

## Study of insect succession and rate of decomposition on a partially burned pig carcass in an oil palm plantation in Malaysia

Heo Chong Chin<sup>1</sup>, Mohamad Abdullah Marwi<sup>1</sup>, Ahmad Firdaus Mohd. Salleh<sup>1</sup>, John Jeffery<sup>1</sup>, Hiromu Kurahashi<sup>2</sup> and Baharudin Omar<sup>3\*</sup>

<sup>1</sup>Department of Parasitology & Medical Entomology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia.

<sup>2</sup>International Department of Dipterology, Hikawadai 1-2-21, Higashikurume City, Tokyo 203-0004 Japan.

<sup>3</sup>Department of Biomedical Science, Faculty of Allied Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia.

\*Corresponding author email: bahar@fskb.ukm.my

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**Abstract.** Insects found associated with corpse can be used as one of the indicators in estimating postmortem interval (PMI). The objective of this study was to compare the stages of decomposition and faunal succession between a partially burnt pig (*Sus scrofa* Linnaeus) and natural pig (as control). The burning simulated a real crime whereby the victim was burnt by murderer. Two young pigs weighed approximately 10 kg were used in this study. Both pigs died from pneumonia and immediately placed in an oil palm plantation near a pig farm in Tanjung Sepat, Selangor, Malaysia. One pig was partially burnt by 1-liter petrol while the other served as control. Both carcasses were visited twice per day for the first week and once thereafter. Adult flies and larvae on the carcasses were collected and later processed in a forensic entomology laboratory. Results showed that there was no significant difference between the rate of decomposition and sequence of faunal succession on both pig carcasses. Both carcasses were completely decomposed to remain stage after nine days. The species of flies visiting the pig carcasses consisted of blow flies (*Chrysomya megacephala*, *Chrysomya rufifacies*, *Hemipyrellia ligurriens*), flesh fly (*Sarcophagidae*), muscid fly (*Ophyra spinigera*), soldier fly (*Hermetia illucens*), coffin fly (*Phoridae*) and scavenger fly (*Sepsidae*). The only difference noted was in the number of adult flies, whereby more flies were seen in the control carcass. Faunal succession on both pig carcasses was in the following sequence: Calliphoridae, Sarcophagidae, Muscidae, Phoridae and lastly Stratiomyidae. However, there was overlap in the appearance of members of these families. Blowflies continued to oviposit on both carcasses. Hence postmortem interval (PMI) can still be estimated from the partially burnt pig carcass.

### INTRODUCTION

Forensic entomology is inexorably related with the fields of medical entomology, taxonomy and forensic pathology (Catts & Haskell, 1990) and it is subdivided into three branches: medicocriminal entomology, store-product entomology and urban entomology (Lord & Stevenson, 1986).

The recovery of entomological fauna from human cadavers is one of the important features of forensic investigation especially

in the estimation of postmortem interval (PMI) (Lee *et al.*, 2004). In Malaysia, Reid (1953) summarized the first forensic entomology case in Penang. Later, Lee (1989, 1996) and Lee *et al.* (2004) reviewed and updated some of the cases at the Institute of Medical Research (IMR) collected throughout the period of 1972 to 2002. Nor Afandy *et al.* (2003) and Ahmad *et al.* (2007) also reviewed forensic entomological specimens received from Hospital Universiti Kebangsaan Malaysia (HUKM).

Animal carcasses had been used as model for forensic entomology research in many part of the world including Malaysia (Lee & Marzuki 1993; Omar *et al.*, 1994). Domestic pig (*Sus scrofa*) was first used by Heo *et al.* (2007) in Malaysia. Lee & Marzuki (1993) studied arthropod succession on monkey (*Macaca fascicularis*) carcasses either fully exposed or partially buried near the fringes of tropical forest. Omar *et al.* (1994) made observation on arthropods on monkey (*M. fascicularis*) carrion at a rubber tree plantation in Malaysia. Heo *et al.* (2007) used pig carcass placed in an oil palm plantation to study the faunal succession and stages of decomposition.

Human corpses may be burned either perimortem or postmortem. Little research has been published on the association between burned animal or humans and insect succession. A study conducted in Hawaii using burnt pig carcasses had shown that burned remains were colonized in a manner different from unburned remains (Avila & Goff, 1998). The present study was carried out to compare insect successions and rate of decomposition between a partially burned pig carcass and an unburned pig carcass (control) in an oil palm plantation in Tanjung Sepat, Selangor, Malaysia.

## MATERIALS AND METHODS

Two young pig (*S. scrofa* L.) carcasses weighing around 10 kg were used in this study. Both of them died of pneumonia and immediately placed in an oil palm plantation in Tanjung Sepat, Selangor, Malaysia (2.6°N, 101.6°E). One carcass was burned partially with one-liter petrol (Petronas- Primax 3®) while the other was unburned and served as control. The partially burned pig carcass simulated a situation whereby a victim was partially burnt by a murderer. The study was first conducted in the afternoon of 3 August 2007, which was taken as the first day.

Observation was made for 16 days, with two visits per day (10 a.m. and 4 p.m.) for the first week and single visit (10 a.m.) thereafter. Climatological data such as

ambient temperature and humidity were recorded by using a mercury thermometer and a hygrometer. Body surface temperature, internal temperature and maggot mass temperature were also recorded during each visit. Adult flies were caught around the carcasses by using sweep net. Adult flies were killed in chloroform, pinned and kept in a insect box. Some of the eggs (approximately 30 eggs) and fly larvae (10-20 larvae) were either collected using forceps for rearing or put into ethyl alcohol 70% for preservation; this collecting procedure is based on that of Catts & Haskell (1990). Dead fly larvae of various stages were immersed in 10% potassium hydroxide (KOH) overnight and then dehydrated in increasing concentrations of alcohol and mounted in Canada balsam on slides. The collected specimens were then processed for species identification by using the key of Kurahashi *et al.* (1997) for adult calliphorid fly, Tumrasvin & Shinonaga (1982) for muscid fly and key of Ishijima (1967) for fly larvae. Processed specimens were kept as a record in the entomological collection of the Department of Parasitology & Medical Entomology, Faculty of Medicine, Universiti Kebangsaan Malaysia.

## RESULTS

The ambient temperature in the palm oil plantation for the 16 days ranged from 27°C to 31°C (mean 29.72°C,  $\pm 1.29^\circ\text{C}$ ), air humidity ranged from 70% to 100% (mean 85.19,  $\pm 9.15\%$ ) (Figure 1). Three times of raining were recorded during the study (day-9, 10 and 13).

Body surface temperature for the control pig carcass from 3 August until 19 August 2007 ranged from 28°C to 31°C (mean 29.42°C,  $\pm 1.16^\circ\text{C}$ ). Internal temperature ranged from 28°C to 38.5°C (mean 32.6°C,  $\pm 5.12^\circ\text{C}$ ) and maggot mass temperature varied from 29°C to 40°C (mean 35.43°C,  $\pm 3.75^\circ\text{C}$ ). Ground surface temperature fluctuated from 25°C to 31°C (mean 29.06°C,  $\pm 1.74^\circ\text{C}$ ) (Figure 2). Five stages of decomposition were observed, there were

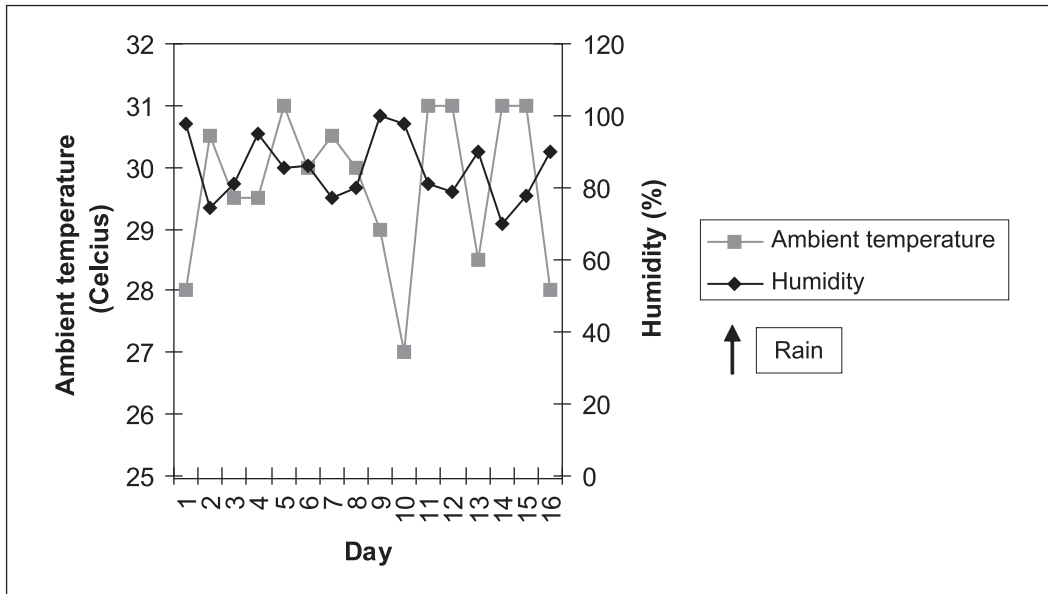


Figure 1. Ambient temperature and humidity of the study site in oil palm plantation in Tg. Sepat, Selangor, Malaysia (2.6°N, 101.6°E).

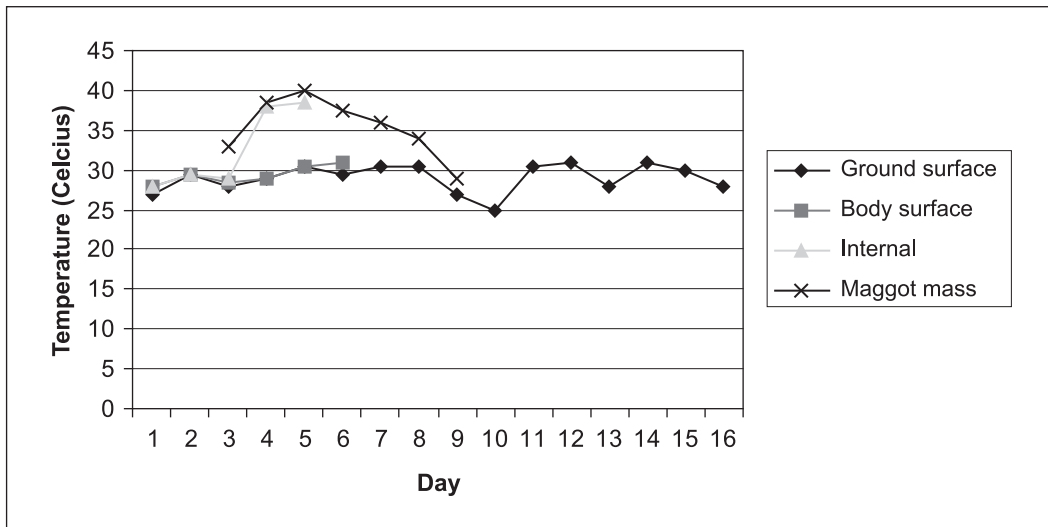


Figure 2. Ground surface, body surface, internal and maggot mass temperatures recorded on a control carcass.

fresh, bloated, active decay, advance decay and dry / remain (Table 1).

Body surface temperature for the burnt pig carcass ranged from 29°C to 32.5°C (mean 30.12°C,  $\pm 1.25^\circ\text{C}$ ). Internal temperature ranged from 28.5°C to 40.0°C (mean 33.3°C,  $\pm 4.84^\circ\text{C}$ ) and maggot mass

temperature varied from 30°C to 43.5°C (mean 36.86°C,  $\pm 5.31^\circ\text{C}$ ). Ground surface temperature recorded ranged from 25°C to 30.5°C (mean 29.10°C,  $\pm 1.34^\circ\text{C}$ ). (Figure 3).

From the graph (Figure 2 & 3), we noticed that there was a higher temperature of body surface, internal and maggot mass

Table 1. Stages of decomposition for burned and control pig carcasses

Stage	Day
Fresh	1- 2
Bloated	3
Active decay	4-6
Advance decay	7-8
Dry / Remains	9-16

temperatures recorded in burned pig carcass compared to control carcass. Ground surface temperature was not much different for both pig carcasses.

On the first day, no adult blowfly was seen around the partially burned pig carcass. However, adult blowflies consisting of *Chrysomya megacephala* (Old World latrine fly), *Chrysomya rufifacies* and *Hemipyrellia ligurriens* were sighted landing on the unburned carcass. Some Platystomatidae fly (*Scholastes* sp.), flesh flies (Sarcophagidae) and *Phumosia testacea* (Calliphoridae) were also seen on the body surface. Ants (Formicidae) and

spider (Arachnida) came to the control carcass and preyed on adult blowflies. Grasshopper (Gryllidae) was seen but it was an incidental visitor and thus has no role in forensic investigations. In the control, within the first hour of placing, fly oviposition started around the mouthpart. Interestingly, a housefly, *Musca domestica* L. was found ovipositing on the dorso-lateral part of the body surface.

On the second day (fresh stage), adult flies of *C. rufifacies* and *C. megacephala* accumulated at nasal orifices, oral cavity and genitourinary orifice of the burned pig carcass, with *C. megacephala* being more dominant. Red ants (*Oecophylla smaragdina*) dominated the whole body surface and caused hindrance to landing of flies on the carcass; they also predated on fly eggs and adult flies on the burned pig. Masses of yellowish blowfly's eggs were seen in oral cavity and on head part. More adult blowfly population consisting of *C. megacephala*, *C. rufifacies* and *Hemipyrellia* sp. were observed on control pig than on the burnt one. The presence of flies on the control pig may be due to the absence of red ant (*O. smaragdina*). Masses

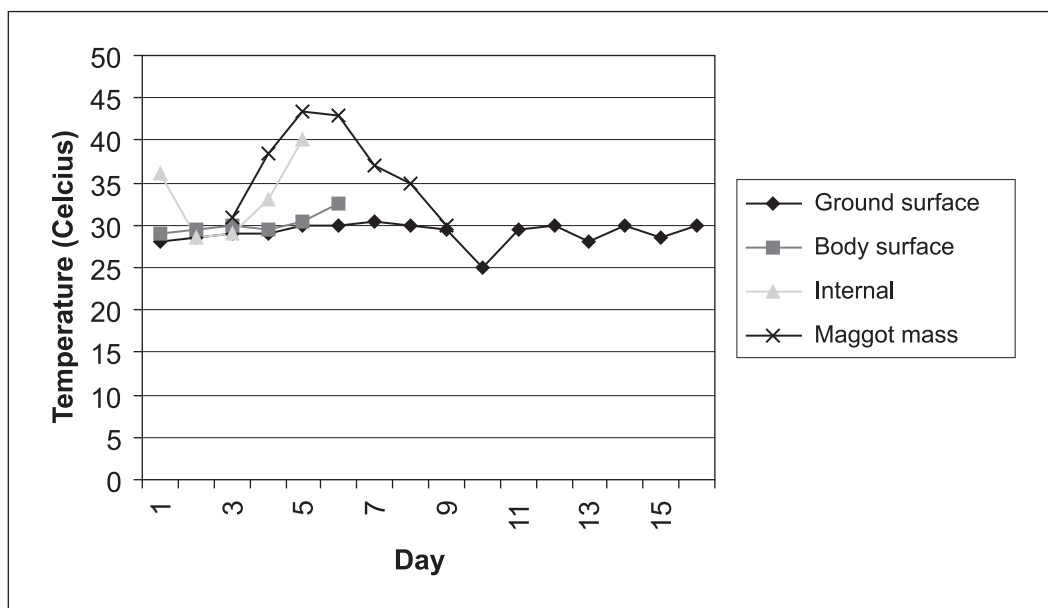


Figure 3. Ground surface temperature, body surface temperature, internal temperature and maggot mass temperature recorded on burned pig carcass. Maggot mass temperature and internal temperature were higher in burned pig carcass than control carcass.

of eggs of flies were also sighted on the head of the carcasses.

Bloated stage began on day-3 for both carcasses. Partial burning of the pig carcass did not prevent it from bloating. Adult flesh flies (Sarcophagidae) were observed on the burned pig. A lot of first instar larvae was found crawling in the mouth and eyes. Adult moth (Lepidoptera) was sighted sucking the fluid coming from the abdomen. Maggot mass occurred at the oral cavity of control carcass and larvae were also seen crawling around anus orifices and surface of abdomen. Rove beetles (Staphilinidae) and scarab beetles (Scarabaeidae) were seen on third day. Third instar fly larvae (*C. megacephala*, *C. rufifacies* and *Hemipyrellia* sp.) can be seen on fourth day on both pig carcasses congregating at the head, eye orbits, abdomen and genitalia. Groups of red ants were observed carrying away fly larvae from the burnt carcass. A lot of adult scavenger fly (Sepsidae: *Sepsis* sp.) landed at the abdomen of control carcass and licked decompositional fluid.

Active decay stage started on day-5 and day-6. Both carcasses were almost similar in their rate of decomposition. Adult fly population on burned pig was very low (approximately 25 adult flies) compared to control pig, which attracted abundance of flies on day-5 (approximately 750 adult flies). *Chrysomya megacephala* was the dominant adult fly collected, followed by *C. rufifacies*, and then *Ophyra spinigera* (Muscidae) from both carcasses. Sarcophagids were rarely seen. The dominant fly larvae (third instar) on both pig carcasses were those of *C. rufifacies* (the hairy maggots). At this stage, the skull was fully exposed and strong odor emanated from the carcasses.

On day-7 and day-8, both pig carcasses entered the stage of advanced-decay. This stage can be clearly recognized by fly larvae of *C. rufifacies* covering all parts of the body to begin skeletonization. *Ophyra spinigera* became the dominant adult species. Red ants population on burned carcass began to decrease and fly larvae started to disperse and migrate to drier areas for pupation. Remaining *C. rufifacies* larvae were sluggish

on the highly decomposed carcass and adult fly insects activity has decreased.

Dry and remains stage began on day-9 and onwards. Both pig carcasses were fully skeletonized at this stage. *Chrysomya rufifacies* third instar larvae were centralized on the carcass and moved in circular motion in a clock-wise direction. Two moths *Ythima baldus* (Nymphalidae) and *Hypolimnas bolina* (Nymphalidae) were observed landing on the skull and sucking the bone fluid of control and burnt carcass, respectively. Some acalyptrate flies (Neriidae and Micropezidae) were observed on the skeleton. Puparia of *C. rufifacies* were found burrowed under the soil. Red ants in the vicinity of carcasses carried away *C. rufifacies* pupae and adult beetles. Millipede (Diplopoda) was incidentally seen passing by, being probably attracted to the odor. Beside that, some pinkish Collembolla were also recovered under the skeleton. Adult coffin flies (Phoridae) increased in population from advanced-decay stage of decomposition and dominated both skeletons.

On day-13, one adult soldier fly, *Hermetia illucens* (Stratiomyidae) landed on the skeleton of control pig, however, no larvae of *H. illucens* were collected from either carcasses. Slug (Molluska) and cockroaches (Blattellidae) were also sighted as visitors to pig skeletons. Newly emerged blowflies such as *C. rufifacies* can be seen on day-12 and day-13 around the nearby vegetation, which can be recognized by their wingless appearance.

## DISCUSSION

Avila & Goff (1998) conducted a decomposition study using domestic pig carcasses in two different ecological habitats (xerophytic and rainforest habitat) in Hawaiian Islands, pig on each habitat was burned while the other pig served as control. They found no marked differences in the arthropod fauna presented on both pig carcasses, but fauna appeared slightly earlier on the burned pig carcass. In our study, we

found arthropods visiting burned and unburned pig carcasses were basically of similar speciation, consisting of *C. megacephala*, *C. rufifacies*, *H. ligurriens*, *O. spinigera*, sarcophagids, phorids and sepsids. The faunal succession pattern was also overlappingly similar in both pig carcasses starting with Calliphoridae, followed by Sarcophagidae, Muscidae, Phoridae and lastly Stratiomyidae. However, blowflies arrived and oviposited earlier on the control carcass, within the first hour of placing; but there was no insect activity noted on the burned pig carcass. This result may indicate that blowflies were not attracted to the freshly burned remains but came only after the remains had cooled down. It could also mean the carcass was too hot for the flies. On the second day, blowflies were seen ovipositing on both pig carcasses.

Avila & Goff (1998) noted that the burned carcasses attracted much more fly oviposition than unburned carcasses, showing that burned carcasses were still extremely attractive to calliphorid flies. Our study showed that the body surface temperature, internal temperature and maggot mass temperature was generally higher in burned carcass compared to unburned carcass from day-1 to day-6. This result indicated that more larvae activities occurred on burned pig and hence generated more heat and thereby quicken the rate of decomposition. Both carcasses were fully decomposed to remains stage on day-9 and this showed that rate of decomposition was almost similar. However, the authors noticed that rate of decomposition was slightly faster in burned pig carcass.

Catts & Goff (1992) suggested that oviposition was deterred by burning. This situation depended on the level of burning and amount of incineration (Byrd & Castner, 2001). There were two cases in Italy whereby the victims were burned and the time since death still could be determined by using insects evidence (Introna *et al.*, 1998). Killers often tried to dispose of a victim by burning

the body, but was unaware of the tremendously high temperatures and the time required to completely incinerate a human body. Even in the extreme heat of a professional crematorium, recognizable pieces of human remains were still present (Murray & Rose, 1993; Kennedy, 1996).

In this study, the obvious difference was that of fly population that visited the pig carcasses. The control carcass attracted more flies than burned carcass. This may be due to the drier skin condition or the remnant of petrol odor on the burnt carcass, which was an unfriendly environment to blowflies. The presence of red ants (*O. smaragdina*) on burned carcass may be one of the factors that reduced the size of fly population.

The most dominant adult fly on a decomposing pig in oil palm plantation was *C. megacephala* and the most dominant larvae were *C. rufifacies* (Heo *et al.*, 2007). Again, similar result was obtained from our study. The larvae of *H. ligurriens* and *C. megacephala* were recovered from both pig carcasses at the early stage of decomposition but they were replaced by *C. rufifacies* larvae at the later stage of decomposition. This behavior showed that this pattern of larval succession occurred on decomposing animal carcasses. *Chrysomya rufifacies* larvae were confirmed once again as predatory on other fly larva such as *C. megacephala* and *Hemipyrellia* sp. (Byrd & Castner, 2001).

In conclusion, five stages of decomposition was observed on partially burnt pig carcass. Burning does not affect the rate of decomposition and the sequence of faunal succession. Therefore, it is demonstrated that estimation of postmortem interval (PMI) was not affected.

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