ASM Sc. J., 13, Special Issue 6, 2020 for InCOMR2019, 73-81

Insect Diversity and Decomposition Pattern of Chicken (*Gallus gallus*) and Fish (*Oreochromis niloticus*) Carrion in Hutan Sri Gading, UiTM Pahang

Roziana Bujang[1*], Muhammad Afnan Syauqi Alias[1], Siti Hajar Samsudin[1], Intan Azzween Natasha Ahmad Razi[1], Nur Athirah Ahmad Zasli[1], and Norhaslinda Arun[2]

[1]*Faculty of Applied Sciences, Universiti Teknologi MARA, Jengka, Pahang, Malaysia*

[2]*Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, Jengka, Pahang, Malaysia*

Study of insect fauna attracted to chicken and fish carrions with the decomposition pattern were conducted in Hutan Sri Gading, Universiti Teknologi MARA, Jengka Campus for a period of seventeen days in August, 2018. Drumstick part of chicken and fish carrions were put at six different locations in Hutan Sri Gading and observations were made every day in first week, once every two days in second week and once every three days in third week at around 9.00 am to 12.00 pm. Five stages of decomposition were recognized; fresh, bloated, active decay, advanced decay, and dry. A total of 16 insect species belonging to four orders and seven families; Drosophilidae, Muscidae, Calliphoridae, Sarcophagidae, Formicidae, Forficulidae, and Scarabaeidae were recorded. The early colonizers to arrive during the fresh stage of decomposition are *Chrysomya megacephala*, *Sarcophaga bercaea*, *Camponotus gigas* and *Crematogaster onusta*. The number of insect species is at most during active stage (7 species) and advanced stage (5 species) for drumstick part of chicken carrions. For fish carrion, the number of insect species is at most during bloated stage (7 species), active stage (7 species) and advanced stage (5 species). On account of their activity and frequency, the Calliphoridae species, *Chrysomya megacephala* were the insects of greatest forensic importance. In this study, the ambient temperatures and relative humidity were recorded throughout the decomposition process. Ambient temperatures and relative humidity showed a reciprocal pattern in all locations where the readings were recorded. These data are the first record of Hutan Sri Gading insects that are associated with decomposition of chicken and fish carrions and can be used as a reference for further study in ecology and forensic entomology.

Keywords: *Gallus gallus*; *Oreochromis niloticus*; forensic entomology

I. INTRODUCTION

All living organism will die and undergo the decomposition process. Decomposition is the process of breaking down an organic material or substance into smaller constituent parts by the action of decomposers. The organisms that usually act as decomposer are the fungi and bacteria. In addition, some insects also contribute to this decomposition process. Different insects are attracted to the difference type of decomposing matter including carrion in order to maintain and balance the ecosystem. Then, they have the potential to be significant evidence in criminal investigations as the subject of forensic entomology (Goff, 2016).

Forensic entomology used the insects and arthropods in forensic analysis and has achieved a lot of importance events since 10 until 15 years ago. In 1998, the first International Seminar on Forensic Entomology was held in Bari/Italy. In Germany, there are many capabilities of that

*Corresponding author's e-mail: roziana2916@uitm.edu.my

development have been hardly used up until now. In 1997, an independent research project of 'Forensic Entomology' was established in Frankfurt (Amendt *et al*., 2000).

The insects are used as evidence to estimate the post-mortem interval (PMI) (Ireland and Turner, 2006). The PMI is the method that will be carried out until several weeks since death. It is very important component in medico-legal investigations. The ecological data of insect that involved in breaking down an organic material process in a certain area need to be authorized.

Wide community of insect are attracted to the decomposition process of carrion which is also important for consumer dynamics at both population and community level. They are a group of decomposers necessary take an advantage on carrion or dead body before other groups take an action. Some are attracted to remains used as a means of oviposition or feeding, while others are attracted by the aggregation of other insects used as a source of food. Insects are essential for breaking down an organic materials or substances of carrion. Different insects are attracted to the difference type of carrion. Thus, this study is carried out in order to determine the insect species that appointment on the different carrion. Szpila *et al*., (2015) stated that a technique which is collects the adult insect, maggots and other immature specimens can be a great compromise of information to determine their tax.

From this study, the species composition and the decomposition pattern of insects in this area can be determined because there is no published data on forensically important insect species yet in Hutan Sri Gading, UiTM Pahang. There is a need to establish an ecological data of insect that involve in decomposition process of carrion in this area. This investigation presents the data on qualitative assessment of dominant insect taxa visiting different type of carrion which are amphibians and aves in Hutan Sri Gading. The results of this study will provide data on important insect decomposer and can serve as a reference for forensic entomology investigations. The objectives of the study are to identify the insect species that visit different types of carrions, drumstick part of chicken (*Gallus gallus*) and fish (*Oreochromis niloticus*) in Hutan Sri Gading and to investigate the effect the relationship of ambient temperature and humidity with decomposition process of carrion.

II. MATERIALS AND METHOD

A. Study Area

This study was carried out at Hutan Sri Gading of Universiti Teknologi MARA Campus Jengka, Pahang (3045'23.7"N, 102034'13.1"E) located 4 km from Bandar Tun Razak, Jengka.

B. Field Method

A total of six carrions were used in this study which are three drumstick part of chickens (*Gallus gallus*) and three fish (*Oreochromis niloticus*). They were placed separately 50 m apart in metal cage 38 cm in diameter and 30cm height to avoid other animals from approaching the carrion. The protection is very important during this study. The protective clothing, mask and glove were used during sampling process to protect from pathogen, pollutant, and contaminants. Tagging warning passer-by was set-up at the study site.

C. Sample Collection and Identification Process

Drumstick part of chicken and fish carrions were put at six different locations in Hutan Sri Gading and observations were made every day in first week, once every two days in second week and once every three days in third week at around 9.00 am to 12.00 pm. The ambient temperature and humidity were recorded and measured by using digital thermometer and environmeter. The aerial net sweeps were used to collect adult insect and were placed in killing jar containing cotton soaked with ethyl acetate as killing agent. This method is effective to retain the good shape and softness of the specimens for further identification. Forceps were used to pick the maggots and other immature specimen and put in vials that contain 70% ethanol. All specimens were labelled based on days and data the specimens were collected. Identification of species were referred to key of insect by Chapman, Simpson and Douglas (2013).

III. RESULT AND DISCUSSION

A. Decomposition Stages in Drumstick Part of Chicken (Gallus gallus) and Fish (Oreochromis niloticus)

There are several different findings in stages of decomposition process. Goff (2010), Ahmad and Ahmad (2009) and Chin *et al*., (2007) stated that the decomposition process were classified into five stages. According to Bharti and Singh (2003), four different stages were classified. From this study, there are five stages of decomposition process in drumstick part of chicken carrion (Figure 1) and fish carrion (Figure 2) which are fresh stage, bloated stage, active stage, advance stage and dry remain stage. The classification of five stages was also used by Martinez *et al*., (2006) for corpses and Apichat *et al*., (2007) for pig carcasses. This observation of decomposition stages was different with observation done by Bharti and Singh (2003) that the experimented in India. In their study, four stages of decomposition process were classified which are fresh stage, bloated stage, decay stage and dry stage. According to Campobasso *et al*., (2001) stated that, there are several factors cause difficulty in observation process which are the age of the corpse, humidity, ventilation, cause of death and constitution. Another factor is different location involve temperature variation.

Fresh stage (Day 1)

Bloated stage (Day 2)

Active stage (Day 3)

Active stage (Day 3)

Advance stage (Day 4-5)

Figure 1. Decomposition stages in drumstick part of chicken (*Gallus gallus*) carrion in Hutan Sri Gading, UiTM Pahang

Fresh stage (Day 1)

Bloated stage (Day 2)

Active stage (Day 3)

Advanced stage (4-7)

Dry stage (Day 8-17)

Figure 2. Decomposition stages of fish (*Oreochromis niloticus*) carrion in Hutan Sri Gading, UiTM Pahang.

B. Identification Insects Species Visiting Different Types of Carrions

This study shows that three orders (Diptera, Coleoptera, Hymenoptera) with six families (Scrabaeidae, Calliphoridae, Drosophilidae, Muscidae, Sarcophagidae, Formicidae) and 12 species (*Onthophagus sulcipennis*, *Chrysomya megacephala*, *Drosophila melanogaster*, *Thricops diaphanus, Sarcophaga bercae, Sarcophaga cannaria, Calomyrmex similis*, *Componatus gigas, Monomorium pharaonis, Odontomachus simillimus, Odontoponera denticulata, Odontoponera transversa*) have been collected on drumstick part of chicken carrion (Table 1). There are four orders (Diptera, Dermaptera, Coleoptera, Hymenoptera) with seven families (Scrabaeidae, Forficulidae, Calliphoridae, Drosophilidae, Muscidae, Sarcophagidae, Formicidae) and 13 species (*Onthophagus sulcipennis*, *Forficula auricularia, Chrysomya megacephala*, *Drosophila melanogaster*, *Thricops diaphanus*, *Sarcophaga bercae*, *Componatus gigas, Crematogaster onusta, Diacamma scalpratum, Monomorium pharaonis, Odontomachus simillimus, Odontoponera denticulata, Odontoponera diversus) have* been collected on fish carrion (Table 1).

In this study, the general pattern of succession of arthropods to carrion was very similar to the five general patterns of succession of arthropods to bodies stated by Wolff *et al.*, (2001). Ants were the first arthropod that attracted on both carrion during fresh stage in my study. Then, the carrion was attracted followed by the flies which started to lay eggs on both carrions. Bloated and active

decay stage begins when decomposition process started by which the flies hatch and eat on carrion cause the carrion to lose their weight. The next stage is advance decay stage where the arthropods started to migrate. The crucial flies such as *Chrysomya megacephala* and *Sarcophaga bercaea* were no presented during this stage. Mostly the arthropod presented were form order Coleptera and Hymenoptera. Arthropod such as from order Diptera (Drosophilidae) and Dermaptera (Forficulidae) were still presented in a small quantity.

Table 1. Species of insects associated with each stage of decaying drumstick part of chicken and fish carrion

Order	Family	Genus/Species	Chicken (*Gallus gallus*)					Fish (*oreochromis niloticus*)				
			Stages					Stages				
			Fresh (1days)	Bloated (2days)	Active (3days)	Advanced (4-5days)	Dry (6-17days)	Fresh (1days)	Bloated (2days)	Active (3days)	Advanced (4-7days)	Dry (8-17days)
Coleoptera	Scarabaeidae	*Onthophagus sulcipennis*	-	-	A	-	-	-	A	A	A	-
Dermaptera	Forficulidae	*Forficula auricularia*	-	-	-	-	-	-	A	A	A	A
Diptera	Calliphoridae	*Chrysomya megacephala*	-	I,A	I,A	-	-	-	I,A	I,A	-	-
	Drosophilidae	*Drosophila melanogaster*	-	-	-	A	-	-	-	A	A	-
	Muscidae	*Thricops diaphanus*	-	-	-	A	-	-	-	A	-	-
	Sarcophagidae	*Sarcophaga bercaea*	-	A	I,A	-	-	-	A	IA	-	-
		Sarcophaga cannaria	-	-	A	-	-	-	-	-	-	-
Hymenoptera	Formicidae	*Calomyrmex similis*	-	-	-	A	-	-	-	-	-	-
		Camponotus gigas	A	A	A	-	-	A	-	-	-	-
		Crematogaster onusta	-	-	-	-	-	A	-	-	-	-
		Diacamma scalpratum	-	-	-	-	-	-	-	A	-	-
		Monomorium pharaonis	-	-	A	-	-	-	A	-	-	-
		Odontomachus simillimus	-	-	-	A	A	-	A	-	A	A
		Odontoponera denticulata	-	-	-	A	A	-	A	-	A	A
		Odontoponera transversa	-	-	A	-	-	-	-	-	-	-
		Pheidologeton diversus	-	-	-	-	-	A	-	-	-	-

Note: I = Immature, A = Adult

Diptera is a dominant order of arthropods that associated with carrion during decomposition process in this study, according to my finding. Diptera and Coleptera are the main insect orders found on the carcass that stated by Turchetto and Vanin (2004). However, a few Coleoptera did not show a clear pattern of succession which is similar with Azwandi *et al.*, (2013). This is may be due to the size of the carrion cause the different duration of decomposition process which is long process taken for a big carcass to complete such as pig compare to my study used. Coleopterans are late comers during the decomposition process, so that if the decomposition process is too short, they may not lay eggs on the remains. It also takes two months for Coleopteran to complete its life cycle (Kulshrestha and Satpathy, 2001). This may be the reason why no beetle larvae were collected in this study. The larval stages play a major role in the decomposition of the carcass.

Ants are the first carrion insect to visit during decomposition because they are also attracted to fresh carrion. However, ants are not normally regarded as a forensically important species (Vitta *et al.*, 2007). In this study, all Hymenoptera order collected are from Formicidae (Calomyrmex similis, Camponotus gigas, Crematogaster onusta, Diacamma scalpratum, Monomorium pharaonis, Odontomachus simillimus, Odontoponera denticulata, Odontoponera transversa and Pheidologeton diversus) family. Four types species from family Formicidae (Pheidologetons diversus, Crematogaster sp., Componatus sp. and Monomorium sp) were also found by Sukchit *et al.*, (2015) during their experiment on pig carcasses. Maramat and Rahim (2015) also found Crematogaster sp. and Odontomachus sp. in their study using rabbit carcasses. Pheidologeton sp. from Formicidae family present on road-killed monkey study by Eddie *et al.*, (2015). Zeariya *et al.*, (2015) found Monomorium pharaonis in their study on dog

and rabbit carcass. They also stated that Hymenoptera (Formicidae), which was observed during the decomposition process, had no effect on the decomposition process. The ants collected are quite similar with my study is due to the same location applied. These habitat species can normally be found in rainforest.

Egg specimens are difficult to collect in this study. Only adult and immature dipterans were collected. There were no eggs collected or identified. This is because the laid eggs are hidden inside the carcass body. Eggs that have been hatched will grow larvae later. During larval phases, there are three larval phases. The larvae were then moulting to the pupa stage, and moults became adult flies. In this study the specific life cycle duration of flies (*Chrysomya megacephala* and *Sarcophaga bercaea*) collected were not well studied and this was difficult to respond to the correct duration of the two flies.

Decomposing carrion supports a wide diversity of several organisms, many of which are insects. Apart from ecological interest, carrion decomposition and succession studies have proven important in forensic entomology. When the sequence of insects colonising carrion is known, an analysis of the insect fauna on a carrion can be used to determine time since death in legal investigations (Anderson and van Laerhoven, 1996). In addition, if an insect can be found exclusively in a rural or urban habitat, analysis of the carrion associated fauna may help to determine whether the remains have been moved from an urban to a rural environment or vice versa (Erzinclioglu, 1983; Catts and Haskell, 1990; Grassberger and Frank, 2004).

C. The Relative Humidity and Ambient Temperature Recorded During Decomposition Process of Carrions

The ranges of daily relative humidity of where the drumstick part of chickens was placed were between 75.3% to 87.1% (mean 81.2% ± 5.9%). Daily relative humidity of where the fish were placed were 71.2% to 85.5% (mean 78.35% ± 7.15%) (Figure 3). The ranges of daily temperature for drumstick part of chicken during collecting the specimen were between 26.8 °C to 29.8 °C (mean 28.3 °C ± 1.5 °C). At the location of fish carrion, the daily temperatures were between 26.4 °C to 29.9 °C (mean 28.15 °C ± 1.75 °C) (Figure 4).

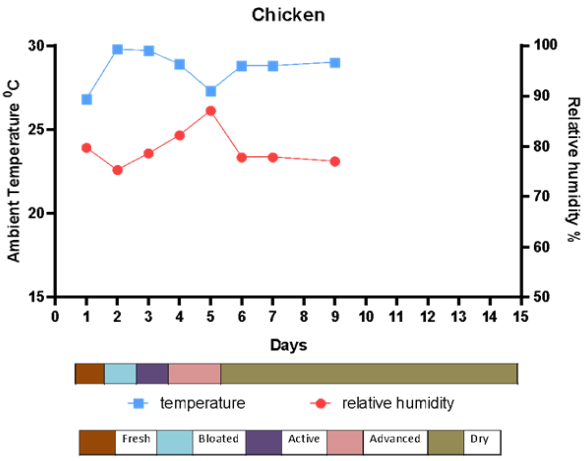

Figure 3. Daily ambient temperature and relative humidity in relation to the decomposition stages of drumstick part of chicken (*Gallus gallus*) carrion

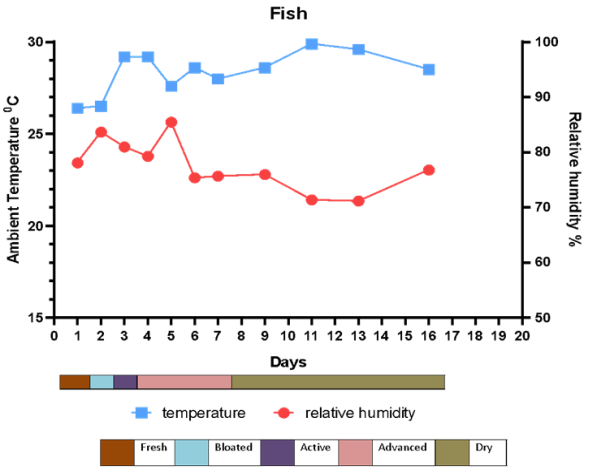

Figure 4. Daily ambient temperature and relative humidity in relation to the decomposition stages of fish (*Oreochromis niloticus*) carrion

Hau *et al.*, (2014) stated that a number of factors, such as environment, temperature, humidity, exposure to the sun, layers and clothing type can affect decomposition processes. Including tropical rainforest in Malaysia, the environmental temperatures, humidity and total rainfall differ from temperate countries in the region. They have distinctive features that support a wide range of species. It means they have a high level of biodiversity. The biotic or living elements of the ecosystem and the abiotic or non-living elements of the ecosystem are mutually dependent. The climate is very wet with more than 2,000 mm annually of rainfall. The average temperature of 28°C per day. The

temperature does not drop below 20°C and seldom exceed 35°C. Tropical rainforest has a wide range of fauna and flora, including insects. The decomposition process can therefore involve various insect species. According to Zeariya *et al*., (2015) stated that many abiotic and biotic factors influence the decomposition rate and the succession of insects to remains, including geographical location, climatic conditions, season, habitat, physical state of the remains and decomposition. A moist environment will hasten decomposition, whereas dryness will slow the rate. This is therefore one possible reason why the tropical rainforests in my study area have relatively low ambient temperatures of 26.4°C to 29.9°C and a higher relative humidity of 71.2 to 87.1 percent during this study.

Figures 3 and 4 show that the ambient temperature and relative humidity have a reciprocal relationship in both carrions. The increased relative humidity is caused by rainy or cloudy days which cause the temperature to fall. In this study, ambient temperature and relative humidity were only recorded during the decay process. However, environmental temperatures can essentially affect the succession of insects during decomposition. Fewer flies attract and lay eggs on the carrion. Anderson (2007) stated that temperature can affect the decay rate by reducing the present maggot mass. Pechal *et al.*, (2014) stated that, the carcasses of the insect exclusion remained in the bloat stage during the first five days of decomposition, whereas those naturally colonized were well advanced in active decomposition. This resulted in significant decomposition differences and emphasized the importance of the assembly of insects in the decomposition process.

In addition, lower ambient temperatures can also influence the maggot growth. Insects are poikilothermic and depend on the temperature to grow successfully. The experiment was conducted by Sharanowski *et al.*, (2008) which is the carcass were placed in three different seasons. Sun-exposed carrion had greater variation in fauna than shaded carrion in spring and fall. Therefore, the decomposition rate may increase during the sunny days. Since maggots play important roles such as a carcass decomposer, favourable ambient temperatures and humidity are essential for optimum decomposition (Benecke, 2001).

IV. CONCLUSION

In conclusion, 16 species with a total of seven families and four orders have been collected manually from six carrions. Three orders were presented on three carrion of chicken, namely Dipteran, Coleopteran and Hymenopteran. Four orders including Dermaptera were collected on three carrion of fish. *Chrysomya megacephala* (Calliphoridae) and *Sarcophaga bercaea* (Sarcophagidae) are common species visiting all nine carrion in this study. Another genus was collected are *Drosophila* sp. (Drosophilidae) and *Thricops* sp. (Muscidae). Forficula auricularia (Forficulidae) from order Dermaptera was only species collected on fish carrion. Flies (Diptera) especially *Chrysomya megacephala*, plays important roles in this study as a decomposition insect in order to decompose all carrion during the decomposition process.

Temperature and relative humidity have been among the main factors affecting the rate of decay. The ambient temperatures and humidity were recorded in this study. Both parameters during the experiment have been found to be quite constant. Insect species that were found during this study may differ from other studies due to geographical factors such as area and climate but there were quite similar in succession pattern.

It is recommended this study should be continued using various animal models that bigger size and more closely resemble to humans' body. The duration of the study should be longer and more replicates in order to obtain more precise results. Future studies should deal with extending not only to low-lying areas but also to high-altitude areas in other parts of tropical rainforest to obtain more ecological data on forensically important insects. Data on insect succession may be important in the investigation of forensic activities. This study is the first standard study on the decomposition of insects, especially in tropical rainforest. This study could therefore encourage other researchers to do more research in this field, as more information can be provided for ecological studies and forensic entomology research.

V. ACKNOWLEDGEMENTS

The authors would like to thank all the staffs from Faculty of Applied Sciences, UiTM Jengka Campus. The authors would like to convey our gratitude to laboratory assistants who help in this research successfully.

VI. REFERENCES

Ahmad, A, & Ahmad, AH 2009 'A preliminary study on the decomposition and dipteran associated with exposed carcasses in an oil palm plantation in Bandar Baharu, Kedah, Malaysia', *Tropical Biomedicine*, vol. 26, no. 1, pp. 1-10.

Amendt, J, Krettek, R, Niess, C, Zehner, R, & Bratzke, H 2000, 'Forensic entomology in Germany', in *Forensic Science International*, vol. 113, pp. 309–314.

Anderson GS & Van Laerhoven, SL 1996, 'Initial study on insect succession carrion in South Western British Columbia', *Journal Forensic Science*,vol. 41, pp. 617-625.

Apichat, V, Wilawan, P, Udomsak, T. Chanasorn, P, & Saengchai, N 2007, 'A preliminary study on insects associated with pig (*Sus scrofa*) carcasses in Phitsanulok, Northern Thailand', *Tropical Biomedicine*, vol. 24, no. 2, pp. 1–5.

Anderson, GS, 2007, 'Forensic entomology: the use of insect in death investigation', viewed 28th November 2018, <http://www.sfu.ca/~ganderso/forensicentomology.htm>.

Azwandi, A, Nina Keterina, H, Owen, LC, Nurizzati, MD, & Omar, B 2013, 'Adult carrion arthropod community in a tropical rainforest of Malaysia: Analysis on three common forensic entomology animal models', *Tropical Biomedicine*, vol. 30, no. 3, pp. 481–494.

Benecke, M, 2001, 'A brief history of forensic entomology', *Forensic Science International*, vol. 120, no. (1-2), pp. 2-14.

Bharti, M, & Singh, D 2003, 'Insect Faunal Succession on Decaying Rabbit Carcasses in Punjab, India', *Journal of Forensic Sciences*, vol. 48, no. 5, pp. 1–11.

Campobasso, CP, Vella, GD & Introna, F, 2001, 'Factors affecting decomposition and diptera colonization', *Forensic Science International*, vol. 120, pp. 18-27.

Catts EP & Haskell NH 1990, 'Entomology and death: a procedural guide', Joyce's Print Shop Inc., Clemson, pp. 1 - 182.

Chapman, R, Simpson, SJ, & Douglas, AE 2013, 'The insects: structure and function', 5th edn, Cambridge University Press, Cambridge, United Kingdom.

Chin, HC, Mohamad, AM, Ahmad, FMS, Jeffery, J, & Omar, B 2007, 'A preliminary study of insect succession on a pig carcass in a palm oil plantation in Malaysia', *Tropical Biomedicine*, vol. 24, no. 2, pp: 23-27.

Eddie I, Chua TH, Hiu J 2016, 'Diversity of forensically important insects in Sabah', *Borneo Journal of Medical Sciences*, vol. 10, no. 1, pp. 30-35.

Erzinclioglu, YZ 1983, 'The application of entomology to forensic medicine', *Medical Science and the Law*, vol. 23, pp. 57-63.

Goff, ML 2010, 'Early postmortem changes and stages of decomposition' in *Current Concepts in Forensic Entomology,* Springer, Netherlands, pp. 1–24.

Goff, ML 2016, 'Entomology', in *Encyclopedia of Forensic and Legal Medicine,* 2nd edn., Elsevier, pp. 428–434.

Grassberger, M, & Frank, C 2004, 'Initial study of arthropod succession on pig carrion in a central European urban habitat', *Journal of Medical Entomology,* vol. 41, pp. 511-523.

Hau, TC, Hamzah, NH, Lian, HH, & Hamzah, S 2014, 'Decomposition process and postmortem changes: review', *Sains Malaysiana*, vol. 43, no. 12, pp. 1873–1882.

Ireland, S, & Turner, B 2006, 'The effects of larval crowding and food type on the size and development of the blowfly, *Calliphora vomitoria*', *Forensic Science International*, vol. 159, no. 2–3, pp. 175–181

Kulshrestha, P, & Satpathy, DK 2001, 'Use of beetles in forensic entomology', *Forensic Science International,* vol. 120, no. 1-2, pp. 15-17.

Maramat R, & Rahim NAA 2015, 'Forensically important flies associated with decomposing rabbit carcasses in mangrove forests in Kuching, Sarawak, Malaysia', *Malaysian Journal of Forensic Sciences*, vol. 6, no. 1 1, pp. 79-83.

Martinez, E, Duque, P & Wolff, M, 2006, 'Succession pattern of carrion feeding insects in Paramo, Colombia', *Forensic Science International*, vol. 166, no. 2-3, pp.182-189.

Pechal, JL, Benbow, ME, Crippen, TL, Tarone, AM, & Tomberlin, JK 2014, 'Delayed insect access alters carrion decomposition and necrophagous insect community assembly', *Ecosphere*, vol. 5, no. 4, pp.1-21.

Sharanowski, BJ, Walker, EG, & Anderson, GS 2008, 'Insect succession and decomposition patterns on shaded and sunlit carrion in Saskatchewan in three different seasons', *Forensic Science International*, vol 179, no. 2–3, pp. 219–240.

Szpila, K, Mądra, A, Jarmusz, M, & Matuszewski, S 2015, '*Flesh flies (Diptera:Sarcophagidae) olonizing large carcasses in Central Europe*', *Parasitology Research*, vol. 114, no. 6, pp. 2341-2348.

Turchetto, M, & Vanin, S 2004, 'Forensic entomology and climatic change', *Forensic Science International,* vol. 146, no. 1, pp 207-209.

Vitta, A, Pumidonming, W, Tangchaisuriya, U, Poodendean, C, & Nateeworanart, S 2007, 'A preliminary study on insect associated with pig (*Sus scrofa*) carcasses in Phitsanulok, Northern Thailand', *Tropical Biomedicine,* vol. 24, no. 2, pp. 1 -5.

Wolff, M, Uribe, A, Ortiz, A, & Duque, P 2001, 'A preliminary study of forensic entomology in Medellin, Colombia', *Forensic Science International*, vol. 120, pp. 53-59.