based on the above, the summary of the skills are:

- i. Character and perspective skills, based on the roles and responsibilities of either the seller or buyer
- ii. Planning and placing goals skills, involving requirements, needs, time and strategy
- iii. Managing trading activities skills, involving the selection of appropriate strategies and ways of action to achieve the goals

- iv. Contingency and initiative skills which involve creativity and flexibility to ensure accuracy and quality
- v. Collaborative skills which involve interaction ability, clarity of presentation
- vi. Reflection skills involve the assessment of the entire process and the findings

The application of these skills will lead to increased thinking and problem-solving skills. In the context of learning, the skills are the basis of self-regulation and are seen as inclined to the development of metacognitive regulation skills. The next analysis table will explain the metacognitive regulation skills in learning.

Table 3: Analysis of Components of Metacognitive Regulation and Related to the Students' Skills

Metacognitive Regulation Components	Student's Skills	References
Planning	<ul style="list-style-type: none"> <li>i. Study how to learn about topics, laying goals</li> <li>ii. Know the source of information</li> <li>iii. Set some of the strategies that can be used</li> <li>iv. Selecting appropriate and accurate strategies</li> <li>v. Design the assignment/task and the time required for the assignment/task</li> </ul>	Schraw & Moshman (1995), Smith (2013), Cera <i>et al.</i> , (2013), Tony Karnain <i>et al.</i> , (2014), Amin & Sukestiyarno (2015), Du Toit & Du Toit (2013) Menz & Cindy Xin (2016), Ackerman & Leiser (2014)
Monitoring	<ul style="list-style-type: none"> <li>i. Manage time to understand the information</li> <li>ii. Take time to implement strategies</li> <li>iii. Perform selected strategies/ operations</li> <li>iv. Focus on the more important thing, what needs to be done first</li> <li>v. Implement an alternative way if the previous way is ineffective</li> <li>vi. Track on relevant matters which are important to remember</li> </ul>	Smith & Mancy (2018) Amin & Sukestiyarno (2015), Adnan & Arsad Bahri (2018), Hasbullah (2015), Du Toit & Du Toit (2013)
Evaluation	<ul style="list-style-type: none"> <li>i. Reflection of objective achievement</li> <li>ii. Evaluate the level of accuracy of the assignment/task</li> <li>iii. Evaluate the level of achievement / how to answer the question is better than before</li> <li>iv. Make sure new knowledge is in line with the original knowledge</li> </ul>	Schraw & Moshman (1995), Amin & Sukestiyarno (2015), Du Toit & Du Toit (2013), Tony Karnain <i>et al.</i> , (2014), Hasbullah (2015), Suriyon <i>et al.</i> , (2013)

The metacognitive regulation component i.e planning, monitoring, and evaluation will be indicators in the learning process. This regulation will influence the work and action of the students in their learning that will affect mastery.

## Results and Discussion

The focus of this review is to answer the question of how entrepreneurial activity can conceptually

develop metacognitive regulation skills of students in solving mathematics problems and ultimately master the mathematics concepts. Then it discussed the impact of an activity on the students and the learning of mathematics. In order to gain a link between entrepreneurial skills and buying and selling activities with metacognitive regulation skills, the researcher provides Table 4, the correlations and a summary of Table 2 and Table 3.

Table 4: A meta-analysis of the relationship between entrepreneurial skills and metacognitive regulation skills

<b>Entrepreneurial Skills (EBSA's Phases)</b>	<b>Descriptions</b>	<b>Relevance to Metacognitive Regulation Skills</b>	<b>Impact on the students</b>
Character and perspective skills	i. Responsibility to the characters either seller or buyer	<u>Planning</u> - plan, adhere to learning and goals	Develop self-determination, confidence
	ii. Mind setting according to the perspective of salesperson or customer		Self-belief
	iii. Know what to do		
Planning and placing goals skills	i. Always review the requirements and needs	<u>Planning</u>	Develop critical thinking
	ii. Plan time, cost and material	- Discover the aims, goals - Manage action	Reasoning
	iii. Target and goals to be achieved	- Manage time	Quickly choose a solutions strategy
	iv. Manage available opportunities with skill		
Managing trading activities skills	i. Know when and where according to needs	<u>Planning</u> - Define strategy - Predict what will happen	Increase communication skill
	ii. High communication skills		The problem-solving exercises
	iii. Can predict risk	<u>Monitoring</u> - Set the time - Manage time - Use application strategy	increase problem-solving skill
	iv. Monitor the current level of achievement	<u>Evaluating</u> - Assess current achievement	

Contingency and initiatives skills	<ul style="list-style-type: none"> <li>i. Be wise to take an alternative if something goes wrong</li> <li>ii. Be aware of changes</li> <li>iii. Avoid risk</li> </ul>	<p><u>Monitoring</u></p> <ul style="list-style-type: none"> <li>- Implement appropriate strategies</li> <li>- Do different mistakes</li> <li>- Reduce the error</li> <li>- Monitor achievements</li> </ul> <p><u>Evaluating</u></p> <ul style="list-style-type: none"> <li>- Assess the suitability of the strategy</li> <li>- Evaluate the achievement level</li> </ul>	<p>Creative and innovative</p> <p>Critical thinking</p> <p>Apply various solutions strategies</p>
Collaborative skills	<ul style="list-style-type: none"> <li>i. Interaction adapted</li> <li>ii. Delivery clear and with appeal</li> </ul>	<p><u>Planning</u></p> <ul style="list-style-type: none"> <li>- Set the goals</li> </ul> <p><u>Monitoring</u></p> <ul style="list-style-type: none"> <li>- Always discuss with certainty</li> </ul> <p><u>Evaluating</u></p> <ul style="list-style-type: none"> <li>- Assess accuracy</li> <li>- Discuss results</li> </ul>	<p>Effect on the student's interaction</p> <p>Discussion</p> <p>Sharing</p>
Reflection skills	<ul style="list-style-type: none"> <li>i. Always evaluate the requirements and needs</li> <li>ii. Make a result assessment</li> </ul>	<p><u>Monitoring</u></p> <ul style="list-style-type: none"> <li>- Keep the strategy exactly with the situation</li> </ul> <p><u>Evaluating</u></p> <ul style="list-style-type: none"> <li>- Do self-reflection</li> <li>- Review the findings</li> </ul>	<p>Reflection learning</p> <p>Self-reflection</p>
Place	<p>Environment, customer, purpose, the goal inactivity, role inactivity</p> <p>Activity instruction</p>	<p><u>Planning</u></p> <ul style="list-style-type: none"> <li>- Set goal</li> <li>- Know the purpose</li> </ul>	<p>Choose the best strategies</p> <p>Plan learning</p>
Product	<p>Material for presentation, sale, Product presentation</p>	<p><u>Planning</u></p> <ul style="list-style-type: none"> <li>- Define strategy</li> <li>- Know the source</li> <li>- Determine time</li> </ul> <p><u>Monitoring</u></p> <ul style="list-style-type: none"> <li>- Implement appropriate strategies</li> <li>- Ensure accuracy</li> </ul>	<p>Creative</p> <p>Excitement</p>

Price	Price adjustment, level, level according to purpose and requirement	<u>Planning</u> - Know the destination - Manage action	Focus on the learning goal Knowing information and learning matters
Promotion	The process of attracting interest, discussing, explaining, arguing	<u>Planning</u> - Set the goals and objectives of the activity  <u>Monitoring</u> - Execute the right strategy - Test the strategy - Debug the mistakes - Discuss results  <u>Evaluating</u> - Self-reflection - Understanding evaluated	Excitement  Engagement Retention by students  Increased problem-solving skills  Peer teaching

Mantell *et al.*, (2002) stated that buying and selling is a person's cognitive need and is the most basic learning of recognising numbers. Individual cognition can be developed in line with the buying and selling activities. During mathematics learning, when cognitive changes occur, then metacognitive regulation skills are also evolving and this situation will have an influence on students' mastery. Studies by Sanchez-Garcia & Carlos (2011), Christianti *et al.*, (2015), Rayung & Ambotang (2016) and Rahmawati (2017) reported that cognitive needs lead to changes in self-esteem and self-management for the better. Entrepreneurship is also one of the examples of individual social skills and this experience is needed as a learning base (Jaslinah, 2012). Almahry *et al.*, (2018), Khar *et al.*, (2017), and Franco and Haase, (2009) explained in their study that through the activities of buying and selling, students' communication improves and affects the mathematics learning process. These collaborative skills will enhance students' metacognitive experiences. This experience will form a temporary framework and will be updated with new experiences during learning process.

According to Palmer and Johansson, (2018), and Rahmawati (2017) entrepreneurship competence involves thinking skills, i.e. skills to analyse needs, comparative differences, and so on to buy or sell something. This skill when applied in the classroom along with mathematics problem solving will train the students' metacognitive regulation skills. The ability to coordinate problem-solving in learning by way of entrepreneurship and playing the roles of seller or buyer will have an impact on mathematics learning by developing metacognitive regulation skills. According to Goh (2010) experience and needs as a seller or buyer is are effective because they test how to think, organise, manage and take initiative or alternative to solve the problem during an activity and learning mathematics. Researchers such as Almahry *et al.*, (2018), Khar *et al.*, (2017), Franco and Haase, (2009), Christianti *et al.*, (2015), and, Rayung and Ambotang, (2016) reported that entrepreneurial, buying and selling activities can enhance student thinking competencies. This indicates that many researchers involved in this study support that metacognitive regulation skills, creative and critical thinking skills develop

simultaneously while doing these activities. In addition, through entrepreneurial skills, buying and selling activities, effective interaction is highly encouraged and this will contribute to the growing aspects of metacognitive regulation skills of students as explained by Adnan and Arsad Bahri, (2018) that is, the students' metacognitive regulation skills are very influential when they can be created during active learning. In active learning, interaction can encourage students to give and share ideas and develop positive behaviours to learning such as concentration, excitement and so on. In the interaction process, when students are aware of the level of previous knowledge, they will manage their thinking by planning, monitoring and evaluating current learning (Franco & Haase, 2009; Khar *et al.*, 2017; Almahry *et al.*, 2018). The real interaction is when students can communicate with their minds through the process of self-metacognition. This process will contribute to the mastery of mathematics. This has been discussed and evidenced in studies that investigated on how metacognition and student achievement correlated (Du Toit & Kotze, 2009; Hasbullah, 2015; Amin & Sukestiyarno, 2015; Menz & Cindy Xin, 2016; Ibrahim & Iksan, 2017; Herlina *et al.*, 2018).

### Conclusion

The present study reviewed the implementation of entrepreneurship, buying and selling activities as a study input targeted at mathematics learning to see the output. In summary, this study can illustrate that the implementation of EBSA can alter the scenario and give re-branding to learning. The contribution to this study was to provide knowledge on the influence of metacognitive regulation and interaction skills in pursuing mathematics learning. Additionally, this study also contributes knowledge of mathematics learning directly. Mathematics is a unique, abstract and complex knowledge that requires mental adaptation and various skills. This study reinforces the statement that learning mathematics requires the mathematical medium itself. An example is a trading activity,

which is also one of the areas of mathematics. Thinking mathematically is the best way to learn mathematics. This study has also clarified the concept of transversal competence and multi-literacies, which combine various competencies to explore other competencies. It also shows a combination of strategies and methods of learning. So, to ensure that the knowledge continues, further studies can be conducted by focusing on other skills to apply in mathematics learning, for example, creating and designing skills. Besides that, this study can also be further developed by producing more specific teaching models or developing modules, aids, tools, mobile apps, and software.

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*Abbreviations:* EBSA: Entrepreneurship, buying and selling activities

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## INNOVATIVE MARKETING OF EMERGING MOSLEM FASHION IN THE PROVINCE OF WEST JAVA INDONESIA

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**Abstract:** Moslem fashion is potentially the next big thing in the retail industry. This research uses a marketing approach to investigate the relationship between marketing innovation and competitive strategy in Moslem fashion online shopping business by engaging in local Small- and Medium Enterprises in West Java. We conducted a quantitative approach by extracting the dimensions of marketing content and technology in marketing innovation. In addition, we looked at the cost leadership, differentiation, and focus on competitive strategy. The author collected the data from 295 respondents who did the survey within three months. The results demonstrate and strongly support the idea that the use of social media in marketing innovation contributes to its competitive strategy, especially in the differentiation strategy. However, the quality of the product becomes the most crucial thing in marketing innovation and has implications for the sustainability of business performance in the Moslem fashion industry in Indonesia.

Keywords: Business performance, competitive strategy, Moslem fashion, technology, West Java.

### Introduction

Moslem fashion for women is clothing that covers their entire body, except for the face and palms, which is also known as the hijab. Indonesia is one of the biggest Moslem fashion markets in the world. Trends in Moslem fashion are increasing in recent years; it is used universally for daily activities, not just during religious times. Moslem fashion is used by housewives, entrepreneurs, artists, employees, students, the young generation, and even toddlers. There are also many kinds of attached accessories to make the Moslem outfit more fashionable.

In fact, in the last decades this trend has been promulgated by prestigious female designers who promoted Indonesian Moslem fashion design in international exposures such as Dian Pelangi, Rani Hatta, Khanaan Shamlan, and many more. This trend of fashion styles has spread abroad, such as in the ASEAN countries, the European region, and the United States (Salim & Ernawati, 2015). In terms of the fashion industry, West Java dominated about 57% of garment production in Indonesia (Salim

& Ernawati, 2015). In 2017 this number grew through offline sales (87%) and online sales (13%). According to Jones (2007), Indonesian women have increasingly chosen to adopt a form of Islamic dress due to a rise in Islamic piety. The growing middle class of young women and educated people led these factors to become explicitly anti-fashion frugal and moral critiques. The critics come from the previous generation on Islamic piety expressions which have changed their fashion style from conventional to Moslem fashion style. We should take note that this growing business sector was initiated by Small and Medium Enterprises (SMEs) and Moslem fashion boutiques that grew into large scale producers at a later stage. This paper investigates the link between competitive strategy and marketing innovation.

Gupta *et al.*, (2016) stated that marketing innovation is a consequence of the desire to be a strong competitor in the market. It is also in line with Freeman *et al.*, (2006) that SMEs attempt to demonstrate their ability to innovate in consumer services. This research focuses on the West Java Province due to their strong consumer

preferences as well as producers' performance. It will contribute to the trend of marketing innovation in the Moslem fashion industry of the Indonesian SMEs. It also provides a profile of Moslem fashion SMEs for policy makers to support market competitiveness.

### ***Business Performance, the Marketing Concept and Marketing Technology***

One of the significant problems of SMEs business development in developing countries is competitiveness (Ahmedova, 2015). Webster (1988) defines that competitiveness of a firm in a market reflects its capability to capture the market through innovative marketing initiatives. Technology is also strongly considered as a basis of value creation which improves efficiency (Porter, 1980). Digital technology is used by marketers to modify individual behaviour, which is a strategy to convince customers to buy their products. Marketers use interactive technologies in order to modify individual behaviour and employ strategies to convince their customers to purchase their products. Pappas *et al.*, (2016) distinguish online shopping behaviour that consists of cognitive and affective perceptions of consumers. This study can be used by SMEs that use digital technology to persuade consumers with cognitive perception in the buying process. Cognitive perception is used to understand consumer profiles to meet consumer preferences with business performance, the marketing concept, and marketing technology. The SMEs use online shopping channels for efficiency, i.e., economic reason rather than affective consumer perception. Economic efficiency results in the benefits of online shopping channels for customers in the form of convenience, time, and cost savings (Pappas *et al.*, 2016).

Business performance is vital for the competitiveness of both buyers and seller firms, Gupta *et al.*, (2016). Marketing innovation through products and processes makes it possible to use resources efficiently to develop competitive advantages. Superior quality, efficiency, and innovation trigger companies

to be in the position of the market leader (Hunt *et al.*, 2006; Knight & Tamer Cavusgil, 2004). The SMEs products must be able to compete with products that are already in the market and well-known brands. When SMEs can provide sustainable products, they are deemed competitive in the market. Marketing contents of online shopping are determined by three dimensions that are the outcomes of interest of online shopping behaviour (i.e., intention to purchase); causal condition of cognitive perceptions (i.e. quality of personalisation, message quality and benefits of personalisation); and causal condition of affective perceptions (i.e. strongly positive emotions, weakly positive emotion, strongly negative emotion, and weakly negative emotion). We only consider two dimensions of online shopping style, which are causal conditions for cognitive perception and online shopping behaviour (Pappas *et al.*, 2016). The last dimension is marketing technology. This marketing innovation can reduce transaction costs for initiating exchanges of knowledge and information as the benefit and risk of online shopping (Gupta *et al.*, 2016 ; Forsythe *et al.*, 2006).

### ***Cost Leadership, Differentiation, and Focus***

Competitiveness is the ability of firms to successfully address opportunities depending upon their ability to contribute to the competitiveness of the partnerships. These factors include mutual understanding about each competency to actualise resources and their market sensing and value creation capabilities (Webster, 1988; Anderson & Gerbing, 1988). Moreover, (Porter, 1980) has defined three basic sustainable competitive advantages that comprise cost leadership strategy; differentiation strategy, and focus strategy. Cost leadership is the ability of firms to reduce the cost of their participation in planning activities like branding, distribution and opportunity identification in the local market to be identified (Gupta *et al.*, 2016). Reducing cost means improving efficiency to increase productivity forecast and provide assurance related to services, quality, and risk by managers. Zanchettin and Mukherjee, (2017)

defined product differentiation as innovative activities which generate opportunities to gain profit for both innovators and their competitors. One of the challenging issues in the product differentiation stage is the complexity of inter-industry differentiation, how a firm’s product can be distinguished from that of other competitors to create their uniqueness for both productivity and market leadership. The last dimension is focused strategy, (Sharma *et al.*, 2018) stated that the refinement and improvement of a firm could lead to advantages, i.e., deeper penetration into an existing customer base. The activities comprise improving production efficiencies by exploiting their current strength and abilities to enhance their performance by higher value creation through improvements in their operational skills and wider accessibility that leads to the firms’ resources.

**Methods**

The sample of SMEs of Moslem fashion online business collected consists of 295 respondents across West Java Provinces from February until April 2018. The general demographic characteristics of the respondents are shown on Table 1.

There is a large number of female respondents (82%) and only 18% of male. That is because the Moslem fashion business is more related to female’s needs, and they understand their market better. The majority (48%) of respondents were starting their business in 2011-2015. By the time of the 2018 research, all respondents (295) had used digital technology, and most of respondents had their profits below 7,500 US \$ (68%) per year in 2018.

**Statistical Analysis**

The data were collected using questionnaires as the instruments and were validated with a constructed test. We tested the results of the questionnaires using reliability test by employing Average Variance Extracted (AVE), Composite Reliability, and Alpha Cronbach test.

Table 2 shows the value of Average Variance Extracted (AVE) on the five variables observed in the study. The AVE value indicates variable validity and fitness. It appears that the AVE values of the five variables ranged from 0.512 to 0.691. Based on statistical criteria, all variables must be above 0.5, as all variables must have AVE values above 0.5. These variables can be considered reliable (Chin & Brown, 2000).

Table 1: Characteristics of the respondents

Characteristics	Categories	N=295	%
Gender	Male	53	18
	Female	242	82
Starting Business	1996 - 2000	9	3
	2001 - 2005	6	2
	2006 - 2010	29	10
	2011 – 2015	142	48
	2016 - 2018	109	37
Profit in 2018	< 7,500 US\$	201	68
	7,501 – 38,500 US\$	67	23
	38,501 – 77,000 US\$	21	7
	77,000 - >	6	2

Table 2: Average Variance Extracted (AVE)

No.	Variable	AVE
1	Business Performance	0.691
2	Competitive Strategy	0.605
3	Unique Resources	0.579
4	Value Creation	0.550
5	Marketing Innovation	0.512

Table 3: Composite Reliability

No.	Variable	Composite Reliability
1	Marketing Innovation	0.956
2	Competitive Strategy	0.955
3	Unique Resources	0.947
4	Value Creation	0.940
5	Business Performance	0.930

Composite reliability test results show that all values are above 0.9, which means that all research variables are reliable because they are above 0.900. The lowest number is recorded in the business performance variable, which is equal to 0.930, and the highest is recorded in the marketing innovation variable, which is 0.956. The high composite reliability value in the five

variables shows the consistency of the value of each indicator in measuring the construct. The survey results show that the highest number is in marketing innovation hence a vital force in the field of Moslem fashion of SMEs that are based on digital marketing. Certainly, the definition of marketing innovation has an emphasis on online technology-based marketing innovations.

Table 4: Cronbach's Alpha

No.	Variable	Cronbach's Alpha
1	Marketing Innovation	0.951
2	Competitive Strategy	0.949
3	Unique Resources	0.939
4	Value Creation	0.931
5	Business Performance	0.912

From Table 4, it can be seen that the Cronbach's alpha values for all variables are above 0.900, which means that all the variables forming elements are reliable and qualified. The lowest Cronbach Alpha value was recorded in the business performance variable, which is

equal to 0.912, and the highest was recorded in the marketing innovation variable, which is equal to 0.951. This overall result also shows that the average composite reliability value is higher than the Cronbach's Alpha value. This means that all the questionnaires submitted to Moslem

fashion SMEs have fulfilled the reliability test. After we passed those tests, then we estimated the data using Structural Equation Modelling (Anderson & Gerbing, 1988) with Partial Least Square Estimation (PLS). We employed PLS because the data were non-normal distribution due to substantial heterogeneity of SMEs sample across the region of West Java Province. This heterogeneity produces a largely heteroscedastic issue between the sample of SMEs. The skewness and kurtosis are not well performed to produce a normal distribution; this data distribution is against that of Best Linear Un-bias Estimator (BLUE). Therefore, PLS was strongly considered to produce robust estimation rather than OLS estimation or Maximum Likelihood.

**Results and Discussion**

Figure 1 illustrates that marketing innovation affects the competing strategy variables of 0.297 (29.7%) with 99% confidence interval. This coefficient illustrates by any changes in Competitive Strategy variable affected by 0.297 units on changes in marketing innovation by

1 unit. On the left side, marketing innovation is decomposed into several indicators which include the product, marketing concept, and marketing technology. The two dimensions of marketing technology and marketing concept are essential factors in the marketing innovation variable that will enhance SME's of fashion online competitive strategy. These results interpreted as market innovation will affect consumers preferences that change the new look and the expansion of Moslem fashion expressions.

A particular product variable in marketing innovation dimension, i.e., sub-indicators of shape, appearance, packaging or accessories, has significantly affected a coefficient smaller than those of the two previous variables. Therefore, the marketing concept has the highest coefficient, followed by marketing technology, and product, which simultaneously affect the marketing innovation. This result is supported by findings of a study (Ellitan, 2010), which confirmed that marketing innovation is affected by product improvement, process, and technology.

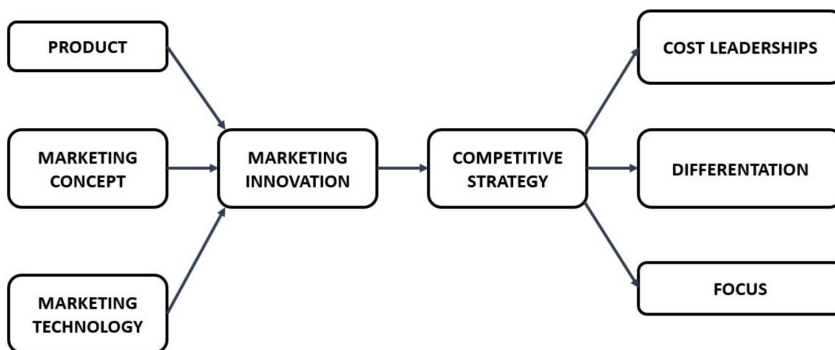


Figure 1: A Research framework

Table 5: Measurement of Marketing Innovation

No	Symbol	Marketing Innovation	Outer Loading Factor
Product			
1	IP11	Create unique product	0.675
2	IP12	Prioritise product quality	0.713
3	IP13	Conduct sales promotion	0.619
4	IP14	Online and offline marketing	0.644
5	IP15	Utilise market research	0.698
Marketing Content			
6	IP21	Developing the right marketing message	0.754
7	IP22	Understanding the consumer appeal	0.726
8	IP23	Using social media in promotion	0.807
9	IP24	Using social media in marketing	0.770
10	IP25	Utilising selebgram in marketing	0.565
11	IP26	Utilising a brand ambassador in marketing	0.505
Technology			
12	IP31	Utilising e-commerce marketing	0.648
13	IP310	Obtaining information about consumer through digital media	0.746
14	IP32	Using electronic media in marketing product	0.774
15	IP33	The influence of social media on sales activities	0.807
16	IP34	The influence of the use of smart phones to purchase	0.796
17	IP35	The effectiveness of the product offered online	0.782
18	IP36	The risk of social impact of negative product review	0.728
19	IP37	The use of social media brings the seller closer to the consumer	0.577
20	IP38	The use of social media has an effect on increasing sales	0.784
21	IP39	Leveraging influencers in marketing products	0.793

Malaysia is one of Indonesia’s biggest competitors in the fashionable hijab segment. Moslem fashion producers and retailers in the country have already had a head start in terms of marketing by utilising e-commerce and social media platforms, particularly Instagram, to market their products. Naelofar and Mimpikita are two of Malaysian Moslem fashion brands that have successfully gone global. Furthermore, as the number of internet users increases in Indonesia, e-commerce, and social media sites offering Moslem fashion

have mushroomed through brands such as Zoya, Hijup, and Hijabenka. Moslem fashion has become a highly sought-after commodity and a rapidly growing industry in Indonesia. On the other side, a competitive strategy was affected by Cost Leadership, Product Differentiation, and Focused Strategy. The coefficient of a decomposed variable is higher than that of Marketing Innovation dimensions, which means direct aggregating of marketing innovations affects through aggregate competitive strategy and decomposed variables of cost leadership,

Table 6: Measurement of Competitive Strategy

No	Symbol	Competitive Strategy	Outer Loading Factor
Cost Leadership			
1	SB11	Determining cost efficient operations	0.763
2	SB12	Determination of a more competitive price	0.800
3	SB13	Dissemination of information related Costs customer with timely, convenient, credible	0.549
4	SB14	The cost efficiency of online campaign through digital media	0.662
5	SB15	The effectiveness of the utilisation of distribution channels through online media	0.700
Differentiation			
6	SB21	The ability to innovate in the design	0.801
7	SB22	The ability to innovate in product quality	0.865
8	SB23	The ability to create different product advantage	0.834
9	SB24	Variation in product development capability	0.845
10	SB25	The ability to create ease for customers to get service	0.830
11	SB26	The ability to implement the latest technology	0.809
Focus			
12	SB31	Anticipating the speed of market demands	0.813
13	SB32	Adapting the speed of the latest technology	0.767
14	SB33	Speed to meet demand (order)	0.793

differentiation, and focused strategy. We imply that in the case of SMEs of Moslem fashion Online Business in the West Java Province, the competitive strategy has been significantly affected by Marketing Innovation.

The research findings have shown that there are product dimensions related to the product quality, marketing concepts through social media, and marketing technology that is in line with the marketing concepts of sales through social media. The 4P marketing concept (product, place, price, and promotion) on digital marketing is dominated by product and promotion in entering the marketplace. Therefore, the concept is no longer significant, and sellers have the freedom to determine prices. In the competitive strategy, differentiation is significant as this dimension relates to the ability of the company to innovate in producing a quality product. The cost leadership and focused strategy are not major dimensions in influencing the competitive strategy of the Moslem fashion business. It is relevant to this study of social media promotion using online technology. The effectiveness and efficiency of online promotions have proven to increase sales.

**Conclusion**

Marketing innovation in SMEs of Moslem fashion business has a strong influence in determining a competitive strategy. This research demonstrates marketing innovation, especially on product uniqueness and utilisation of social media that will improve the competitive strategy of SMEs of Moslem fashion online business in West Java. This strategy will support Indonesia’s target to be the centre of global Moslem fashion in 2020. The target is attainable since Indonesian Moslem fashion is unique and more diverse compared to those from other countries. The Indonesian government also encourages local Moslem fashion designers and the local community to introduce their brands to global customers. These efforts combined make Indonesia a firm contender to becoming a global Moslem fashion centre and international business and future business for younger generations and its impact on the sustainability of the companies’ business. Aggressive marketing and product development must be embedded into the SMEs and MSEs have to ensure that the Moslem fashionable wares will penetrate the large potential market in China,



India, and the Middle East. These three countries also have the potential of a Moslem population. The possibility of Moslem fashion to become a world fashion trend is not only based on religion but also on the idea that Moslem fashion is part of the modern lifestyle.

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