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Kertas Asli/*Original Articles*

Effects of Layered Clothing on the Post-mortem Decomposition of Rat Carcasses on Grass Bushes and Dead Leaves

(Kesan Pakaian Berlapis Terhadap Penguraian Postmortem Bangkai Tikus di atas Dedaun Rumput yang Telah Mati)

NOOR HAZFALINDA HAMZAH*, DARISHINI MANIMARAN, KHAIRUL OSMAN, NUR MAHIZA MD ISA, GINA FRANCESCA GABRIEL

ABSTRACT

A post-mortem decomposition is defined by the evaluation of the physical and chemical changes of a cadaver or a carcass in order to estimate the cause of death and the time of death. The purpose of this study is not to replicate a real crime scene but to enhance knowledge of the effects of clothing in a decomposition process, mainly, the effects of layered cotton clothing on the post-mortem decomposition of adult female rat carcasses. Fifteen rats were divided into three groups: control, one-layered and two-layered clothed. The control subjects were unclothed and used to compare the post-mortem changes with the clothed subjects, one-layered and two-layered rat carcasses. All subjects were placed outdoor, 2.5 meters away from each other on grass bushes and dead leaves. Ambient temperature and humidity were recorded to observe if it associates with the post-mortem changes of the rats. Insect activity on each subject was observed. Post-mortem changes were measured using the Total Body Score system. The results showed that the control group underwent a faster decomposition compared to the clothed groups. The different layers of clothing did not show a vast difference in post-mortem changes. The ambient temperature of 28°C influences the post-mortem decomposition. The decomposition was rapid under the dominance of maggots compared to ants as ant colonies delayed the decomposition process. The study gave the knowledge of the effect of clothing in decomposition of female rats in forensic science.

Keywords: Post-mortem decomposition; clothing; cotton; rats; total body score; ants; maggots

ABSTRAK

Pereputan post-mortem ditakrifkan sebagai penilaian perubahan fizikal dan kimia mayat atau bangkai haiwan untuk menganggarkan penyebab kematian dan masa kematian. Tujuan kajian ini bukan untuk meniru sesuatu tempat kejadian jenayah sebenar tetapi untuk meningkatkan pengetahuan tentang kesan pakaian dalam proses pereputan, terutamanya kesan pakaian kapas berlapis kepada pereputan post-mortem bangkai tikus betina dewasa. Sejumlah lima belas tikus dibahagikan kepada tiga kumpulan: kawalan, satu lapisan dan dua lapisan pakaian. Subjek-subjek kawalan adalah tidak berpakaian dan digunakan untuk membandingkan perbezaan perubahan post-mortem dengan subjek berpakaian. Semua subjek diletakkan pada jarak 2.5 meter antara satu sama lain di atas dedaun rumput yang telah kering. Suhu udara dan kelembapan direkodkan untuk melihat jika ia mempengaruhi kadar pereputan post-mortem. Aktiviti serangga pada setiap subjek diperhatikan. Perubahan post-mortem diukur dengan menggunakan sistem Skor Keseluruhan Badan. Keputusan menunjukkan kumpulan kawalan mereput lebih cepat berbanding kumpulan berpakaian. Lapisan pakaian kapas berbeza tidak menunjukkan perbezaan besar dalam perubahan post-mortem. Lapisan pakaian tidak signifikan untuk proses pereputan. Suhu persekitaran 28°C mempengaruhi kadar pereputan post mortem. Pereputan post-mortem adalah pantas di bawah dominasi berengga berbanding dengan semut kerana koloni semut melambatkan proses pereputan. Kajian ini memberikan pengetahuan tentang kesan pakaian dalam proses pereputan tikus betina untuk sains forensik.

Kata kunci: Pereputan post-mortem; pakaian; kapas; tikus; skor keseluruhan badan; semut, ulat

INTRODUCTION

Taphonomy is a study of variables such as dispersion, burial, erosion, preservation and decompositional changes after death (Ururahy-Rodrigues et al. 2008). Out of the many types of taphonomy, longitudinal taphonomy research primarily observed the full decomposition of a carcass or a cadaver (Simmons et al. 2010). Post-mortem decomposition is a significant process whereby an examination on a cadaver is done to investigate the cause of death through the inspection and evaluation of its physical and chemical changes (Teo et al. 2014). Consequently, the decomposing remains possess an important role in balancing the ecosystem by providing shelter, food source and nutritious resources to arthropods (Voss et al. 2011). It takes several days or months for a dead organism to entirely decompose, as the changes and duration solely depend on environmental conditions and entomological activities (Statheropoulos et al. 2011). However, by inspecting the decompositional changes, the post-mortem interval (PMI) can be estimated.

The process of decomposition is generally divided into five stages based on observational variables (Marhoff et al. 2016). The stages are as follows; fresh, early decomposition, advanced decomposition, skeletonization and extreme decomposition. The fresh stage is where autolysis, putrefaction, algor mortis, rigor mortis, and livor mortis occur sequentially (Goff 2010). Autolysis occurs due to destruction of cells by enzyme, (Teo et al. 2013) marked by the discoloration of skin and slippage (Shirley et al. 2011). This process is followed by putrefaction, whereby microbial activities are initiated and elevates. Algor mortis is when the temperature of the body begins to deplete due to the ambient temperature. The discoloration of the body due to gravitational pull is called livor mortis. This effect often helps in distinguishing the position of the dead body at the time of death. Rigor mortis, on the other hand, occurs when adenosine triphosphate is consumed and there are no more muscle contractions and relaxation. Therefore, these changes cause rigidity of the mechanical tissues (Brooks 2016).

In the early decomposition stage, chemical reactions occur in the body, causing distension of the abdomen. These reactions cause the fluids to be forced out of the body through openings such as nostrils, eyes, mouth, and anus. Entomologically, significant scavengers and insects are attracted to cadavers at this stage. The skin turns into dark-grey due to the binding of sulfur onto haemoglobin. In the advanced decay stage, high mass of tissues is lost due to the feeding of maggots and the purging of decomposition fluids into the environment, creating a cadaver decomposition island. Within this island, there is a high concentration of calcium and other nutrients (Benninger et al. 2008). Skeletonisation and extreme decay occur simultaneously where decomposition will no longer take place and insect activities are slowed down. At this point in the process, bones are more visible to the naked eye (Teo et al. 2014) .

PMI can be affected by exogenous and endogenous factors. Exogenous factors are external factors, outside and on the surface of a dead body, such as temperature, humidity, pH, insects' infestation and other barriers. Both temperature and humidity act as one of the most important influencers of the rate of decomposition of a body. In this context, temperature represents the ambient temperature, soil temperature and the climate, while humidity represents the moisture of the surrounding air. Both acts as a buffer for temperature (Shirley et al. 2011). Temperature also correlates well with bacterial growth. At a very low and high temperature, the microbial activity is lesser (Goff 2010). Different types of microorganisms could only withstand specific optimum temperatures. Besides, pH also plays an important role in controlling and regulating the growth and activity of microbes (Shirley et al. 2011). Furthermore, physical and chemical barriers also alter the rate of decomposition of a body. In this context, physical barriers represent how exposed the body is to the environment, which includes different types of coverings, such as a plastic bag or clothing (Goff 2010). Chemical barriers such as insecticides are often carried by insects and are transferred to the body when they infest on the body. The pH levels are high at this point due to the breakdown of protein. However, as the carcass decomposes and with the involvement of these chemical barriers, acids such as acetic acid, oxalic acid and fatty acid are released. This reaction directly decreases the pH levels (Stroud 2017). On the other hand, the mass of the carcass largely impacts the speed of decomposition. The smaller the size of a carcass, the faster the rate of decomposition whereas the larger the size of a carcass, the slower the rate of decomposition (Matuszewski et al. 2014). This factor is also considered as forensically important in determining the PMI of a dead body.

Endogenous factors are internal factors that exist within the deceased such as organ pathology. At times, the high temperature of the dead body may be caused by diseases such as stroke, central fever, hyperthermia or necrotic intoxication, or antemortem (Zhou & Byard 2011). Failure to monitor the temperature of the dead body once collected from the crime scene can cause inconsistencies in the temperature readings. An example of a pathological condition that can alter temperature is obesity. Obese individuals have high abdominal fats, which traps the heat within the body. It takes a long time for an obese dead body to decompose (Teo et al. 2013).

Researchers have developed countless amounts of methods and tools to determine the PMI of a dead body. One of the methods is by determining the accumulated degree days (ADD) which is the sum of the average daily ambient temperatures between the date of death and the date of being found (Gelderman et al. 2018). The ADD represents the thermal energy required for biochemical reactions that could possibly take place in a dead body (Simmons et al. 2010). In addition, to obtain ADD, the Total Body Score (TBS) is calculated based on the stages of decomposition. The longer the PMI is, the more difficult and less accurate it is to determine the time of death (Sharma et al. 2015). The TBS system is used as a qualitative scale, which is expected to give different values of categories, corresponding to the size, and other factors that might affect the dead body's time of death. At times, the scale might be used differently, depending on the users (Nawrocka et al. 2016). The TBS scale using photographs was first developed by (Megyesi et al. 2005) based on the decomposition stages described by (Galloway et al. 1989). Table 1-3 explain the TBS system (Dautartas 2009).

Table 1: TBS scoring for region (i) head and neck

Stage of decomposition	Score	Observation of post mortem change
Fresh	1	Fresh, no discoloration.
	2	Pink-white appearance with skin slippage and some hair loss.
	3	Gray to green discoloration: some flesh still relatively fresh.
	4	Discoloration and/or brownish shades particularly at edges, drying of nose, ears and lips.
	5	Purging of decompositional fluids out of eyes, ears, nose, mouth, some bloating of neck and face may be present.
	6	Brown to black discoloration of flesh.
Advanced decomposition	7	Caving in of the flesh and tissues of eyes and throat.
	8	Moist decomposition with bone exposure <50% of the area being scored.
	9	Mummification with bone exposure <50% of the area being scored.
Skeletonization	10	Bone exposure >50% of the area being scored with greasy substances and decomposed tissue.
	11	Bone exposure >50% of the area being scored with desiccated or mummified tissue.
	12	Bone largely dry, but remaining some grease.
	13	Dry bone.

Source: Dautartas (2009)

Table 2: TBS scoring for region (ii) body trunk

Stage of decomposition	Score	Observation of post mortem change
Fresh	1	Fresh, no discoloration.
	2	Pink-white appearance with skin slippage and marbling present.
	3	Gray to green discoloration: some flesh still relatively fresh.
	4	Bloating with green discoloration and purging of decompositional fluid.
	5	Postbloating following release of the abdominal gases, with discoloration changing from green to black.
Advanced decomposition	6	Decomposition of tissue producing sagging of flesh; caving in of the abdominal cavity.
	7	Moist decomposition with bone exposure <50% of the area being scored.
	8	Mummification with bone exposure <50% of the area being scored.
Skeletonization	9	Bones with decomposed tissue, sometimes with body fluids and grease still present.
	10	Bones with dessicated or mummified tissue with bone exposure <50% of the area being scored.
	11	Bone largely dry, but remaining some grease.
	12	Dry bone.

Source: Dautartas (2009)

Table 3: TBS scoring for region (iii) fore- and hind limbs

Stage of decomposition	Score	Observation of post mortem change
Fresh	1	Fresh, no discoloration.
	2	Pink-white appearance with skin slippage of forelimbs and/or hindlimbs.
	3	Gray to green discoloration: some flesh still relatively fresh.
	4	Discoloration and/or brownish shades particularly at edges, drying of fingers, toes and other projecting extremities.
	5	Brown to black discoloration; skin having a leathery appearance.
Advanced decomposition	6	Moist decomposition with bone exposure <50% of the area being scored.
	7	Mummification with bone exposure <50% of the area being scored.
Skeletonization	8	Bone exposure <50% of the area being scored, some decompositional tissue and body fluids remaining.
	9	Bone largely dry, but remaining some grease.
	10	Dry bone.

Source: Dautartas (2009)

Malaysia is located on the equator, therefore the tropical climate in Malaysia is hot and relatively high air humidity than Western countries (Teo et al. 2013). Microclimates are distinct climates of smaller individual regions within an area that differs from the surrounding environment (Marhoff et al. 2016). Thus, temperature plays a role in affecting the rate of decomposition of a cadaver (Brooks 2016). Researchers in Malaysia have studied insect succession on pig carcasses, (Heo et al. 2007) decomposition, dipteran associated with exposed carcasses in an oil plantation (Azwandi & Abu Hassan 2008), and clothing effect on decomposition process of buried rabbit carcasses (Teo et al. 2013). This current research specifically aims to study the effects of one and two-layered clothing on the post-mortem decomposition of the rat. Rats were used instead of pigs and rabbits in order to sustain a controlled environment (Celata 2015).

RESEARCH METHOD

SUBJECT DEFINITION

15 adult, female rats, weighing between 300 to 500 grams in average were killed with an excessive amount of carbon dioxide at the Animal House, UKM and then, they were transferred to the burial site located at the UKM forensics burial area in UKM Bangi. Once euthanized, the rats were divided randomly and equally into 3 groups. The first group is the controlled group where no clothes were worn by them. The second group wore a one-layered cotton clothing whereas the third group wore two-layers of cotton clothing. Animal ethic approval was obtained for this study. The ethical approval code was FSK/2018/NOOR/14-MAY/919-JUNE-2018-DEC.-2018-AR-CAT2.

SUBJECT DIVISION

The five controlled rats (UC1-UC5), five one-layered clothed rats (OC1-OC2, OC4-OC6) and five two-layered clothed rats (TC1-TC3, TC5-TC6) were put separately in their respective rat trap cages, which means, one rat was placed in one cage. The rats were caged in order to protect the rats from scavengers with exception for entomologically involved insects. After the caging was done, the cages were placed 2.5 meters apart from each other. All 15 cages were placed on the bushy ground outdoors and exposed to the environment. The experiment was held at the burial site, fenced area, and locked from the outside. The burial site was locked after every observation, every day, to avoid trespassing and disturbance to the nature of the experiment.

SUBJECT OBSERVATION

All the rats were observed in between 10-11 am for 10 consecutive days. Throughout the observation process, the rats were photographed and data were taken on its post-mortem changes. The observation was based on the TBS. Other than that, insect activities were observed and taken into account. The temperatures such as the ambient temperature and air humidity were measured with a K-type EL-USB-2 (RH/temp data logger) thermocouple and printed out. These observations were made until the carcasses reach its early skeletonization stage, where there is very little flesh left and no more entomological activities were seen.

STATISTICAL METHODS

Two different statistical tests were used in this study; Kruskal-Wallis H Test to determine the differences between the TBS scores and Spearman's rank-order correlation to determine the relationship between the average ambient temperature and the TBS scores for all the three groups.

RESULTS AND DISCUSSION

GENERAL OBSERVATIONS

During the 10 days of observation, it was noted that some cages were exposed to sunlight and some cages were placed under shaded regions. This phenomenon is due to the tall trees that block the sunlight from reaching the floor bed. Ants were present in most of the subjects from day 1 onwards, regardless of the clothing factor. Sunlight exposed areas seemed to invite more maggots than ants whereas areas where there were more dead leaves and less sunlight invited more ants than maggots. Flies were seen first on some of the subjects in the one-layered group followed by the unclothed group and two-layered group.

UNCLOTHED GROUP (UC1-UC5)

The observations began on the day the rats were set up in its cages. On day 1, caving in of eyes and browning of the nose were noted in all five rats. However, there was some major ant colony activity on subjects UC1 and UC3. Subject UC5's ears protruded out of the cage, making it vulnerable for scavengers to consume the ear part while attempting to drag the cage. By day 2, the trunk and limb regions have started bloating. However, there were no signs of discoloration due to the rats being heavily furred. Genitals were moist, indicating that the purging of fluids from the trunk region has begun. Subject UC3 was colonized by ants, specifically at the hind limbs. Skin slippage was seen to occur more rapidly, especially on the head, neck and trunk regions.

On day 3, some bones were exposed on the head region accompanied by tissues that were turning black. The trunk region was moist and decomposing. By this time, a massive number of maggots were observed, especially on the trunk region. Fly and larval activity was seen, besides the visibility of red ant colonies. However, subject UC4's cage was dragged about half a meter to the fence nearby by a scavenger. On day 4, the limb regions were already undergoing early mummification process as the tissues were dry. Mummification was seen on the head region of subject UC5. By day 5, the head and neck regions were moist and some bone regions were exposed. At this point, the forelimbs were seen to decompose faster than the hind limbs. Fly activity and maggot activity have depleted. However, more than half of the bones were exposed in subject UC4.

By day 6, subject UC4 has already skeletonized, with traces of grease, dried up tissues and detached fur. Insect and larval activity have reduced, besides, dead maggots were seen on the surface of the carcass. On day 7, mummification was observed on the head regions. Soil particles were seen covering the head region of subject UC5. The bones of subject UC4 were mixed up, indicating that there was some physical disturbance prior to the observation. On days 8 and 9, the head regions were mostly mummified, with more than half bone exposed. The trunk and limb regions were mummified. The limb regions of subject UC3 were skeletonized.

ONE-LAYER CLOTHED GROUP (OC1-OC5)

Day 0 of observation began when the rats were wrapped with a layer of cotton cloth. The next day, eyes have caved in, the nose has turned brown, and the genital area was moist. Subject OC4 was colonized by ants, especially on the head region. By day 2, flies were seen actively on and around the subjects. Tissues, especially the chin areas were missing. Massive larval activity was observed on subject OC5. On day 3, tissues of the head and neck regions were turning black. Forelimbs were bloated while the hind limbs were still leathery and the trunk regions were bloated. Internal organs of subject OC5 was seen protruding out. By this time, subject OC3 was colonized by ants.

On day 4, larval and fly activities were still lively. At this point, some bone was exposed on the head and neck regions, and the trunk regions were moistly decomposing. The forelimbs were mummifying with some bones exposed whereas the hind limbs were still attached to its tissue. However, the clothing for subject OC3 was missing most likely due to scavenger activities. Ants were colonizing subject OC4 and the internal organs on the trunk region of subject OC5 were seen protruding. By day 5, the head regions were less moist and mummifying. Less larval activity was observed throughout. The next day, all the regions were undergoing mummification with a little moisture on the trunk regions. On day 7, the subjects were seen to be moist again. This is due to the rain activity prior to the observation, in which the thermocouple did not read. On days 8 and 9, the subjects were completely mummified in spite of the rain activity that has caused the moisture.

TWO-LAYER CLOTHED GROUP (TC1-TC3, TC5-TC6)

Day 0 of observation began when the rats were wrapped with two-layers of cotton cloth. Only subjects TC1, TC2, TC3, TC5, and TC6 were chosen to be added to the observation. On day 1, caved-in eyes and brownish nose were noted. The next day, fur has detached, and skin slippage noted on the head regions. Forelimbs and the trunk regions were slightly bloated. On day 3, fluid was seen purging out from the trunk regions. Facial tissue was noted to turn black. At this point, fly and larval activity were seen to be active. Subjects TC1 and TC2 were colonized by ants.

On day 4, the head and neck regions were slightly moist while mummifying. The trunk regions were seen to be moist with active larval decomposition. Subjects TC1 and TC6 were partly covered with soil, which indicates ant activity. Larval activity has depleted compared to the previous days.

On day 5, the head, and trunk regions were undergoing mummification. A group of dead larvae was noted on subject TC3. On the following day, some bones were exposed on the head and limb regions. On day 7, all the regions were undergoing mummification. However, subject TC1 were colonized by ants. On days 8 and 9, the subjects have fully mummified. On day 7, subject TC1 was unclear and covered with soil particles, and therefore, it was not scored. The TBS scores of the subjects from the control group (UC), one-layered group (OC) and two-layered group (TC) from day 0 to day 9 of observation is shown in Figure 1.

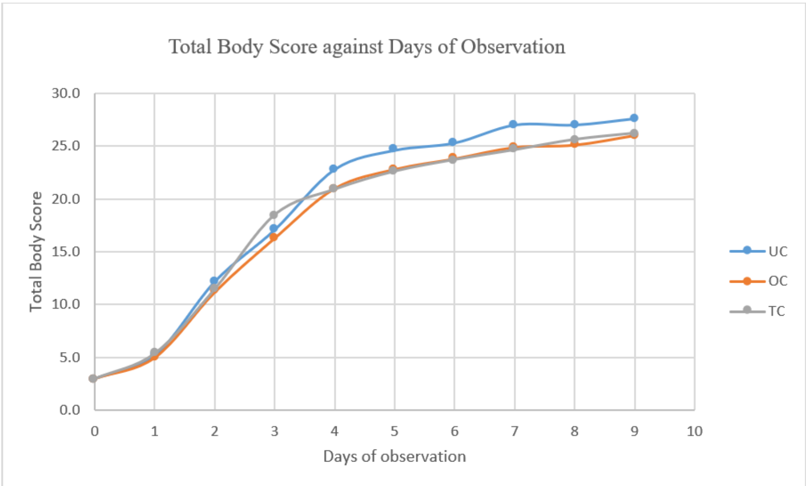

Figure 1: TBS scores of all 15 subjects from day 0 to day 9. UC is unclothed group, OC is one-layered group and TC is two-layered group

TEMPERATURE TREND

There seems to be a difference between the unclothed group and the clothed groups, whereas there seem to be no much differences between the one-layered group and two-layered group. The TBS scores of all three groups increase with days of observation. The ambient temperature and humidity were averaged based on its 24-hour of data reading by a thermocouple using the Weather Link software from day 0 to day 9. Figure 2 shows that the average humidity linearly increases while the average ambient temperature linearly decreases. Table 4 shows a summary of average TBS scores of each group, average humidity and average ambient temperature.

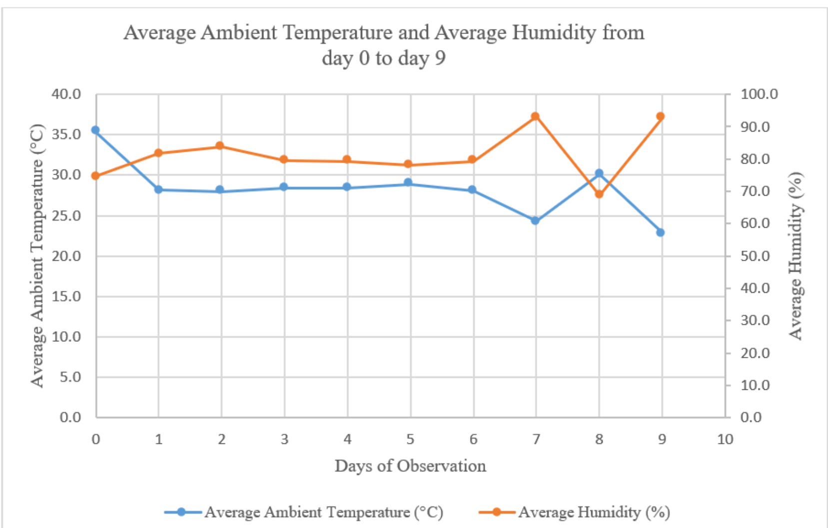

Figure 2: Average ambient temperature and average humidity from day 0 to day 9

Table 4: The average ambient temperatures, average humidity and the average TBS scores for all three groups from day 0 to day 9

Day	Average Ambient Temperature (°C)	Average Humidity (%)	Average TBS UC	Average TBS OC	Average TBS TC
0	35.4	74.6	3.0	3.0	3.0
1	28.2	81.8	5.2	5.0	5.4
2	28.0	83.7	12.2	11.2	11.5
3	28.4	79.5	17.1	16.3	18.5
4	28.4	79.3	22.8	21.0	20.9
5	28.9	78.2	24.6	22.8	22.6
6	28.1	79.4	25.3	23.8	23.7
7	24.3	93.2	27.0	24.9	24.6
8	30.1	68.8	27.0	25.1	25.6
9	22.9	92.9	27.6	26.0	26.2

STATISTICAL TEST

A Kruskal – Wallis H test was conducted to determine the differences between the TBS scores of the unclothed group (UC), one-layered group (OC), and two-layered group (TC). The TBS score among the unclothed subjects with a mean rank of 79.29 is higher than the one-layered and two-layered subjects with mean ranks of 71.72 and 72.39 respectively as shown in Table 5. There was no significant difference between the TBS scores of each group as the significant value was 0.621, $p > 0.05$. Whereas, a Spearman's rank-order correlation was run to determine the relationship between the average ambient temperature and the TBS scores for all the subjects in all three groups. Based on Table 6, there was a strong, negative correlation between average ambient temperature and TBS scores with a correlation coefficient of -0.377, which was statistically significant with a p-value of 0.040. Figure 3 shows the association between the TBS scores for all the subjects with the average ambient temperature throughout the observation period.

Table 5: Mean rank of the unclothed group (UC), one-layered group (OC) and two-layered group (TC) of Kruskal-Wallis

	Group	N	Mean Rank
TBS Score	UC	50	79.29
	OC	49	71.72
	TC	49	72.39
	Total	148	

Table 6: Spearman's correlation association between the average ambient temperature and TBS scores from day 0 to day 9

		TBS score	Average Ambient Temperature	TBS score
Spearman's rho	Average Ambient Temperature	Correlation Coefficient	1.000	-0.377*
		Significant value	.	0.040
		Number of data	30	30
	TBS score	Correlation Coefficient	-0.377*	1.000
		Significant value	0.040	.
		Number of data	30	30

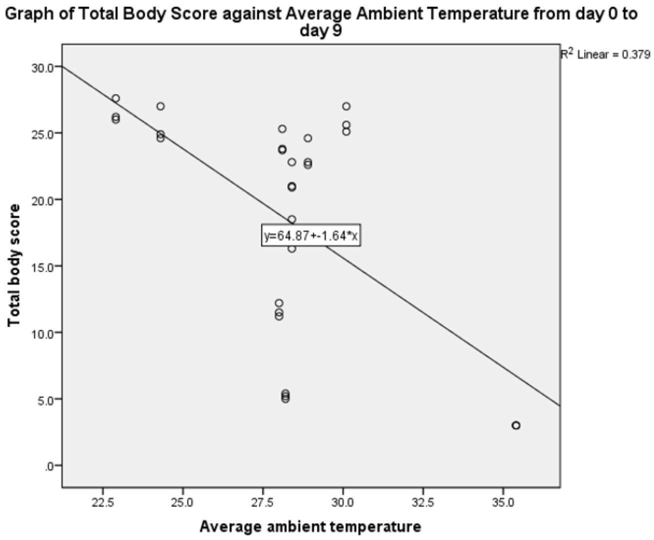

Figure 3. The association between the TBS scores and the average ambient temperatures from day 0 to day 9

Throughout the 10-day observation period, it was clear that there were visual differences in the post-mortem decomposition of the unclothed, one-layer clothed and two-layer clothed subjects. However, the TBS scores obtained are not statistically significant to the layers of clothing. Ants, maggots and the ambient temperature have played its role by influencing the decomposition rate. The key factor related to these results are the adjustments made by the environment itself, which is out of man's control. However, this shall be overlooked in this study, as the changes in nature are considered as to being a part of a real post-mortem decomposition process. This study's main purpose is to explore the effects of clothing and the rate of post-mortem decomposition.

STATISTICAL ANALYSIS

Kruskal-Wallis H test, a non-parametric rank-based test was used to determine the relationship between the TBS scores of the unclothed group (UC), one-layered group (OC) and two-layered group (TC). This test was used because the data was not normally distributed based on its test of normality as shown in Table 7. Compared to the Analysis of Variance (ANOVA) test, Kruskal-Wallis H test does not assume a normal distribution pattern. As a result, there was no significant difference between the TBS of all three groups. This result supports the hypothetical statement that types or layers of clothing does not vastly impact the post-mortem decomposition changes (Matuszewski et al. 2014).

The Spearman's rank-based correlation test was used to determine the association between the ambient temperature and the post-mortem decomposition changes of the carcasses by using their TBS as a continuous measurement. This test was used as there were no data that are in an approximate bivariate normal distribution (Beversdorf 2008). Based on the statistical test, there was a significant difference between the ambient temperature and the post-mortem decomposition changes. The negative correlation coefficient expresses that with an increase in the ambient temperature, there is a decrease in the TBS.

Table 7: Test of normality

	Group	Number of data	Significant value
TBS Score	UC	50	0.002
	OC	49	<0.01
	TC	49	<0.01

The post-mortem decomposition of a carcass or a cadaver speeds up with an increase in ambient temperature (Teo et al. 2014). During the current study, the thermocouple malfunctioned on days 0, 7, 8 and 9. Therefore, the data for days 0, 7, 8 and 9 were removed. Figure 4 shows the average ambient temperature and average humidity from day 1 to day 6. With the removal of the temperature reading, it now shows that the average ambient temperature is positively correlated to the TBS scores whilst being a significant difference to one another as shown in Table 5. The reformed data from day 1 to day 6 is reliable as there were no defects on these readings for 6 consecutive days. Figure 5 shows a positive association between the TBS and the average ambient temperatures from day 1 to day 6, as suggested by previous researchers (Srnka 2003; Teo et al. 2014) Moreover, these temperatures are relevant due to the fact that Malaysia is a tropical country where the annual mean temperature is 28°C and will only increase by 0.95°C in every 32 years (Chee-Loong et al. 2018).

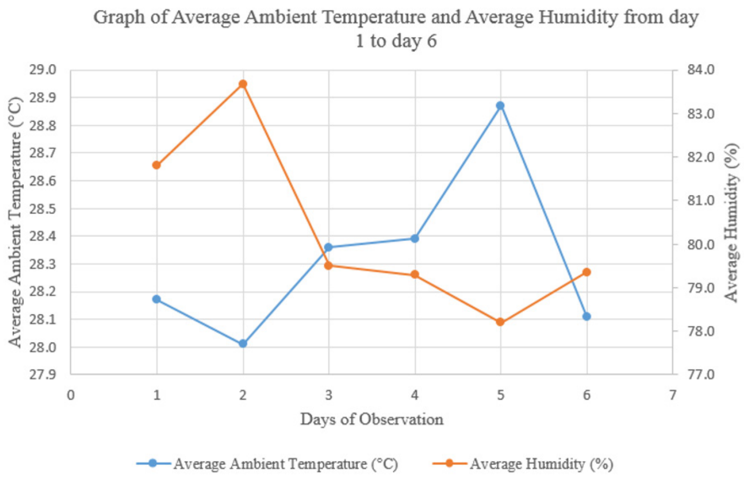

Figure 4: Average ambient temperature and average humidity from day 1 to day 6

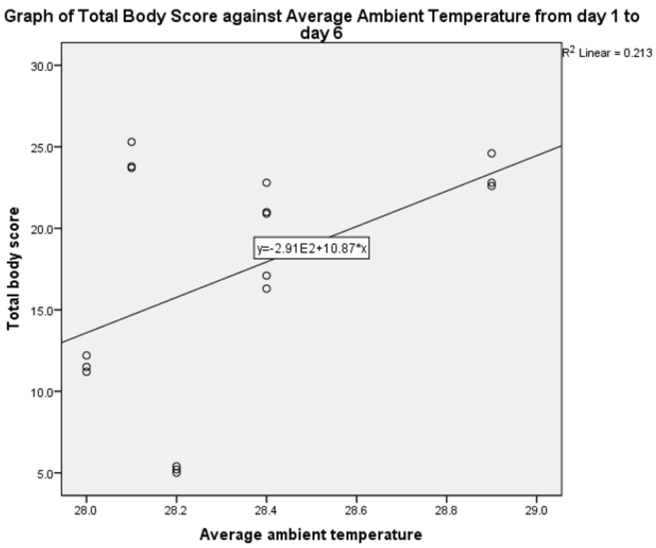

Figure 5: The association between the TBS and the average ambient temperatures from day 1 to day 6

INSECT ACTIVITY

Throughout the 10-day observation period, it is found that the presence of ants in a mid-large or large sum could slow down the post-mortem decomposition of a carcass. Figure 6 shows maggots as its dominant insect whereas Figure 7 shows ants as its dominant insect on the carcasses. From the figures, it is certain that in the presence of ants, the stage of decomposition is lengthened whereas, in the presence of majority maggots, it is sped up (Campobasso et al. 2001; Miller 2002). This phenomenon is due to the fact that ants feed on the carrion while carrying the maggots away from the carcass. This tends to occur rapidly in tropical countries like Malaysia (Campobasso et al. 2009).

Day 3 Day 6 Day 8

Figure 6: Observation of subject TC2 on Days 3, 6 and 8. Presence of majority maggots sped up the rate of decomposition

Day 3 Day 6 Day 8

Figure 7: Observation of subject TC4 on days 3, 6 and 8. Presence of ants slowed down the decomposition process

CONCLUSION

There was a difference in the TBS score obtained from the control subjects and the clothed subjects. However, layers of cotton clothing were not significant to the post-mortem decomposition of the carcasses. Ambient temperature was statistically associated with the post-mortem decomposition of the carcasses, but, obtaining a negative correlation. This is due to the malfunction of the thermocouple on days 0, 7, 8, and 9. However, removing these outliers resulted in a significant association and a positive correlation, which supports the theory that an increase in temperature, increases the rate of post-mortem decomposition. For further study, it is suggested that a specific sun exposure is chosen, either a shaded or sunny region. If both conditions occur simultaneously, it could be a key factor in influencing the post-mortem changes of the carcass. Besides, it is also important to make sure all the electronic devices that will be used in the future, functions well to avoid error in data collection.

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Noor Hazfalinda, Hamzah
Darishini Manimaran
Khairul Osman
Gina Francesca Gabriel

Forensic Science Program, Faculty of Health Sciences
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abdul Aziz,
50300 Kuala Lumpur
Malaysia.

Nur Mahiza Md Isa
Jabatan Patologi & Mikrobiologi Veterinar, Fakulti Perubatan Veterinar
Universiti Putra Malaysia,
43400 UPM, Serdang,
Selangor, Malaysia

Corresponding Author: Noor Hazfalinda Hamzah : raviera@yahoo.com