COMPOSITION AND LIFE CYCLES OF NECROPHAGOUS FLIES INFESTING WRAPPED AND UNWRAPPED RABBIT CARCASSES IN JOHOR FOR FORENSIC APPLICATIONS

NUR NAJWA BINTI ZULKIFLI

FACULTY OF SCIENCE
UNIVERSITI TEKNOLOGI MALAYSIA

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NUR NAJWA BINTI ZULKIFLI

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To my beloved family and friends

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ABSTRACT

In forensic cases, corpses are frequently discovered wrapped in some material, probably as a means for disguising, as well as enabling easier handling and preventing evidence transfer. The use of such wrapping materials may affect insect colonization patterns, which in turn causing erroneous estimation of post-mortem interval (PMI). Hence, this present study utilized rabbit carcasses wrapped in a used rug with both sides remained open provided empirical data on species composition and completion of life cycles of necrophagous flies infesting in Johor, Malaysia. Result does not revealed differences in species composition between the wrapped and unwrapped rabbit carcasses. Six necrophagous fly species (*viz. Chrysomya megacephala, Chrysomya rufifacies, Hemipyrellia tagaliana, Ophyra chalcogaster, Ophyra spinigera* and unidentified Sarcophagidae) were consistently observed in all the decomposing wrapped and unwrapped rabbit carcasses during the three replicate experiments. While completion of life cycle for Sarcophagidae was not observed during the 30 days period of observation, completion of life cycles for the remaining five species i.e. *C. megacephala* (7.66-7.91 days), *C. rufifacies* (8.33-8.50 days), *H. tagaliana* (~14 days), *O. chalcogaster* (~15 days) and *O. spinigera* (~16 days) were observably similar in all the carcasses examined in this present study. Since forensic entomological baseline data for Johor on oviposition and completion of life cycle for these necrophagous flies remain unreported, the results reported here may prove useful for estimating minimum PMI *via* entomological assessment within this region or within the similar biogeoclimatic conditions.

ABSTRAK

Dalam kes forensik, mayat sering ditemui dibungkus menggunakan bahan tertentu dengan tujuan menyembunyikan mayat serta memudahkan pengendalian dan mengelakkan pemindahan bukti. Penggunaan bahan pembungkus berkemungkinan mempengaruhi corak infestasi serangga yang kemudiannya menyebabkan kesalahan dalam menganggar sela-masa kematian (PMI). Justeru, kajian ini menggunakan bangkai arnab yang dibungkus menggunakan ambal terpakai dengan kedua belah hujungnya dibiarkan terbuka menyediakan data empirikal komposisi spesies dan kitar hidup lengkap lalat nekrophagus yang menginfestasi bangkai arnab di Johor, Malaysia. Hasil kajian tidak menunjukkan perbezaan dalam komposisi spesis antara bangkai arnab yang dibungkus dengan yang tidak dibungkus. Enam spesis lalat necrophagous (iaitu *C. megacephala*, *C. rufifacies, H. tagaliana, O. chalcogaster, O. spinigera* dan Sarcophagidae yang tidak dapat dikenalpasti) dapat diperhatikan secara konsisten pada semua bangkai arnab yang dibungkus dan juga tidak berbungkus dalam ketiga-tiga replikat eksperimen. Meskipun kitar hidup lengkap Sarcophagidae tidak diperhatikan sepanjang 30 hari pemerhatian, kitar hidup lengkap lima spesis yang lain i.e. *C. megacephala* (7.66-7.91 hari), *C. rufifacies* (8.33-8.50 hari), *H. tagaliana* (~14 hari), *O. chalcogaster* (~15 hari) dan *O. spinigera* (~16 hari) didapati serupa dalam semua bangkai arnab yang dikaji. Memandangkan, data asas entomologi forensik di Johor berkenaan pengovipositan dan tempoh kitar hidup lengkap untuk lalat nekrofagus belum lagi dilaporkan, hasil kajian ini mungkin berguna dalam menganggar PMI menerusi penilaian entomologi dalam rantau ini atau kawasan yang memiliki biogeoklimatik yang serupa.

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LIST OF ABBREVIATIONS

a.m.	-	*ante meridiem*
ADD	-	Accumulated degree days
ADH	-	Accumulated degree hours
ANOVA	-	Analysis of Variance
C. megacephala	-	*Chrysomya megacephala*
C. rufifacies	-	*Chrysomya rufifacies*
CGS	-	Crow-Glassman Scale
cm	-	Centimetre
CO1	-	Cyctochrome oxidase 1
CO11	-	Cytochrome oxidase 2
DNA	-	Deoxyribonucleic acid
e.g.	-	Exampligratia (For example)
etc.	-	Et cetera
H. tagaliana	-	*Hemipyrellia tagaliana*
i.e.	-	In essence
Inc.	-	Incorporation
IQR	-	Inter Quartile Range
kg	-	Kilogram
KOH	-	Potassium Hydroxide
mm	-	Millimetre
O. chalcogaster	-	*Ophyra chalcogaster*
O. spinigera	-	*Ophyra spinigera*
p.m.	-	*post meridiem*
PMI	-	Post-mortem interval
SD	-	Standard Deviation

sp	-	species
Viz.	-	Videlicet (namely)

LIST OF SYMBOLS

%	-	Percentage
℃	-	Degree Celsius
~	-	approximately
±	-	Plus-minus sign
↔	-	Rain throughout the day
Δ	-	Rain in the forenoon
●	-	Rain during the night
◊	-	Rain in the afternoon
‡	-	Intermittent rain
Ø	-	No rain
α	-	Alpha

CHAPTER 1

INTRODUCTION

1.1 Background

Forensic entomology is a subdivision of forensic science (Gennard, 2007) that originates from two Greek words i.e. *entomon* (insects) and *logos* (study) (Hogue, 1993). Forensic entomologist mainly deals with insect evidence recovered from dead bodies for estimating the post-mortem interval (PMI) i.e. the time elapsed between death and the discovery of the body (Eberhardt and Elliots, 2008). It has been indicated that within 72 hours of death, pathological changes such as rigor mortis, algor mortis, and livor mortis would provide reasonably accurate information to forensic pathologist for estimating PMI (Gennard, 2007). However, such pathological changes would no longer provide reliable information for estimating PMI as the duration of discovery exceeded that of 72 hours after death. In such situation, entomological evidence have been reported to provide more reliable estimation of PMI (Gennard, 2007; Mahat and Jayaprakash, 2013).

In general, estimation of PMI using entomological evidence relies largely on the fact that insects are poikilotherms i.e. they are unable to regulate body temperature for sustaining biochemical processes (Higley and Haskell, 2001). Studies further

reveal that the oviposition and developmental patterns of necrophagous insects vary according to variations in biogeoclimatic conditions (Goff, 2009) (e.g. habitat and rainfall) and presence of toxic substances (Mahat *et al.*, 2009; Kelly *et al.*, 2009a), as well as physical condition of the decomposing body (Mahat *et al.*, 2016). Because mitigation of insect development by any factors e.g. biogeoclimatic conditions and presence of drugs and poisons can potentially alter its oviposition and developmental patterns (Goff and Lord, 2010), conducting forensic entomological studies across the varying conditions and habitats appears necessary (Mahat *et al.*, 2014).

It has been indicated that the presence of ammonia-rich compounds and moisture within the decomposing body being a factor that attracts colonization of necrophagous insects, usually within minutes of death (Abd-Rashid *et al.*, 2008b). In view of the categorical roles of insects, Smith (1986) divided them into (a) necrophagous species, (b) predators and parasite of necrophagous species, (c) omnivorous species and (d) adventive species. Being the primary colonizers on corpses and carcasses during the early stage of decomposition, necrophagous species especially Calliphoridae have been responsible for majority of the biomass loss (Anderson, 2010).

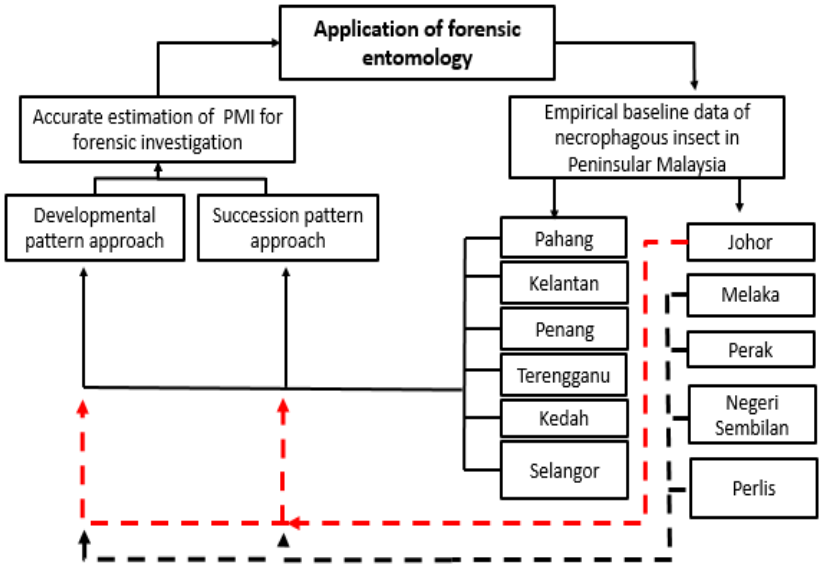
In this context, it is pertinent to indicate that about 500 murder cases are reported yearly in Malaysia (Kosmo, 11 September 2017), and in many cases the bodies were recovered wrapped, probably as a means to cover/hide the bodies. For example, a body of a boy wrapped using a blanket was found hidden in a barrel in a house in Paya Nahu Flat, Sungai Petani, Kedah (Utusan Malaysia, 24 November 2016). In another case example, a body of a boy wrapped in a black plastic bag was found in a drain in Kepong, Selangor (Berita Harian, 21 July 2017). Considering the circumstances surrounding death of such cases, specific forensic entomological studies focussing on the influence of varying wrapping materials/methods merit forensic significance.

In addition to estimation of PMI, entomological evidence especially those from Calliphorid flies have been indicated as useful for determining the presence of antemortem wounds (Eberhardt and Elliots, 2008), suggesting the possible cause of death (Gennard, 2007; Mahat *et al.,* 2012) and secondary disposal (Campobasso *et al.,* 2001), as well as human identification (Goff, 2009). Interestingly, while species composition and development of necrophagous insects infesting dead bodies and animal carcasses in several states in Malaysia (Mahat and Jayaprakash, 2013) have been reported, the same for other states such as Johor, the southernmost part of Peninsular Malaysia, remains unreported so far.

1.2 Statement of the Problem

Being an integral aspect for forensic investigation, estimation of PMI using entomological evidence can be made by interpreting (a) the life cycle stages of the oldest necrophagous species recovered from the corpse, as well as (b) succession of the different species of insects on the decomposing body (Gennard, 2007). While interpretation of the life cycle for the oldest necrophagous species may provide the minimum PMI estimate (hours to about a week) (Gennard, 2007; Mahat *et al.*, 2009), larger spectrum of estimate (weeks to years) can be provided by interpreting the succession of insects (Anderson, 2010). Because of differences in species composition and duration for completing the life cycle among necrophagous insects due to differences in biogeoclimatic regions have been reported, estimating PMI using the baseline data established in a specific region for another, may prove inappropriate (Anderson, 2010). This aspect triggers the needs for establishing specific entomological baseline data for various biogeoclimatic regions for forensic application.

In forensic cases, corpses are frequently recovered wrapped in some material, probably as a means for disguising, as well as facilitating easier handling and preventing blood stains transfer. In this aspect, accessibility of insects to the body (Voss *et al.*, 2011), as well as the type and extent of wrapping (Anderson, 2010) are factors affecting insect colonization patterns. It has been reported that, wrapping and clothing may initially prevent insect accessibility, however, upon establishment of maggot masses, the clothing and wrapping may provide suitable shelter and microclimate for insects to develop (Kelly *et al.*, 2009b). Interestingly, while general studies on the influence of wrapping on necrophagous insects have been reported, an issue pertaining to the thickness of the material that may have influenced oviposition and life cycles remains unreported, so far. Hence, considering (a) the usefulness of entomological evidence in forensic investigation and (b) because empirical baseline data for composition of necrophagous flies in both wrapped and unwrapped rabbit carcasses in Johor remain unreported, this present study that addresses such important aspects acquires forensic consideration. Putting in forensic perspective within Peninsular Malaysia, the theoretical framework for this present study is presented in Figure 1.1.



Note: Dotted lines represent the incomplete forensic entomology empirical baseline data in Peninsular Malaysia with red ones indicating this present study.

Figure 1.1: Research theoretical framework.

1.3 Objectives and Hypothesis

Considering all the aspects discussed above, this present study was designed:

1. To study the species compositions of necrophagous flies on wrapped and unwrapped rabbit carcasses decomposing in Johor, Malaysia.
2. To compare the oviposition and duration for completing life cycles for necrophagous flies on wrapped and unwrapped rabbit carcasses decomposing in Johor, Malaysia.

It was hypothesized that the duration for completing life cycles for necrophagous flies would be significantly different between wrapped and unwrapped rabbit carcasses.

1.4 Scope of the Study

This present study focused on the composition and completion of life cycles for necrophagous flies infesting wrapped and unwrapped male domestic rabbit (*Oryctolagous cuniculus*) carcasses (1.5-2.0 kg) decomposing during August-October 2016 within the Universiti Teknologi Malaysia (UTM) Johor Bahru Campus. While the wrapped carcasses were wrapped in a layer of used rug (length: 43cm, width: 32cm; thickness: 0.8cm) with both ends remained open, unwrapped carcasses were left to decompose on the ground without wrapping. Following the entomological observation method prescribed by Mahat *et al.* (2016), presence of oviposition, larvae, pre-pupae, pupae and emergence of tenerals, as well as ambient and carcass temperatures, total daily rainfall and humidity were recorded.

1.5 Significance of the Study

The data gathered in this study elucidated for the first time, the species composition and completion of life cycles for necrophagous flies infesting wrapped and unwrapped rabbit carcasses decomposing in Johor, Malaysia. In view of its practical values in forensic investigations of unnatural deaths, this present study would pave the way for completing the forensic entomological baseline data for Malaysia. The data can be particularly useful for estimating the time interval since death for human bodies as well as wildlife animals wrapped with similar wrapping materials/methods for forensic investigations in Malaysia and other countries with similar biogeoclimatic conditions.

REFERENCES

Abd El-Bar, M.M. and Sawaby, R.F. (2011). A preliminary investigation of insect colonization and succession on remains of rabbits treated with an organophosphate insecticide in El-Qalyubiya Governorate of Egypt. *Forensic Science International.* 208 e26-e30.

Abd. Razak Osman (2016, Nov 24). Polis nafi mayat kanak-kanak mangsa dera diawet. *Utusan Malaysia Online,* Retrieved Sept 11, 2017, from http://www.utusan.com.my/berita/jenayah/polis-nafi-mayat-kanak-kanak-mangsa-dera-diawet-1.411771.

Abd-Rashid, R., Khairul, O., Mohd. Iswadi, I., Zuha, R.M., and Rogayah, A.H. (2008b). Determination of malathion levels and the effect of malathion on the growth of Chrysomya megacephala (Fabricius) in malathion exposed rat carcass. *Tropical Biomedicine.* 25: 184-190.

Abd-Rashid, R., Siti, A.S., Siti, F.R., Reena, A.R., Sharifah, S.S., Nurul, F.Z., and Nazni, W.A. (2008a). Forensic implications of blowfly *Chrysomya rufifacies* (Calliphoridae: Diptera) development rates affected by ketum extract. *World Academy of Science, Engineering and Technology* 79.

Ahmad, A. and Ahmad, A. H (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* 26: 1-10.

Ahmad, A., Abu Hassan, A., Dieng, H., Satho, T., Ahmad, H., Aziz, A.T. and Boots, M. (2011). Cadaver Wrapping and Arrival Performance of Adult Flies in an Oil Palm Plantation in Northern Peninsular Malaysia. *Journal Medical Entomology* 48(6): 1236-1246.

Al-Misned, F.A.M. (2004). Effect of temperature on development and mortality of immature *Sarcophaga* (*Liosarcophaga*) *dux* Thomson (Diptera: Sarcophagidae). *Journal King. Saud. Univ. Agri. Science.* 16:53-60.

Alwar, V.S. and Seshiah, S. (1958). Studies on the life history and bionomics of *Sarcophaga dux* Thomson. *Indian vet. Journal.* 35:559-565.

Amendt, J., Krettek, R., and Zehner, R. (2004). Forensic Entomology, Naturwissenschaften, 91 51-65.

Anderson, G.S. (2010) Factors that influence insect succession on carrion. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*, 201-50.

Anderson, G.S. and Cervenka, V.J. (2002). Insect associated with the body: their use and analysis. In Sorg, M.H. and Huglund, W.D. (editors). Advances in forensic taphonomy: method, theory and archeological perspectives. Boca Raton, FL: CRC Press, 173-200.

Aubernon, C., Charabidzé, D., Devigne, C. and Delannoy, Y. (2001). Experimental study of *Lucilia sericata* (Diptera Calliphoridae) larval development on rat cadavers: Effects on climate and chemical contamination. *Forensic Science International.* 253 125-130.

Azwandi, A., Nina Katerina, H., Owen, L.C., Nurizzati, M.D. and Omar, B. (2013). Adult carrion arthropod community in a tropical rainforest of Malaysia: analysis on three common forensic entomology animal models. *Tropical Biomedicine.* 30(3): 481-494.

Bansode, S.A., More, V.R., and Zambare, S.P. (2016). Effect of Different Constant Temperature on the Life Cycle of a Fly of Forensic Importance *Lucilia cuprina*. *Entomol Ornithol Herpetol* 5:183.

Benecke, M. (2001). A brief history of forensic entomology. *Forensic Science International* 120 2-14.

Benecke, M. and Wells, J.D. (2001). DNA techniques for forensic entomology. In: J.H., Byrd, and J.L., Castner, (editors). Forensic Entomology: The Utility of Arthropods in Legal Investigation. *Boca Raton, Florida: CRC Press.* p 341-352.

Beyer, J.C., Enos, C.W. and Stajic, M., (1980). Drug identification through analysis of maggots. *Journal of Forensic Science.* 25: 411-412.

Bharti, M. and Singh, D., (2003). Insect faunal succession on decaying rabbit carcasses in Punjab, India. *Journal of Forensic Science* 48 (5): 1133-1143.

Bourel, B., Martin-Boyer, L., Hedouin, V., Revuelta, E., and Gosset, E. (1995). Estimation of post mortem interval by arthropod study: The case of a corpse wrapped in a plastic bag. *Paper presented at 47th Annual Meeting of the American Academy of Forensic Sciences, Seattle.*

Bourel, B., Tournel, G., Hedouin, V., Deveaux, M., Goff, M. L. and Gosset, D. (2001). Morphine extraction in necrophagous insects remains for determining ante-mortem opiate intoxication. *Forensic Science International.* 120:127–31.

Bulletin Cuaca Bulanan (October, 2016). Jabatan Meteorologi Malaysia, Kementerian Sains, Teknologi dan Inovasi (MOSTI) retrieved at www.met.gov.my/web/metmalaysia/publications/bulletinpreview/monthlyweather.

Byrd, J.H. and Allen, J.C., (2001). Computer modeling of insect growth and its application to forensic entomology. In*:* J.H., Byrd, and J.L., Castner, editors. Forensic Entomology: The Utility of Arthropods in Legal Investigation. *Boca Raton, Florida: CRC Press.* p 303-330.

Byrd, J.H., Lord, W.D., Wallace, J.R. and Tomberlin, J.K. (2010). Collection of Entomological Evidence during Legal Investigation. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*, 201-50.

Campobasso, C.P. and Introna, F. (2001). The forensic entomologist in the context of the forensic pathologist role. *Forensic Science International.* 120 132-139.

Campobasso, C.P., Di Vella, G. and Introna, F. (2001). Factor affecting decomposition and Diptera colonization, *Forensic Science International.* 120 18-27.

Catts, E.P. and Goff, M.L. (1992). Forensic entomology in criminal investigation. *Annual Review of Entomology.* 37: 253-272.

Catts, E.P. and Haskel, N.H. (1990). Entomology and Death: a procedural guide. *Joyce's Print Shop, Cherson. SC.*

Cavalho, L.M.L., Linhares, R.X. and Palhares, F.A.B. (2012). The effect of cocaine on the development rate of immatures and adults of *Chrysomya alboceps* and *Chrysomya putoria* (Diptera: Calliphoridae) and its importance to postmortem interval estimate. *Forensic Science International.* 220 27-32.

Cavalho, L.M.L., Thyssen, P.J., Linhares, R.X. and Palhares, F.A.B. (2000). A checklist of arthropods associated with pig carrion and human corpses in Southeastern Brazil. *Member of Institute Oswaldo Cruz.* 95, 135-138.

Centeno, N., Maldonado, M., and Olivia, A. (2002). Seasonal pattern of arthropods occurring on sheltered and unsheltered pig carcasses in Buenos Aires province (Argentina). *Forensic Science International,* 126 63-70.

Clarkson, C.A., Hobischak, N.R. and Anderson, G.S. (2004). A comparison of the developmental rate of *Protophormia terraenovae* (Robineau-Desvoidy) raised under constant and fluctuating temperature regimes. *Can. Society Forensic Science Journal* 37(2): 95-101.

Davies, L. and Ratcliffe, G.G. (1994). Development rates of some pre-adult stages in blowflies with reference to low temperatures. *Medical Veterinary Entomology*. 8 245-254.

Denno, R. F., and Cothran, W. R. (1976). Competitive interaction and ecological strategies of sarcophagid and calliphorid flies inhabiting rabbit carrion. *Annals of the Entomological Society of America 69:109–13.*

Early, M. and Goff, M.L. (1986). Arthropod succession patterns in exposed carrion on the Island of Oahu, Hawaii. *Journal of Medical Entomology* 23: 520-531.

Eberhardt, T.L. and Elliot, D.A. (2008). A preliminary investigation of insect colonization and succession on remains in New Zealand. *Forensic Science International*, 176, 217-223.

Erzinclioglu, Z. (1989). Entomology and the forensic scientist: How insects can solve crimes. *Journal of Biology and Education* 23:300–2.

Evidence Act 1950 (Act 56). *Percetakan Nasional Malaysia Berhad.*

Forbes, S.L. and Dadour, I. (2010). The Soil Environment and Forensic Entomology. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*, 201-50.

Gennard, D.E. (2007). Forensic Entomology- An Introduction. *Hoboken, NJ: John Wiley and Sons.*

Goff, M.L. (1992). Problems in Estimation of Postmortem Interval Resulting from Wrapping of the Corpse: A Case Study from Hawai, *Journal of Agric. Entomology*. 9(4):237·243.

Goff, M.L. (2009). Forensic Entomology. In: Resh, V.H. and Cardé, R.T. (editors). Encyclopedia of Insects. *Academic Press.* Pp. 381-386.

Goff, M.L. (2010). Decomposition Stages. In: Amendt, J., Goff, M.L., Campobasso, C.P. and Grassberger, M. (editors). Current Concepts in Forensic Entomology. *Springer Dordrecht Heideiberg. London, New York.*

Goff, M.L. and Lord W.D. (2010). Entomotoxicology, insect as toxicological indicators and the impact of drugs and toxins on insect development. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*; 427-36.

Goff, M.L. and Lord, W.D. (1994). Hanging out at sixteenth hole: problems in estimation of postmortem interval using entomological technique in cases of death

by hanging. *46th American Academy of Forensic Sciences Annual Meeting, San Antonio, Texas.*

Goff, M.L. and Lord, W.D., (2001). Entomotoxicology: Insects as toxicological indicators and the impact of drugs and toxins on insect development. In*:* J.H., Byrd, and J.L., Castner, editors. Forensic Entomology: The Utility of Arthropods in Legal Investigation. *Boca Raton, Florida: CRC Press*. p 331-340.

Goff, M.L., Miller, M.L., Paulson, J.D., Lord, W.D., Richards, E. & Omori, A.I., (1997) Effects of 3,4-methylenedioxymethamphetamine in decomposing tissues on the development of *Parasarcophaga ruficornis* (Diptera: Sarcophagidae) and detection of the drug in postmortem blood, liver tissues, larvae and puparia. *Journal Forensic Science*. 42: 276-280.

Greenberg, B. Kunich, J.C. (2002). Entomology and the law – Flies as forensic indicator. *Cambridge, U.K: Cambridge University Press*.

Gunatilake, K. and Goff, M.L. (1989) Detection of organophosphate poisoning in a putrefying body by analyzing arthropod larvae. *Journal Forensic Science.* 34 (3): 714-716.

Haefner, J. N., Wallace, J. R. and Merritt, R. W. (2004). Pig decomposition in lotic aquatic systems: The potential use of algal growth in establishing a postmortem submersion interval (PMSI). *Journal of Forensic Science.* 49:330–36.

Hall, R.D. (2001). Introduction-perception and status of forensic entomology. In*:* J.H., Byrd, and J.L., Castner, editors. Forensic Entomology: The Utility of Arthropods in Legal Investigation. *Boca Raton, Florida: CRC Press.* p 1-16.

Hall, R.D. (2010). The Forensic Entomologist as Expert Witness. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*, 201-50.

Hall, R.D. and Huntington, T.E. (2010) Introduction: Perceptions and Status of Forensic Entomology. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*, 201-50.

Harvey, M., Dadour, I. and Gaudieri, S. (2003). Mitochondrial DNA cytochrome oxidase 1 gene: potential for distinction between immature stages of some forensically important fly species (Diptera) in Western Australia. *Forensic Science International.* 131: 134-139.

Hedouin, V., Bourel, B., Becart, A., Tourel, G., Deveaux, M., Goff, M.L. & Gosset, D., (2001). Determination of drug levels in larvae of *Protophormia terraenovae* and *Calliphora vicina* (Diptera: Calliphoridae) reared on rabbit carcasses containing morphine. *Journal Forensic Science.* 46 (1): 12-14.

Heo, C.C., Latif, B., Silahuddin, S.A., Nazni, W.A., and Omar, B. (2015). Morphological descriptions on the larvae of *Hypopygiopsis humipennis* (Walker, 1856) (Diptera: Calliphoridae). *Tropical Biomedicine.* 32(1): 151-159.

Heo, C.C., M.A. Marwi, R. Hashim, N.A. Abdullah,C.D. Chen, J. Jeffrey, H. Kurahashi, and O. Baharudin. (2009b) Ants (Hymenoptera: Formicidae) associated with pig carcasses in Malaysia. *Tropical Biomedicine.* 26:106-109.

Heo, C.C., Marwi, M.A., Jeffery, J. and Omar, B. (2008a). Insect succession on a decomposing piglet carcass placed in a man-made freshwater pond in Malaysia. *Tropical Biomedicine.* 25(1): 23-29.

Heo, C.C., Marwi, M.A., Mohd Salleh, A.F., Jeffery, J. and Omar, B. (2007). A preliminary study of insect succession on a pig carcass in a palm oil plantation in Malaysia. *Tropical Biomedicine* 24 (2): 23-27

Heo, C.C., Marwi, M.A., Mohd. Salleh, A.F., Jeffery, J., Kurahashi, H. and Omar, B. (2008b). Study of insect succession and rate of decomposition on a partially burned pig carcass in an oil palm plantation in Malaysia. *Tropical Biomedicine.* 25(3): 202–208

Heo, C.C., Sulaiman, S., Othman, H., Jeffery, J., Kurahashi, H. and Omar, B. (2010). Insect succession associated with a hanging pig carcass placed in an oil palm plantation in Malaysia. Sains Malaysiana 39(6): 921-926.

Heo, C.C., W.A. Nazni, H.L. Lee, J. Jeffery, O. Baharudin, C.D. Chen, K.W. Lau, and M.A Sofian. (2009a) Predation on pupa of Chrysomya rufifacies (Macquart) (Diptera: Calliphoridae) by parasitiod, Exoristobia philippinensis Ashmead (Hymenoptera: Encyrtidae) and Ophyra spinigera larva (Diptera: Muscidae). *Tropical Biomedicine.* 26: 369-372.

Herrero, S., (2003). Legal issues in forensic DNA. In: S.H., James and J.J., Nordby editors. Forensic science: an introduction to scientific and investigative techniques. *Boca Raton, Florida: CRC Press.* p 581-596.

Higley, L.G., Haskell, N.H., (2001). Insect development and forensic entomology. In: J.H., Byrd and J.L., Castner, editors. *Forensic Entomology: The Utility of Arthropods in Legal Investigation*. Boca Raton, Florida: CRC Press. p 287-302.

Hogue, C.L. (1993). Latin American Insects and Entomology. *University of California Press, Berkeley, Los Angeles.*

Introna, F., Campobasso, C.P. and Di Fazio, A. (1996). Forensic entomology activity in Southern Italy: an entomological study on animal corpses, Firenze, Italy, *Tip. TAF Firenze,* 756 (abstract 23-080).

Introna, F., Campobasso, C.P. and Goff, M.L., (2001). Entomotoxicology. *Forensic Science International.* 120: 42-47.

Introna, F.J., LoDico, C., Caplan, Y.H. and Samlek, J.E., (1990). Opiate analysis of cadaveric blowfly larvae as an indicator of narcotic intoxication. *Journal Forensic Science.* 35: 118-122.

Joseph, I., Mathew, D.G., Sathyan, P. and Vargheese, G. (2011). The use of insects in forensic investigations: an overview on the scope of forensic entomology. *Journal of Forensic Dental Sciences.* Vol. 3 Issue 2.

Karlsen, T. (2013). Life of a Blowflies. Retrieved from https://prezi.com/sm0itymwges0/forensics-life-cycle-of-a-blowfly/.

Kavitha, R., Chen, C.D., Lee, H.L., Nazni, W.A., Saadiah, I. and Edah, M.A. (2008). Estimated post-mortem intervals (PMI) of pathologist and entomologist in Malaysia: a comparison. *Proc. ASEAN Congress Tropical Medicine Parasitology*. 3: 21-27

Kavitha, R., Nazni, W.A., Tan, T.C. Lee, H.L. and Azirun, M.S. (2013). Review of forensically important entomological specimens collected from human cadavers in Malaysia, *Journal of Forensic and Legal Medicine,* 20 480-482.

Kelly, A.G., Melanie, S.A., Lauren, M.G., Xavier, A.C. and Toop, T. (2009a). Effect of morphine on the growth rate of *Calliphora stygia* (Fabricius) (Diptera: Calliphoridae) and possible implications for forensic entomology. *Forensic Science International.* 193 21-25.

Kelly, J.A., Linde, T.C.v.d., and Anderson, G.S. (2009b) The influence of clothing and wrapping on carcass decomposition and arthropod succession during the warmer seasons in Central South Aftrica, *Journal of Forensic Science.* 54 1105-1112.

Khan, A.A.M., Wan Mahmood, W.M.A., Shamsuddin, S.A., Zaini, N.S.A., Mohamed, K. And Abd Rashid, R. (2015). Analysis of Paracetamol In Forensic Blowfly Samples From Intoxicated-Paracetamol Carcass. *Malays. Appl. Biol.* 44(1): 31–35.

Kintz, P., Godelar, B., Tracqui, A., Mangin, P., Lugnier, A.A. and Chaumont, A.J., (1990). Fly larvae: a new toxicological method of investigation in forensic medicine. *Journal of Forensic Science.* 35: 204-207.

Klotzbath, K., Krettek, R., Bratzke, H., Püschel, K., Zehner, R., and Amendt, J. (2004). The history of forensic entomology in German-speaking countries. *Forensic Science International.* 144 259-263.

Kreitlow, K.L.T. (2010). Insect Succession in a Natural Environment. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press*, 201-50.

Kumara, T., Abu Hassan, A., Che Salmah, M.R. and Bhupinder, S. (2009a). The infestation of *Dermestes ater* (De Geer) on a human corpse in Malaysia. *Tropical Biomedicine.* 26(1): 73-79.

Kumara, T., Disney, R.H.L.H., Ahmad, A.H., Flores, M., Hwa, T.S., Mohamed, Z., Che Salmah, M.R. and Bhupinder, S. (2012). Occurance of oriental flies associated with indoor and outdoor human remains in the tropical climate of north Malaysia. *Journal of Vector Ecology*. Vol. 37, no. 1.

Kurahashi, H. (2002). Key to the calliphorid adults of forensic importance in the Oriental Region, pp. 127-138. In B. Greenberg and J. C. Kunich (editors.), Entomology and the law. *Cambridge University Press*, Cambridge, MA.

Kurahashi, H. Benjaphong, N. and Omar, B. (1997). Blowflies (Insecta: Diptera: Calliphoridae) of Malaysia and Singapore. *Raffles Bulletin Zoology*; 5(Supplement):1-88.

Lebih 500 kes bunuh setahun (2012) *Kosmo!*, Retrieved Sept 11, 2017, from http://www.kosmo.com.my/kosmo/content.asp?y=2012&dt=0108&pub=Kosmo&sec=Rencana_Utama&pg=ru_09.htm.

Leclercq, M. and Brahy, G., (1985). Entomologie et medecine legale: datation de la mort. *Journal of Medicine Legal*. 28: 271-278.

Lee, H.L. (1989). Recovery of forensically important entomological specimens from human cadavers in Malaysia-an update. *Malaysian Journal of Pathology*. 11: 3336.

Lee, H.L., Krishnasamy, M., Abdullah, A.G. and Jeffery, J. (2004). Review of forensically important entomological specimens in the period of 1972-2002. *Tropical Biomedicine*. (supplement 1): 6975.

Li, X., Cai, J.F., Guo, Y.D., Wu, K.L., Wang, J.F., Liu, Q.L., Wang, X.H., Chang, Y.F., Yang, L., Lan, L.M., Zhong, M., Wang, X., Song, C., Liu, Y., Li, J.B., and Dai, Z.H. (2010). The availability of 16S rRNA for the identification of forensically important flies (Diptera: Muscidae) in China. *Tropical Biomedicine.* 27(2): 155-166.

Liu, X., Shi, Y., Wang, H. and Zhang, R., (2009). Determination of malathion levels and its effect on the development of *Chrysomya megacephala* (Fabricius) in South China. *Forensic Science International.* 192: 14-18.

Luise, E.D., Magni, P., Staiti, N., Spitaleri, S. and Romano, C. (2008). Genotyping of human nuclear DNA recovered from the gut of fly larvae. *Forensic Science Internatinal*. Genetics Supplement Series. 1: 591-592.

Mabika, N., Masendu, R., and Mawera, G. (2014). An initial study of isect succession on decomposing rabbit carrions in Harare, Zimbabwe. *Asian Pacific Journal of Tropical Biomedicine.* 4(7): 561-565.

Mahat, N. A., Zafarina, Z., and Jayaprakash, P.T. (2009). Influence of rain and malathion on the oviposition and development of blowflies (Diptera: Calliphoridae) infesting rabbit carcasses in Kelantan, Malaysia. *Forensic Science International*. 192(1–3), 19-28.

Mahat, N.A. and Jayaprakash, P.T. (2013). Forensic Entomology in Malaysia. *Malaysian Journal of Forensic Sciences*. Vol. 4, No. 1.

Mahat, N.A., Jayaprakash, P.T., and Zafarina, Z. (2012). Malathion extraction from larvae of *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae) for determining death due to malathion. *Tropical Biomedicine.* 29(1): 9-17

Mahat, N.A., Yin, C.L. and Jayaprakash, P.T. (2014). Influence of Paraquat on Chrysomya megacephala (Fibrious) (Diptera: Calliphoridae) Infesting minced beef substrates in Kelantan, Malaysia. *Journal of Forensic Sciences.* Vol. 59, No 2.

Mahat, N.A., Zainol-Abidin, N.L., Nordin, N.H., Abdul-Wahab, R. and Jayaprakash, P.T. (2016). Pattern of oviposition and development of *Chrysomya megacephala* (Fibrious) (Diptera: Calliphoridae) and *Chrysomya rufifacies* (Macquart) (Diptera: Calliphoridae) on burned rabbit carcasses. *Forensic Science International.* 260 9-13.

Mann, R.W., Bass, W.M. and Meadows, L. (1990). Time since death and decomposition of the human body: variables and observations in case and experimental field studies. *Journal Forensic Science.* 35: 103-111.

Marchenko, M.I. (2001). Medicolegal relevance of cadaver entomofauna for the determination of the time of death. *Forensic Science International.* 12089-109.

Matuszewski, S., Konwerski, S., Frątczak, K. and Szafalowicz, M. (2014). Effect of body mass and clothing on decompositionof pig carcasses. *International Journal of Legal Medicine.*

Megnin, J.P., (1894). La faune des cadavres: application de l'entomologie a la medicine legale. *Encyclopedie scientifique des aide-memoires.* Paris: Masson et Gauthier-Villaars.

Merritt. R.W. and Wallace, J.R. (2010). The Role of Aquatic Insects in Forensic Investigation. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. *Boca Raton, FL: CRC Press,* 201-50.

Miller, M.L., Lord, W.D., Goff, M.L., Donnelly, D., McDonough, E.T. and Alexis, J.C. (1994). Isolation of amitriptyline and nortriptyline from fly puparia (Phoridae) and beetle exuviae (Dermestidae) associated with mummified human remains. *J. Forensic Sci.* 39:1305-1313.

Mohd-Salleh, A.F., Talib, A., Marwi, M.A., Mohd-Isa, N.H., Abdullah, S.R., Raja-Kamal-Bashah, R.M.Z. and Omar, B. (2009). Effects of temperatures on larval development of *Chrysomya megacephala* (Fabricius) and *Chrysomya rufifacies* (Macquart) (Diptera: Calliphoridae): application in forensic science. *Malaysian Journal of Health Sciences.* 7 (2): 89-96.

Moore, P. D. (2008). Tropical Forest. *Facts On File, Inc.*

Morton, R. J., and Lord, W. D. (2002). Detection and recovery of abducted and murdered children: Behavioral and taphonomic influences. In Advances in forensic taphonomy: Method, theory, and archaeological perspectives, Haglund, W. D., and Sorg, M. H., Eds. *Boca Raton, FL: CRC Press,* 151.

Munro, B.Z. (2005). Correlation in Statistical Methods for health care research, 5th edition. *Philadelphia, Lippincott Williams and Wilkins.* Pp. 239-258.

Murty, O.P., Cheh, L.B., Bakit, P.A., Hui, F.J., Ibrahim, Z.B. and Jusoh, N.B. (2008). Suicide and ethnicity in Malaysia. *Am. J. Forensic Med. Pathol.*. 29 (1): 19-22.

Nazni, W.A., Jeffrey J., Heo, C.C., Chew, W.K. and Lee, H.L. (2011b). Illustrated key to adult flies of forensic importance in Malaysia. *Institute for Medical Research, Kuala Lumpur, Malaysia.* Bulletin No. 25.

Nazni, W.A., Lim, L.H., Dhang, C.C., Chin, H.C., Abdullah, A.G., Wan-Norjuliana, W.M., Kian, C.W., Jeffery, J., Hashim, R. and Azirun, S.M. (2011a). Comparative insect fauna succession on indoor and outdoor monkey carrions in a semi-forested area in Malaysia. *Asian Pacific Journal of tropical Biomedicine*. S232-S238.

Nolte, K.B., Pinder, R.D. and Lord, W.D., (1992). Insect larvae used to detect cocaine poisoning in a decomposed body. *Journal Forensic Science.* 37: 1179–1185.

Nur Afiradina Arshad. (2017, July 21). Mayat kanak-kanak ditemui dalam plastic hitam. *Berita Harian.* Retrieved Sept 11, 2017, from https://www.bharian.com.my/berita/kes/2017/07/304110/mayat-kanak-kanak-ditemui-dalam-plastik-hitam.

O'Brien, C. and Turner, B. (2004). Impact of paracetamol on the development of *Calliphora vicina* larval development. *International Journal Legal Medicine.* 118: 188-189.

Omar, B. (2002). Key to third instar larvae of flies of forensic importance in Malaysia. In: B., Greenberg and J.C., Kunich, editors. Entomology and the law-Flies as Forensic Indicators. *Cambridge: Cambridge University Press*. pp 120-127.

Omar, B., Marwi, M.A., Ahmad, A., Zuha, R.M. and Jeffery, J. (2003). Synanthropic index of flies (Diptera: Muscidae and Calliphoridae) collected at several locations in Kuala Lumpur and Gombak, Malaysia. *Tropical Biomedicine.* 20(1): 7782.

Omar, B., Marwi, M.A., Oothuman, P. and Othman, H.F. (1994b). Observations on the behaviour of immatures and adults of some Malaysian sarcosaprophagous flies. *Tropical Biomedicine.* 11: 149-153.

Omar, B., Marwi, M.A., Suleiman, S. and Oothuman, P. (1994a). Dipteran succession in monkey carrion at a rubber tree plantation in Malaysia. *Tropical Biomedicine* 11: 77-82.

Prescott, L.F. (2000). Paracetamol, alcohol and the liver. *British Journal of Clinical Pharmacology*. 49: 291-301.

Pritam, H.M.H. and Jayaprakash, P.T. (2009). Noctunal oviposition behavior of necrophagous dipterans in Kelantan, Malaysia. *Journal of Forensic Science.* 54(5): 1135-1140.

Reid, J. A. (1953). Notes on houseflies and blow flies in Malaya. *Bulletin Institute Medical Resources.* 7: 1-26.

Rivers, D.B. and Dahlem, G.A. (2014). The Science of Forensic Entomology. *John Wiley and Sons Ltd. West Sussex, United Kingdom.*

Rodriguez, W.R. (1997). Decomposition of buried and submerged bodies. In: W.D. Haglund, M.A. Sorg (Editors). Forensic Taphonomy: The postmortem fate of human remains. *CRC Press, Boston.* Pp 459-467.

Rumiza, A.R., Khairul, O., Zuha, R.M. and Heo, C.C. (2010). An observation on the decomposition process of gasoline ingested monkey carcasses in a secondary forest in Malaysia. *Tropical Biomedicine.* 27(3): 373–383.

Sadler, D.W., Robertson, L., Brown, G., Fuke, C. and Pounder, D.J., (1997a). Barbiturates and analgesics in Calliphora vicina larvae. *Journal of Forensic Science.* 42 (3): 481-485.

Schoenly, K. (1992). A statistical analysis of successional patterns in carrion-arthropod assemblages: implications for forensic entomology and the determination of the postmortem interval. *Journal of Forensic Science.* 37: 1489-1513.

Schroeder, H., Klotzbach, H. and Püschel, K. (2003). Insects' colonization of human corpses in warm and cold season. *Legal Medicine.* 5, S372-S374.

Sharanowski, B.J., Walker, E.G. and Anderson, G.S. (2008). Insect succession and decomposition patterns on shaded and sunlit carrion in Saskatchewan in three different seasons. *Forensic Science International*. 179 219-240.

Shi, Y., Lin, X., Wang, H. and Zhang, R. (2009). Seasonality of insect succession on exposed rabbit carrion in Guangzhou, China. *Insect Science.* 16 425-439.

Silahuddin, S.A., Latif, B., Kurahashi, H., Walter, D.E., and Heo, C.C. (2015). The importance of habitat in the ecology of decomposition on rabbit carcasses in Malaysia: implications in forensic entomology. *Journal of Medical Entomology* 52(1): 9-23.

Smith, K.G.V. (1986). A Manual of Forensic Entomology. *New York: British Museum (Natural History)* and *Cornell University Press*.

Sukontason, K., Bunchu, N., Chaiwong, T., Moophayak, K. and Sukontason, K.L. (2010). Forensically important flesh fly species in Thailand: morphology and developmental rate. *Parasitology Resource.* 106:1055-1064.

Sukontason, K., Methanitikorn, R., Chaiwong, T., Kurahashi, H., Vogtsberger, R.C. and Sukontason, K.L. (2007). Sensilla of the antenna and palp of *Hydrotaea chalcogaster* (Diptera: Muscidae). *Micron.* 38, 218-223.

Sukontason, K., Sukontason, K.L., Ngern-Klun, R., Sripakdee, D. and Piangjai, S. (2004). Differentiation of the third instar of forensically important fly species in Thailand. *Annual Entomology Society Am.* 97 (6): 1069-1075.

Sukontason, K.L., Paitoon, N., Kanchai, C., Vichairat, K., Piangjai, S., Boonsriwong, W., Bunchu, N., Sripakdee, D., Chaiwong, T., Kuntalue, B., Siriwattanarungsee, S. Sukontason, K. (2006). Morphological comparison between *Chrysomya rufifacies* (Macquart) and *Chrysomya villeneuvi* Patton (Diptera: Calliphoridae) puparia, forensically important blowflies. *Forensic Science International.* 164 230-234.

Sukontason, K.L., Sukontason, K., Piangjai, S., Boonchu, N., Chaiwong, T., Vogtsberger, R.C., Kuntalue, B., Thijuk, N. and Olson, J.K. (2003). Larval morphology of *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae) using scanning electron microscopy. *Journal of Vector Ecology.*

Syamsa, R.A., Ahmad, F.M.S., Zuha, R.M., Khairul, A.Z., Marwi, M.A., and Shahrom, A.W. (2012). An occurance of *Synthesiomyia nudiseta* (Wulp) (Diptera: Muscidae) from a human corpse in a high-rise building in Malaysia: A case report. *Tropical Biomedicine.* 29(1): 107-112.

Tan, S.H., Mohd-Aris, E., Surin, J., Omar, B., Kurahashi, H. & Mohamed, Z. (2009). Sequence variation in the cytochrome oxidase subunit I and II genes of two commonly found blowfly species, Chrysomya megacephala (Fabricius) and Chrysomya rufifacies (Macquart) (Diptera: Calliphoridae) in Malaysia. *Tropical Biomedicine.* 26 (2): 173-181.

Tan, S.H., Rizman-Idid, M., Mohd-Aris, E., Kurahashi, H. & Mohamed, Z. (2010). DNA-based characterisation and classification of forensically important flesh flies (Diptera: Sarcophagidae) in Malaysia. *Forensic Science International.* 199: 43-49.

Tantawi, T.I., El-Kady E.M., Greenberg, B., and El-Ghaffar, H.A., (1996). Anthropod succession on exposed rabbit carrion in Alexandria, Egypt. *Journal of Medical Entomology*, 33(4):566-80.

Tomberlin, J.K., Crippen, T.L., Tarone, A.M., Singh, B., Adams, K., Rezenom, Y.H., Benbow, M.E., Flores, M., Longnecker, M., Pechal, J.L., Russell, D.H., Beier,

R.C. and Wood, T.K. (2012). Interkingdom responses of flies to bacteria mediated by fly physiology and bacterial quarum sensing. *Animal Behavior*. 84, 1449-1456.

Tomberlin, J.K., Mohr, R., Benbow, M.E., Tarone, A.M. and VanLaerhoven, S. (2011). A roadmap for bridging basic and applied research in forensic entomology. *Annual Review of Entomology*. 56: 401-421.

Tracqui, A., Keyser-Tracqui, C., Kintz, P. and Ludes, B. (2004). Entomotoxicology for the forensic toxicologist: much ado about nothing? *Internatonal Journal of Legal Medicine.* 118 (4): 194-196.

Tullis, K. and Goff, M.L. (1987). Arthropod succession in exposed carrion in a tropical rainforest on Oahu Island, Hawaii. *Journal of Medical Entomology.* 24: 332-339.

Turner, B. and Wiltshire, P. (1999). Experimental validation of forensic evidence; a study of the decomposition of buried pigs in a heavy clay soil. *Forensic Science International.* 101:113–22.

Vannessa, L. (2014). *Succession and bioaccumulation studies of blowflies decomposing pesticides-intoxicated rabbit carcass.* Master's thesis, Universiti Malaysia Sarawak, (UNIMAS).

Verma, K. and Paul, R.M.P. (2013). Assessment of Post Mortem Interval, (PMI) from Forensic Entomotoxicological Studies of Larvae and Flies. *Entomol Ornithol Herpetol*. 2:104.

Voss, S.C., Cook, D.F. and Dadour, I.R. (2011). Decomposition and insect succession of clothed and unclothed carcasses in Western Australia. *Forensic Science International*. 211 67-75.

Wang, J., Li, Z., Chen, Y., Chen, Q. and Yin, X. (2008). The succession and development of insects on pig carcasses and their significances in estimating PMI in South China. *Forensic Science International.* 197 11-18.

Wang, Y., Ma, M., Jiang, X., Wang, J., Li, L., Yin, X., Wang, M., Lai, Y. and Tao, L. (2017). Insect succession on remains of human and animals in Shenzhen, China. *Forensic Science International.* 271 75-86.

Wells, J.D. and Kurahashi, H., (1994). *Chrysomya megacephala* (Fabricius) (Diptera: Calliphoridae) development rate, variation and implications for forensic entomology. *Japan. Journal of San. Zoology.* 45: 303-309.

Wells, J.D. and LaMotte, L.R. (2010) Estimating the Postmortem Interval. In: Byrd JH, Castner JL, editors. Forensic Entomology: the utility of arthropods in legal investigation. 2nd Edition. Boca Raton, FL: *CRC Press*, 201-50.

Wells, J.D. and LaMotte, L.R., (1995). Estimating maggot age from weight using inverse prediction. *Journal of Forensic Science* 40: 585-590.

Wells, J.D. and LaMotte, L.R., (2001) Estimating the postmortem interval. In*:* J.H., Byrd, and J.L., Castner, editors. Forensic Entomology: The Utility of Arthropods in Legal Investigation. *Boca Raton, Florida: CRC Press*. pp 263-286.

Wells, J.D. and Stevens, J.R. (2008). Application of DNA-based methods in forensic entomology. *Annual Review of Entomology* 53: 103-120.

Wells, J.D., Introna, F., Jr., Di Vella, G., Campobasso, C.P., Hayes, J. and Sperling, F.A.H., (2001). Human and insect mitochondrial DNA analysis from maggots. *Journal of Forensic Science.* 46 (3): 685–687.

Wigglesworth, V.B. (1972). The principle of insect physiology. *London: Chapman and Hall.*

Williams, H., (1984). A modal for the aging of fly larvae in forensic entomology. *Forensic Science International.* 25: 191-199.

Yang, S.T., and Shiao, S.F. (2012). Oviposition preference of two important blow fly species, *Chrysomya megacephala* and *C. rufifacies* (Diptera: Calliphoridae), and implications for postmortem interval estimation. *Journal of Medical Entomology*. Vol. 49, No. 2.

Zuha, R.M., See, H.W., Disney, R.H.L. and Omar, B. (2014). First record of genus *Puliciphora* Dahl (Diptera: Phoridae) associated with rabbit carcasses placed in concealed environment in Malaysia. *Forensic Science International.* 245 e36-e37.