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FORENSICALLY IMPORTANT FLIES (INSECTA: DIPTERA) INVOLVED IN THE DECOMPOSITION OF RABBIT CARCASSES AT A COASTAL AREA IN SARAWAK, MALAYSIA

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ABSTRACT

Sarco-saprophagous insect plays an important role in organic matter decomposition. The biological, ecological, and behavioural specificity of the taxa are important in the renewal of the decay history of a corpse or carcass, which frequently goes back to the lethal event. This study aims to determine forensic important flies and environmental factors that influence the decomposition stage of rabbit carcasses at the coastal area in Mukah, Sarawak (Malaysian Borneo). Three carcasses of European rabbits, *Oryctolagus cuniculus,* were used as animal models and they were placed at coastal area at Kampung Bunut beach in Mukah, Sarawak, Malaysia. Five decomposition stages, which are fresh, bloated, active decay, advanced decay, and dry remains, were observed throughout this study. A total of 75 individuals belongs to seven species of forensically important flies were collected and identified, namely *Chrysomya defixa*, *Ch. megacephala*, *Ch. rufifacies*, *Hemipyrellia ligurriens*, *Musca domestica*, *Synthesiomya nudiseta*, and *Parasarcophaga dux*. The common fly species found on decomposing rabbit was *Ch. megacephala*. Based on observation, the intensity of sunlight is directly proportional to the environmental temperature. Meanwhile, environmental temperature is shown to inversely related to the relative humidity. High temperatures hasten the decomposition of the carcass. However, the windy conditions around the coastal area cause rapid dehydration and bodily liquefaction. Therefore, the carcasses were shriveled before all of the bodily tissues had completely decomposed. The data on dipteran composition and environmental effects on decomposition would be useful for further medico-legal cases in Mukah, Sarawak. This is one of the few studies of flies as forensically significant species in Sarawak.

Keywords: Forensic important flies, dipteran, medico-legal decomposition, coastal area

ABSTRAK

Serangga sarco-saprofagus memainkan peranan penting dalam penguraian bahan organik. Kajian biologi, ekologi dan pengkhususan kelakuan taksa adalah penting dalam pembaharuan sejarah pereputan mayat atau bangkai, yang sering berlaku dalam peristiwa kematian. Kajian ini bertujuan untuk mengenalpasti spesies lalat berkepentingan forensik dan faktor persekitaran yang mempengaruhi peringkat penguraian bangkai arnab di kawasan pantai di Mukah, Sarawak (Malaysia Borneo). Tiga bangkai arnab Eropah, *Oryctolagus cuniculus*, digunakan sebagai model haiwan dan diletakkan di kawasan pantai di pantai Kampung Bunut di Mukah, Sarawak, Malaysia. Lima peringkat penguraian, iaitu segar, kembung, pereputan aktif, pereputan lanjutan, dan sisa kering, diperhatikan sepanjang kajian ini. Sebanyak 75 individu tergolong dalam tujuh spesies lalat berkepentingan dalam forensik telah dikumpul dan dikenal pasti, iaitu *Chrysomya defixa*, *Ch. megacephala*, *Ch. rufifacies*, *Hemipyrellia ligurriens*, *Musca domestica*, *Synthesiomya nudiseta* dan *Parasarcophaga dux*. Spesies lalat yang biasa ditemui pada arnab yang mereput ialah *Ch. megacephala*. Berdasarkan pemerhatian, keamatan cahaya matahari adalah berkadar terus dengan suhu persekitaran. Sementara itu, suhu persekitaran ditunjukkan berkait songsang dengan kelembapan relatif. Suhu yang tinggi mempercepatkan penguraian bangkai. Walaubagaimanapun, keadaan berangin di sekitar kawasan pantai menyebabkan dehidrasi yang cepat dan pencairan badan. Oleh itu, bangkai telah mengecut sebelum semua tisu badan mereput sepenuhnya. Data mengenai komposisi dipteran dan kesan alam sekitar terhadap penguraian berguna untuk kes-kes medikolegal selanjutnya di Mukah, Sarawak. Ini adalah salah satu daripada beberapa kajian tentang signifikasi lalat sebagai spesies penting dalam bidang forensik di Sarawak.

Kata kunci: Lalat berkepentingan forensik, spesies diptera, penguraian medikolegal, kawasan pantai

INTRODUCTION

Organism will undergo decomposition process where organic material is broken down into simpler forms of matter when they die and were use complex cross-feeding and interkingdom interactions to break down organic matter (Strickland & Lynch 2024). Arthropods such as flies play a very significant role as decomposers aside from microorganisms like bacteria and fungi. They contribute to the ecosystem maintenance and balance by decomposing organic material such as carcasses (Cai 2015; Tomberlin & Benbow 2015). As a side benefit, valid complementary data can be obtained from the study of Diptera to estimate the post-mortem interval (PMI) in forensic cases. Diptera infests corpses in various environments and situations such as savannah, forest, indoor, within water, and everywhere else (Byrd & Castner 2010). Insect colonization and period depend on environmental and corpses conditions (Archer 2003; Campobasso et al. 2001). Therefore, Ren et al. (2018) suggested that databases should be created for each bio-geoclimatic zone where insects are utilized to assess colonization time.

According to Byrd and Castner (2010), there are 10 forensically important dipterans, which are from the family of Calliphoridae, Sarcophagidae, Muscidae, Piophilidae, Scathopagidae, Sepsidae, Sphaeroceridae, Stratomyidae, Phoridae and Psychodidae were reported. However, the prominent families engaged in the decomposition process of all carcasses include families Calliphoridae, Muscidae and Sarcophagidae (Adrus & Rahim 2018; Azwandi et al. 2013; Maramat & Rahim 2015a; 2015b). Family Calliphoridae or commonly

known as blowflies, are a large and diverse family of robustly built flies found around the world (Hill & Abang 2010). These medium-sized flies are found in approximately 1000 species (Byrd & Castner 2010). Calliphorids are often the first to colonize a corpse, arriving within minutes if the weather and time of year are favorable (Pohjoisäki et al. 2010). Different species also have distinct environmental preferences as results shown in various studies (Azmi & Lim 2013; Maramat & Rahim 2015a; Moretti et al. 2008; Voss et al. 2008).

The relationship between man and Muscidae, such as *Musca domestica* and *M. sorbens*, dates back to the dawn of recorded history (Greenberg & Kunich 2002; Schmidt 2006). Muscid flies are recognized for their agricultural, medicinal, and veterinary relevance due to their widespread distribution and close relationship with human settlements (many are synanthropic species) (Byrd & Castner 2010). Sarcophagid flies, also known as flesh flies, are subtropical or tropical dement that visit dead bodies. They are part of the insect faunal succession and play a critical stage of decomposition (Singh & Bharti 2008).

Richards and Goff (1997) defined decomposition as a natural process that returns organic matter to the ecosystem. Numerous factors can influence the decomposition process, including temperature, humidity, total rainfall, and the presence of arthropods (Heo et al. 2007). Malaysia experiences equatorial climate, which is hot and humid all year (Tang 2019). The ecological data on forensically important flies involved in the decomposition process in a specific area, such as Sarawak, is still insufficient and must be established. This is because a cadaver's geographic location or bio-geoclimatic zone substantially affects the insect species there (Ren et al. 2018). Since the taxonomic composition of fauna varies widely by location, it is critical to identify the forensically important insects that are unique to a given place when estimating the postmortem interval (PMI) (Tabor et al. 2005).

Carrion arthropods have been studied in different parts of the world to identify the species' makeup and successional pattern (Tabor et al. 2005). A few such studies have been out in Malaysia, especially in Peninsular Malaysia (Shafe'I & Zuha 2016). Currently, only a few published studies on forensically significant insect species identified in monkey and rabbit carcasses in Sarawak (Adrus & Rahim 2018; Maramat & Rahim 2015a; 2015b). Nevertheless, no study has been done at the coastal area, particularly in Mukah, Sarawak, which has different environmental conditions from previous studies. Apart from that, many death bodies and suicide cases has been reported to be happened at coastal area in Mukah from 2015 to 2021 (Bernama 2015; Joni 2021; Lawrence 2021; Shahminon 2019). Therefore, it is necessary to collect ecological data on insects that decompose organisms in this area. The main objective of this study is to determine forensic important flies associated with the decomposition of rabbit carcasses at the coastal area in Mukah, Sarawak during Northeast monsoon season. Besides, this study is also done to determine the environmental factors that influence the decomposition stage of rabbit carcasses at the coastal area in Mukah, Sarawak during Northeast monsoon season. The data is vital to update the list of significant forensic flies on rabbit carcasses in the coastal region of Sarawak, as there is little information on forensic entomology there. In addition, this data set may provide information about significant dipteran decomposers and be used in forensic entomology investigations.

MATERIALS AND METHODS

Study Site

The experiment has been carried out in Kampung Bunut beach in Mukah, Sarawak, Malaysia (Figure 1), located approximately between 2°54'23" N, 112°6'31" E with an altitude of 13 feet (4 metres) above sea level. This region has a warm tropical climate with an average annual temperature of 26.9°C. Mukah also experiences an average annual rainfall of 3,579 mm. The study was done during Northeast Monsoon season (Nov until March). The carcasses were placed in a wired metal cage under exposed sunlight on sand on the beach.

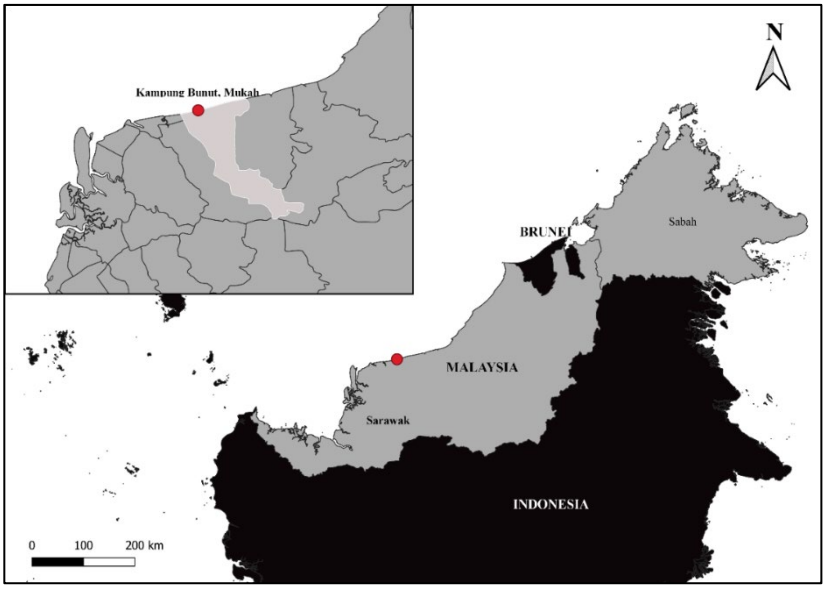

Figure 1. Map of the study area

Preparation of Animal Models (Carcasses)

Three carcasses of European rabbits, *Oryctolagus cuniculus,* were used as animal models in this experiment. The utilization of animal models for this experiment has been permitted by Animal Ethics Committee of UNIMAS (Referral Number: UNIMAS/AEC/T/F07/024). The average weight of the rabbits measured using a weighing scale was 670 g. The rabbits were then carefully euthanized by using cervical dislocation method and the open wound were avoided as possible. The euthanized animal model was placed in a small metal cage. The cage was secured to the ground with wooden holders to deter other vertebrate scavengers from disturbing the carcass. This experiment was replicated for three times.

Flies Collection and Identification

The carcass was observed twice daily throughout each replication period, once in the morning (0800 - 1000 hrs) and once in the evening (1600 - 1800 hrs). Each of the replication took five days to complete the decomposition stage. Apart from that, the weather was observed, determined, and recorded. The environment temperature was also measured using infra-red thermometer. The humidity of the environment was determined using Huafeng-AccuWeather application in smartphone. Five decomposition stages (fresh, bloated, active decay, advance decay, and dry remains) were observed and determined in all carcasses following to Nazni et

al. (2011). Photo of the carcass was taken twice daily to document the decomposition process using a smartphone camera. Adult dipterans were caught using a jar and placed in a killing jar containing cotton soaked in ethyl acetate. The date and time on which the specimens were obtained was labeled on each specimen. Stereo microscopes (Olympus SZX7) with magnification of 8x to 56x were used to magnify the flies and identify the species. Illustrated keys to adult flies of forensic importance in Malaysia by Nazni et al. (2011) was referred to identify each species.

Data Analysis

The mean of environmental parameters (environmental temperature, relative humidity, and sunlight intensity) was plotted on the line graph and were relates to each decomposition stages by using Microsoft Excel software. Meanwhile, the relative abundances of the species and their family were calculated and analyzed in percentage by using Microsoft Excel Version 2021.

RESULTS

Dipteran Succession on the Carcasses

Seven species from three families were collected from the experiment (Table 1 and 2). Two genera were from family Calliphoridae, which are from genus *Chrysomya*, and genus *Hemipyrellia*. Genus *Chrysomya* consisted of three species, which are *Chrysomya defixa, Ch. megacephala* and *Ch. rufifacies*. Meanwhile, genus *Hemipyrellia* consisted only one species, which is *Hemipyrellia ligurriens. Ch. megacephala* (Figure 2) was relatively the most abundant species to be collected throughout the experiment with relative abundance of the species expressed as percentage of total dipteran collected is 56% (Table 1). The least abundant calliphorid is *Ch. defixa* (Figure 3) with relative abundance of the species only 1.33%. In family level, family Calliphoridae is the most abundant family to be collected with relative abundance of family expressed as percentage of total dipteran collected is 86.67%.

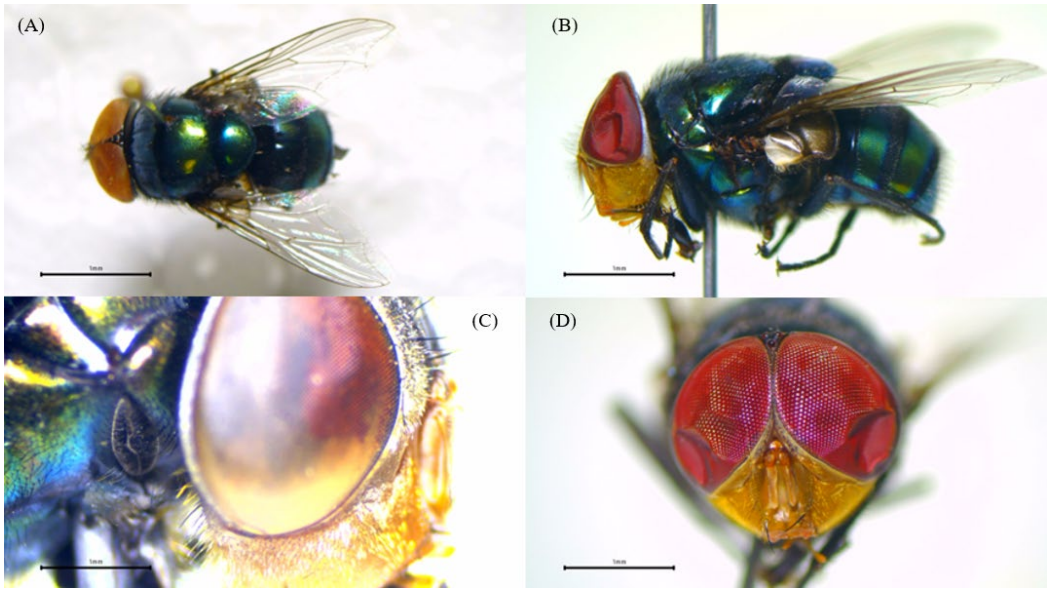

Figure 2. Photo of *Ch. megacephala.* (A) shows dorsal view of the fly. (B) shows lateral view of the fly. (C) shows the large brownish mesothoracic spiracle. (D) shows ventral view of the fly

Table 1. Number of individuals by species captured per day. Percentage (%) shows relative abundance (RA) of the species expressed as percentage of total dipteran collected. RB% shows relative abundance of family expressed as percentage of total dipteran collected

Family	Species	Time of Collection										Total by species	RA%	RB%
		Day 1		Day 2		Day 3		Day 4		Day 5				
		Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening	Morning	Evening			
Calliphoridae	*Chrysomya defixa*	0	0	0	0	1	0	0	0	0	0	1	1.33	86.67
	Chrysomya rufifacies	0	0	0	4	11	1	0	0	0	0	16	21.33	
	Chrysomya megacephala	0	0	0	22	18	2	0	0	0	0	42	56.00	
	Hemipyrellia ligurriens	0	3	0	3	0	0	0	0	0	0	6	8.00	
Muscidae	*Musca domestica*	0	0	0	2	1	0	0	0	0	0	3	4.00	5.33
	Synthesiomyia nudiseta	0	0	0	0	1	0	0	0	0	0	1	1.33	
Sarcophagidae	*Parasarcophaga dux*	0	0	2	2	2	0	0	0	0	0	6	8.00	8.00
TOTAL												75	100	100

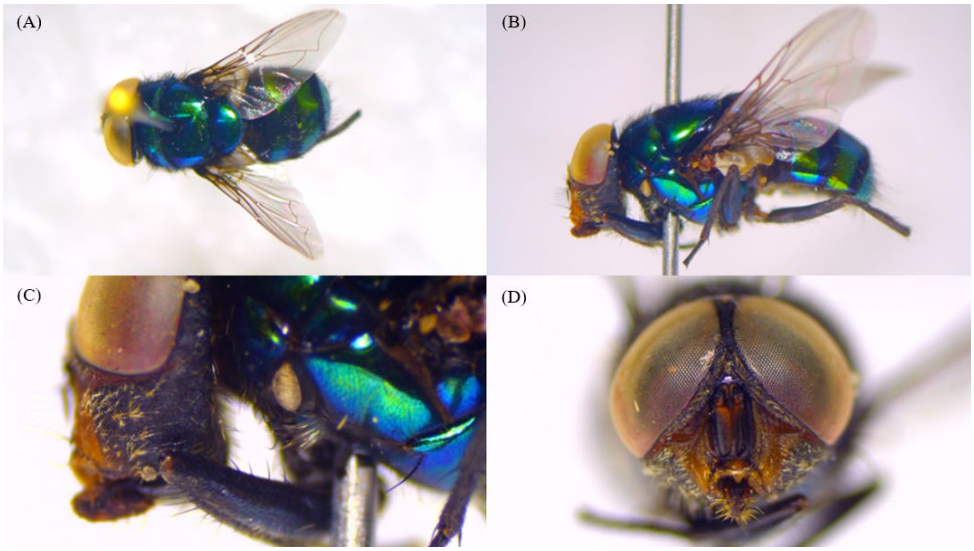

Figure 3. Photo of *Ch. defixa*. (A) shows dorsal view of the fly. (B) shows lateral view of the fly. (C) shows the post-genal area covered with black and brown hairs, and white yellowish mesothoracic spiracle. (D) shows ventral view of the fly

Family Muscidae was the second most abundant dipteran family collected throughout the experiment with family relative abundance of 5.33%. This family consisted of two species and two different genera. From genus *Musca*, about 4% of *Musca domestica* (Figure 4) were collected. Meanwhile, for genus *Synthesiomyia*, about 1.33% of *Synthesiomyia nudiseta* were collected. Only one species was collected from the family Sarcophagidae with species relative abundance of 8%, which is *Parasarcophaga dux* (Table 1).

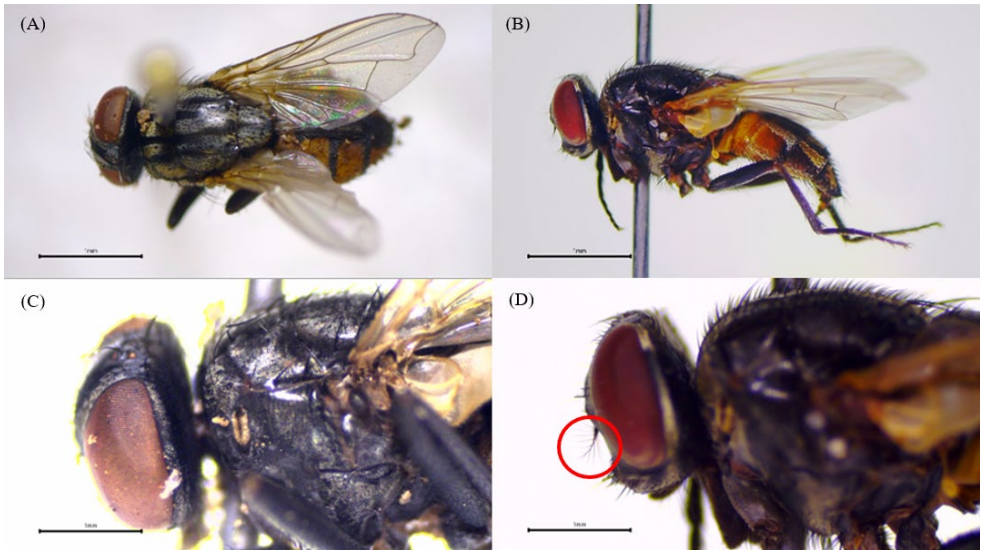

Figure 4. Photo of *M. domestica.* (A) shows dorsal view of the fly. (B) shows lateral view of the fly. (C) shows the fly has yellowish mesothoracic spiracle. (D) shows the arista plumose of the fly

For entomofauna invasion pattern throughout the experiment, ants, which are not the species of interest in this study were observed to invade carcass starting the fresh stage which is on the morning of the first day. These species invasion was observed until the evening of the fourth day. For dipteran succession, *H. ligurriens* (Figure 5) and one unidentified species was observed invade the carcass first on the evening of the first day (Table 2). These species were not observed on the next morning, but *P. dux* (Figure 6) was present. In the evening, blowflies started to dominate the carcass where *Ch. megacephala* is the most abundant. *M. domestica* from the family of Muscidae also observed apart from *P. dux* and three unidentified species. A few *Ch. rufifacies* (Figure 7) started to be spotted again with four individuals were collected. On the third day morning, number of *Ch. megacephala* and *M. domestica* started to drop while *Ch. rufifacies* started to increase. One individual of *Ch. defixa* and *Sn. nudiseta* were spotted only at this time. *Parasarcophaga dux* observed to be maintained with two individuals to be collected and one unidentified species. The evening of the third day was the last time of adult flies to be present. Only two species were collected which are a *Ch. rufifacies* and two *Ch. megacephala.*

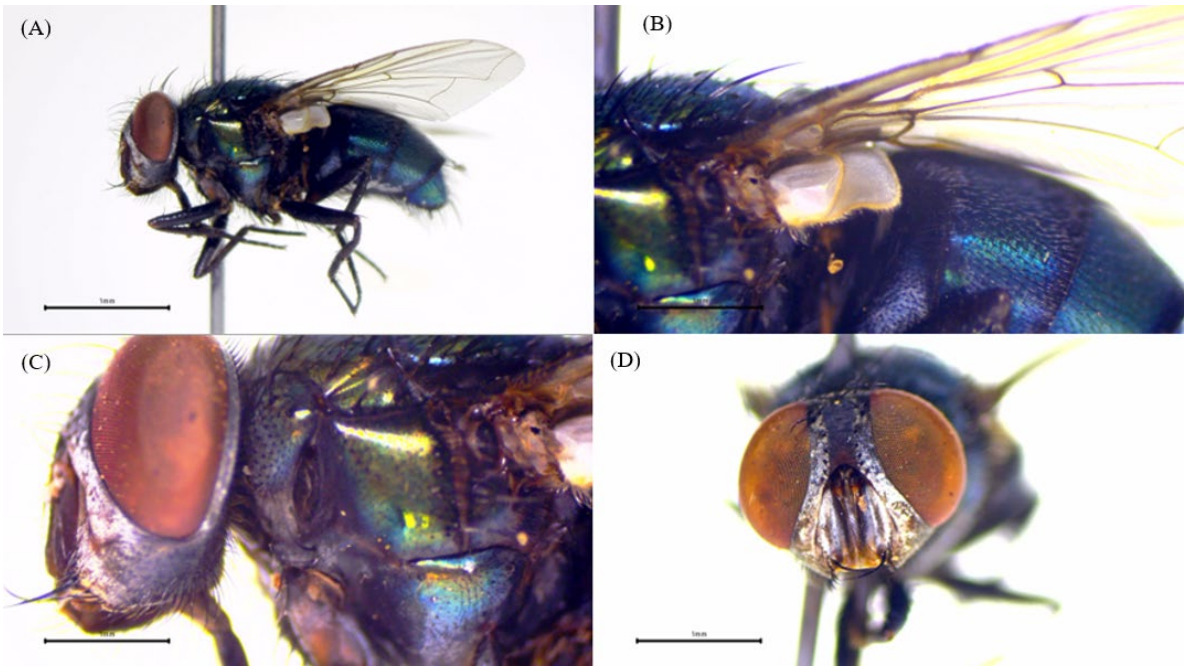

Figure 5. Photo of *H. ligurriens.* (A) shows lateral view of the fly. (B) shows thoracic squama is brownish white. (C) shows the fly has brownish mesothoracic spiracle, and silverish gena. (D) shows the ventral view of the fly

Table 2 Present of dipteran species in different decomposition stages of rabbit carcasses at coastal area in Mukah, Sarawak
A – absence; P – present

Family	Species	Decomposition stage				
		Fresh	**Bloated**	**Active**	**Advanced**	**Dried**
		(Day 1)	(Day 1-2)	(Day 3)	(Day 3-4)	(Day 5)
Calliphoridae	*Chrysomya defixa*	A	A	P	A	A
	Chrysomya rufifacies	A	P	P	P	A
	Chrysomya megacephala	A	P	P	P	A
	Hemipyrellia ligurriens	A	P	A	A	A
Muscidae	*Musca domestica*	A	P	P	A	A
	Synthesiomyia nudiseta	A	A	P	A	A
Sarcophagidae	*Parasarcophaga dux*	A	P	P	A	A

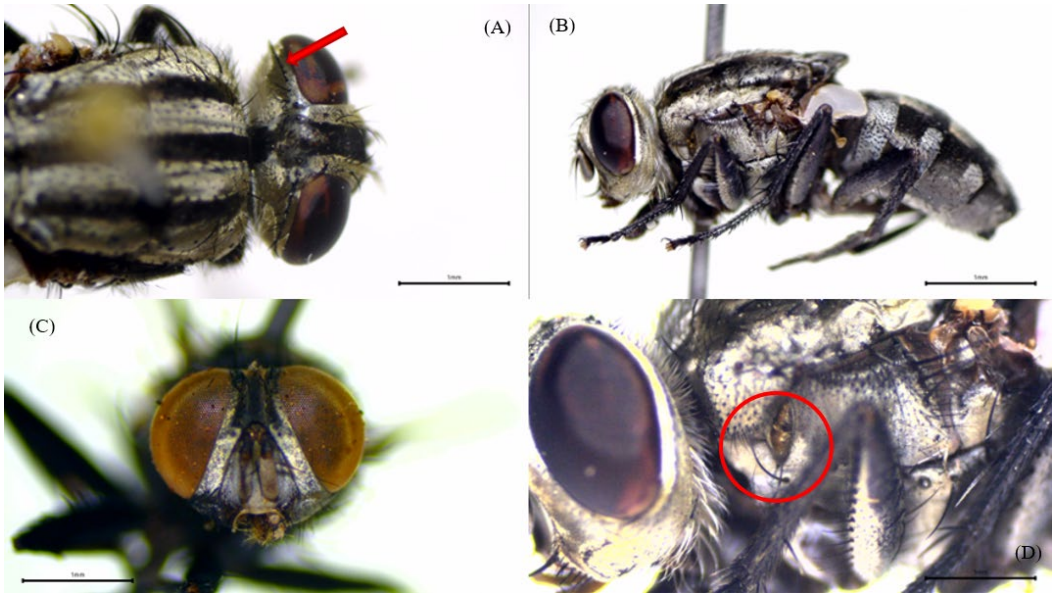

Figure 6. Photo of *P. dux*. (A) shows dorsal view of the fly with the marker showing the fly has one row of black postocular setae. (B) shows lateral view of the fly without wings. (C) shows ventral view of the fly. (D) shows the fly has brownish mesothoracic spiracle, and bare propleuron

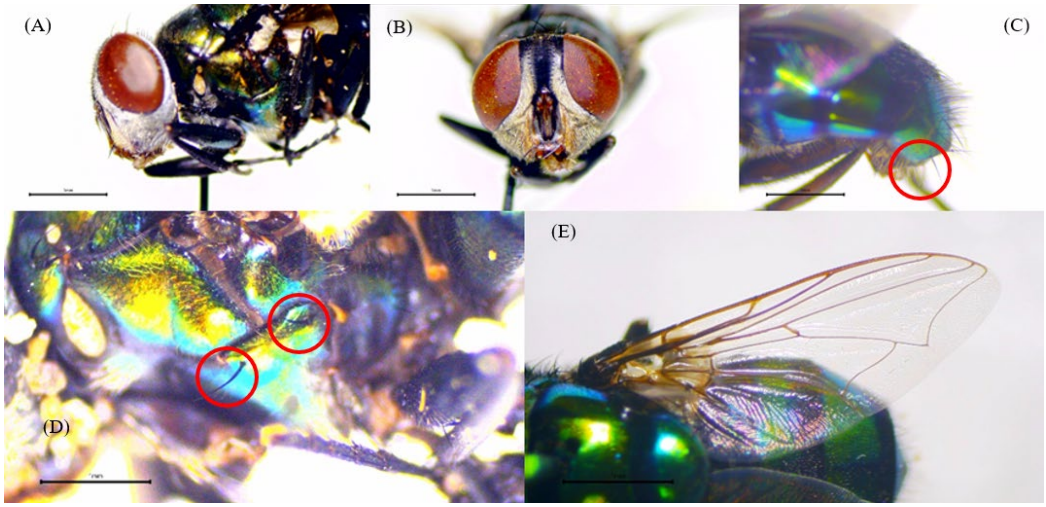

Figure 7. Photo of *Ch. rufifacies.* (A) shows gena and postgenal area of the fly is silvery white, and mesothoracic spiracle is white color. (B) shows ventral view of the fly. (C) shows the fly has tergite 5 with white hair among the black hairs. (D) shows stenopleural bristles of the fly is 1+1. (E) shows the wing venation of the fly

Carcass Decomposition Stage Observation

Five decomposition stages, which are fresh, bloated, active decay, advanced decay, and dry remains, were observed throughout each replication of the study period (Figure 8). Fresh stage was begun as the heart of the rabbits stopped after euthanized until the evening of the first day. This stage took about seven hours. As the fresh stage ended, bloated stage begun in the evening of the first day up to the evening of the second day. This stage took 24 hours to complete.

Active decay stage replaced the bloating stage on the morning of the third day, which took seven hours to complete. The decomposition stage continues with advanced decay in the evening of the third day, lasted until the evening of the fourth day. It took about 24 hours to complete. On the morning of the fifth day, dry remains stage was started.

During the fresh stage, the outside appearance of the carcass was like those of living rabbits (Figure 8). Non-concentrated odour started to present when the carcass begins to bloat. During bloating, the abdomen of the carcass became bluish and increased in volume. When the active decay begun, the skin of the rabbit was appeared blacken, emitted not much smell, and maggots started to appear. The body of the carcass started to puncture and disintegrated distinctively. Activity of the maggots were the most active in this stage. During advanced decay, the soft internal tissues were fully degraded. The body of the carcass was fully disintegrated, and non-concentrated odour was present. The activity of maggots started to slow down and began to burry themselves into the sand. Number of adult flies present were decreases. As the dry remain stage started, smell was absent, and no adult flies or maggots were present. A bit of dried tissues, harden and sandy fur, and bones of the rabbit were left.

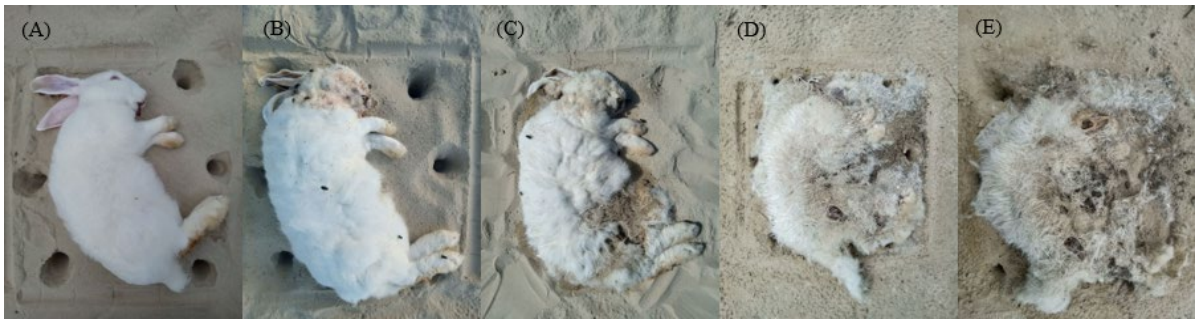

Figure 8. Rabbit carcass on each stage of decomposition. *A* shows fresh rabbit carcass after being euthanized. *B* shows the bloated rabbit carcass. *C* shows active decay stage was ongoing. *D* shows advanced decay of the rabbit carcass. *E* shows the dried remains of mummified rabbit carcass

Environmental Parameters against Decomposition Stages

The mean environmental temperature (MET) for the first day was 31.3°C, the mean relative humidity (MRH) was 81.8%, and the mean sunlight intensity (MSI) was 33.0×10^2 Fc (Figure 9 and 10). The carcass was fresh on the first day and start to bloat in the evening. On the second day, the MET was decreased to 30.5°C, the MRH was increased to 83.2%, and the MSI was increased to 48.2×10^2 Fc. The bloating stage was still ongoing on carcasses. During the third day, where active decay started on the morning, MET spiked up to 34°C, the MRH dropped to 80.3%, and the MSI is the highest which was 57.1×10^2 Fc. Advance decay took place in the evening of this day. On the fourth and fifth day, where advanced decay and dry remains stage happened, the MSI was constantly dropped from 51.5×10^2 Fc to 23.1×10^2 Fc. The MET also showing the same trend on those days where it dropped from 31.7°C on the fourth day to 29.9°C on the fifth day. Oppositely, the MRH of those days keep increasing from 83.8% on the fourth day to 87.3% on the fifth day. The wind was also present all days as the study is a coastal area.

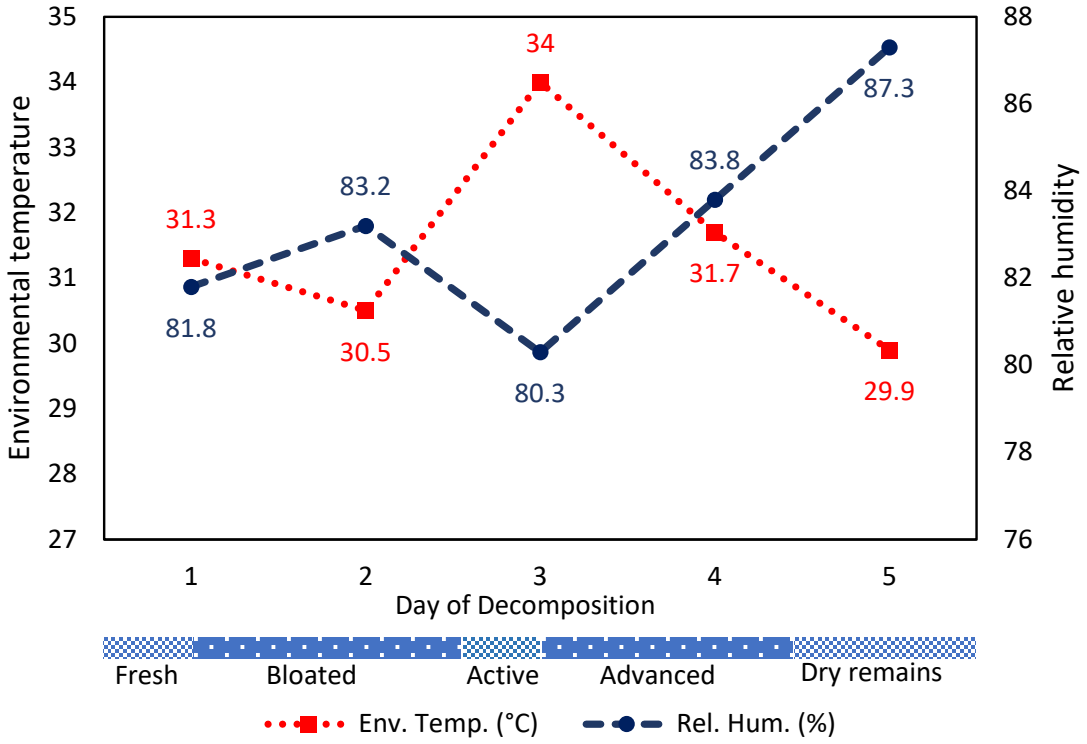

Figure 9. Daily fluctuations of mean environmental temperature and relative humidity of the experimental sites of coastal area

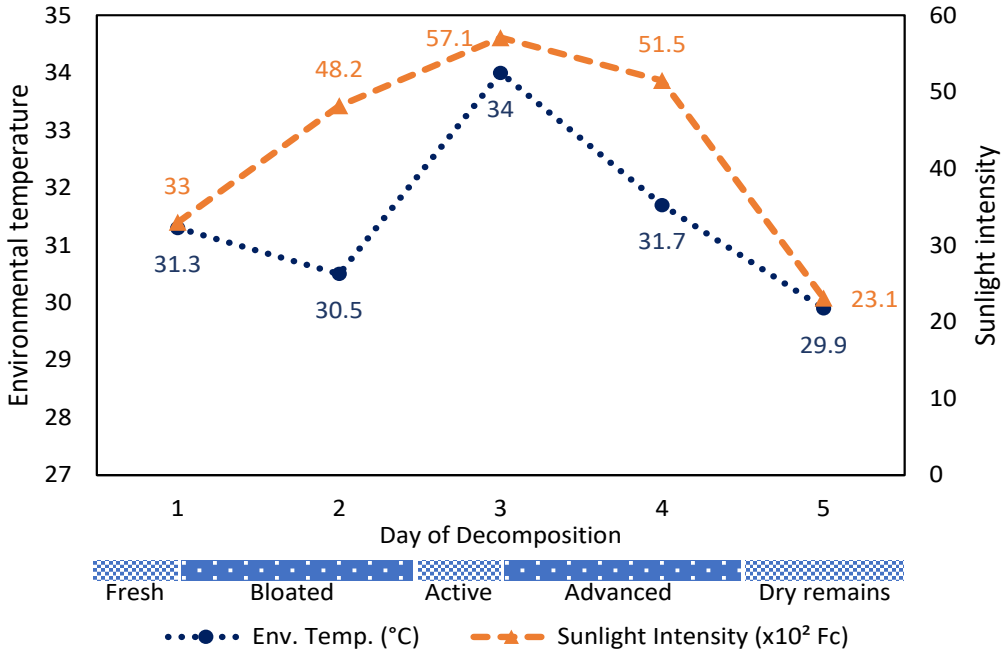

Figure 10. Daily fluctuations of mean environmental temperature and mean sunlight intensity on carcasses during exposure at the experimental sites of coastal area

DISCUSSION

Decomposition defined as the process where the tissue is breakdown and is contributed by the interaction of autolysis and putrefaction process, often with superimposed insect activity (Byard et al. 2008). It is a crucial process that contributes to carbon cycles in the environment. There are three families and seven species of forensically important flies were associated with decomposition process at coastal environment and the result was differs from previous experiment done by Maramat and Rahim (2015a; 2015b), and Adrus and Rahim (2018) in other environments in Sarawak. This shows that dipteran colonization on decomposing carcass is vary depending on environment as stated by Payne (1965) which suggested the pattern of entomofauna succession is unique to each locality and environmental conditions in which decomposition happen.

Calliphoridae, Muscidae, and Sarcophagidae families were predominantly associated with the decomposition process during this study and it was similar observations have been reported in Kuching's mangrove forests (Maramat & Rahim 2015a) and peat swamp forests (Adrus & Rahim 2018; Maramat & Rahim 2015b). Nevertheless, this study did not find the Tachinidae family, which was found in earlier investigations.

In the coastal area, the most common families associated to rabbit carcasses were Calliphoridae, with *Ch. megacephala* and *Ch. rufifacies* being the most prevalent species. This is consistent with findings by Azmi and Lim (2013) and observations in Sarawak's mangrove and peat swamp forests (Maramat & Rahim 2015a; 2015b). According to Lee et al. (2004), the genus *Chrysomya* is predominant to invade decomposing carcasses, and these species commonly associated with medico-legal investigations in Malaysia (Heo et al. 2007). *Chrysomya defixa* was uniquely found in this study, and has been not be reported elsewhere in Malaysia, suggesting it may be causes by specific to the environments.

Ants were the first entomofauna observed to colonize the carcass during fresh stage which consistent with findings in mangrove and peat swamps forests (Maramat & Rahim 2015a; 2015b). However, ants are not forensically important (Vitta et al. 2007). Dipteran succession only began during the bloating stage, with *Ch. megacephala*, *Ch. rufifacies*, *H. ligurriens*, *M. domestica*, and *P. dux* invading due to the smell from putrefaction (Nazni et al. 2011). The appearance of *H. liggurriens* exclusively during this stage implies that it could serve as a stage-specific biomarker for coastal environments. In the active decay stage, *Ch. defixa* and *Sn. nudiseta* appeared but were not significant stage-specific biomarkers due to limited collection numbers. Only *Ch. megacephala* and *Ch. rufifacies* were seen during advanced decay, which is aligned with Nazni et al. (2011) who described minimized insect activity at this stage. Due to the mummification of the carcasses, no dipteran was observed during the dry remains stage, in contrast to the findings in mangrove and peat swamp forests.

Autolysis, which is the breakdown of surrounding cells, happens during the fresh stage, while putrefaction, microbial proliferation within the body, initiated in the bloated stage (Bernard 1991; Nazni et al. 2011). These processes influenced by environmental temperature, with higher temperatures will accelerate autolysis (Tsokos 2005). The high temperatures of the coastal environment expedited the fresh stage to half a day in comparison to 24 hours in mangrove forests (Maramat & Rahim 2015a) and 24-48 hours in peat swamp forests (Adrus & Rahim 2018).

Protein breakdown leads to nitrogen product accumulation, raising tissue pH and promoting bacterial growth, enhancing putrefaction (Mayer 2006). The optimal temperature range for bacterial development (25-35°C) was met in this study, initiating the bloating stage by the evening of the first day (Campobasso et al. 2001). This was earlier than observed in oil palm plantations (Ahmad & Ahmad 2009) and mangrove forests (Maramat & Rahim 2015a). In peat swamp forests, the bloating stage varied depending on the carcass type (Adrus & Rahim 2018).

Humidity can lengthen decomposition time by soaking tissues, but the rapid decomposition observed in this coastal study, completed in five days, suggests other extrinsic factors like wind, direct sunlight, and sand accelerated decomposition (Campobasso et al. 2001). These factors likely caused the carcasses to mummify rather than fully decompose, differing from longer decomposition times in mangrove and peat swamp forests (Adrus & Rahim 2018; Maramat & Rahim 2015a).

CONCLUSION

The dominant species of all dipterans colonized the carcasses is *Ch. megacephala*. A potential stage-specific biomarker was identified in carcasses decomposition at coastal area, which is *H. ligurriens* for bloated stage. No dipteran colonized the carcasses at coastal area during fresh and dried remain stage. Environmental conditions of coastal area affected the decomposition rate of carcasses at coastal area in Mukah, Sarawak during Northeast Monsoon. Sunlight causing indirect effect on the decomposition by increase the environmental temperature. Higher temperature decreased the humidity which accelerated the decomposition. Windy condition causing liquefaction of carcasses to evaporate faster. The sand also absorbs the liquefaction. Hence, the carcasses were mummified. As recommendation for future study, animal models that resemble more to human being such as *Sus scrofa* should be utilized. The dipteran collected through any successional study should not be keep in ethanol as it may damage the sample and causing misidentification. This study also should be done in different season at the same site to improve understanding on dipteran successional pattern on decomposing carcasses at coastal area all year round. The data on succession of dipteran can aid forensic investigation. This study is a preliminary study focusing on forensic important flies associated with decomposing rabbit carcasses at coastal area in Sarawak.

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AUTHORS DECLARATIONS

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Conflict of Interest
All authors declare that they have no conflict of interest to influence the finding of this paper.

Ethic Declarations
The utilization of animal models used for this experiment has been permitted by Animal Ethics Committee of UNIMAS with Referral Number, UNIMAS/AEC/T/F07/024.

Data Availability Statement
Data available on request.

Authors Contributions
Mohd. Allif Najmi Musa (MANM) and Madinah Adrus (MA) conceptualized this research and designed experiments; MANM and Mohd Aiman Hakim Ahmad Sabri (MAHAS) participated in the design and interpretation of the data; MANM and MA wrote the paper and participated in the revisions of it. All authors read and approved the manuscript.

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