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Original Article

Reconstruction of postmortem interval from evaluation of decomposition rates and patterns based on modes of death using porcine models

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ABSTRACT

Background and aim: Decomposition patterns and rates are important in forensic taphonomy for estimating postmortem interval and determining the hidden mode of death. The current research documents decomposition rates for four different modes of death using domestic pigs as proxies for human remains in Northern Cross River State, Nigeria.
Methodology: Four porcine specimens were subjected to different modes of death (burning, strangulation, poison and blunt force trauma) and placed in open earth surface environment. Physical and chemical postmortem changes were monitored over 30 days, incorporating assessments of total body score (TBS), accumulated degree days (ADD), and insects colonization.
Results: Distinct variations in the rates of decomposition between different modes of death. Fire-induced rapid early decomposition was observed among burnt carrion as a result of desiccation of tissues brought about by fire. The toxic environment probably brought about by insect mortality delayed decaying in poisoned carrion. Blunt trauma carrions decomposed more quickly than the strangulated and drowned specimens, while the environmental exposure accelerated tissue breakdown. Insects were a principal agent in the degradation of soft tissues, whose species diversity and activities differed between modes of death. Analyses of the soils demonstrated a modification of the physicochemical characteristics after decomposition fluids had acted, especially nitrogen enrichment, but were indicative of the importance of the role of soil in modulating decay rates.
Conclusion: These findings present foundational insights into the advancement of forensic taphonomy and contribute to the enhancement of medico-legal investigations in Nigeria and other resource-constrained regions.

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Keywords:
Postmortem Interval; Modes of Death; Burning; Strangulation; Poison.

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INTRODUCTION

Postmortem interval (PMI) is one of the most important factors in medico-legal investigations, which answers many questions regarding the death of the deceased. The exact time of death is not possible to determine, but approximate estimates are based on physical and chemical changes during decomposition, influenced by environmental conditions (Karmakar *et al.*, 2007; Kulkarni *et al.*, 2016). Understanding decomposition involves studying biological processes and taphonomy, which examine postmortem changes and the effects of the environment on remains. These insights are essential for PMI estimation, biological profiling, and victim identification (Vass, 2001; Madea *et al.,* 2005).
In such instances, other evidence such as entomological data becomes imperative, since insect colonization and morphological degradation patterns differ among biogeoclimatic zones (Teo *et al.,* 2013). Forensic taphonomy research generally utilizes animal models, such as porcine cadavers, in order to simulate human decomposition. These studies examine differences in the rate of decomposition according to various modes of death—burns, drowning, poisoning—and environments, including open-air, burial, and aquatic settings. These kinds of studies also help estimate the PMI and identify the victim, even in clandestine situations, according to Swann et al. (2010) and Marais-Werner *et al.* (2017). Growing natural calamities and violent crimes like flooding, bombings, and homicides demand a developed forensic investigation approach. Estimation of PMI helps to establish links between victims and perpetrators with strong evidence to support the crime investigations.

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The analysis of the decomposition patterns and environmental influences helps forensic experts work toward these challenges. The outcome of this study will be of paramount importance to disaster victim identification, biological profiling, and criminal justice and will contribute to medico-legal systems in solving crimes and identification of remains in complex scenarios. These findings contribute to strengthening forensic science and its role in dealing with global and local security challenges.

MATERIALS AND METHODS

Ethical Approval

An An approval was gotten prior to the commencement of this research from the Ethics and Research Committee of the Faculty of Basic Medical Sciences, University of Cross River Staten through a letter with an approval number UNICROSS/FBMSREC/2023/003.

Study Location

This study was carried out in an indoor setting at the Department of Anatomy and Forensic Anthropology Research Facility (DAFARF) specially designed for Forensic Taphonomy studies at the Faculty of Basic Medical Sciences, University of Cross River State, Okuku Campus, Yala, Cross River State Nigeria.

Experimental Design

This research was carried out in the Department of Anatomy and Forensic Anthropology Research Facility (DAFARF), in the Faculty of Basic Medical Sciences, University of Cross River Okuku-Campus, in Yala Local Government Area of Cross River State, Nigeria. Forensic taphonomy research is the only activity allowed in the research facility. This study cohorts included Four (4) pigs (*Sus scrofa domestica*) of ten (10) months old weighing between 35-36Kg. The Animals were sacrificed through four different modes of death which include death by blunt neck trauma, poisoned, burnt, and strangulation. From the design, this research lasted for one month duration (30 days) for the modes of death evaluation study.

Modes of Death Protocols:

According to Magyesi *et al*. (2005) Crow-Glassman scale 1, charring method was used where the animal was tied against a stick and with the help of little petrol poured on the grass fibers set at the base and light was ignited through a long stick. Another pig was poisoned with 20mls of snipper which is insecticide, a synthetic organo-phosphorus which belongs to 2,2-dichlorovinyl dimethyl phosphate (DDVP compound), an insecticide and miticide containing the active ingredient *bifenthrin (*Franjic, 2020). It took the animal less than three minutes before death was confirmed. Sniper insecticide manufactured by Loveland Products, United State of America, was purchased from a chemical shop at Ogoja Cross River State. 20ml of the poison was orally administered to poison the animal (Keough *et al.,* 2017).

The pig sacrificed through cervical blunt trauma, the protocol involved, crude hitting of heavy stick on the posterior region of the neck and death was confirmed within two minutes. Lastly, strangulation was done by tying the pig (both fore and hind limbs) and another rub was tied to the neck of the animal to enhance strangulation, death was also confirmed here with two minutes. The four modes of death was carried out simultaneous by the researchers and research assistants' team. All the four carrions confirmed death were left on open earth surface protected with iron cages to avoid scavengers' attacks for the evaluation of physical postmortem changes. Ante and postmortem rectal (Core) temperature were taken in each animal using rectal thermometer according to the laid down protocols by *(*Franjic, 2020 and Moffatt, (2016). By day two (2), routine visits to the carcasses were three time daily to get the accumulated degree days, total body score of the rate of decomposition based on Magyesi *et al*., (2005) scoring charts; and based on regions (head and neck, trunk, and limbs). Similarly, photographs were taken for each visit to the carrions for further physical decay interpretations. The research onsite visitations lasted for the thirty days experimental period, three times daily for the first fourteen (14) days and reduced to twice daily for the last sixteen days.

Temperature and Accumulated Degree Days (ADD)

Both core and ambient temperature readings were taken on a ten (10) minutes interval for the first two hours (2) and increased to 30 minutes duration for another 6hours to complete the first 8hrs of research day one, to observe the onset of early autolytic postmortem changes like pallor mortis, algor mortis, rigor mortis and livor mortis. Regular site visits and checks were conducted three times daily for the first two weeks (14) of the inquiry, then was reduced to twice daily for the final sixteen days. During each visit, the minimum and maximum temperatures at the site were noted to determine the accumulated degree days (Rysavy and Goff, 2015; Megyesi *et al.,* 2005).

Insect Collection Technique

Using an insect magnetic net, insects were collected from all the pigs. With the help of insect magnetic nets, insects found on, around, and under the carcasses were carefully gathered. All captured insects were preserved in 10% formal saline fluid and kept for identification (Abajue *et al.,* 2016; Ahmad *et al*., 2019). The collected insects were analysed by forensic entomologist at the Department of Zoology, University of Calabar.

Total Body Score

The degree of body decomposition was quantified using Total Body Score (TBS), a scale frequently used in taphonomic studies to examine the progress of decay. In this study both onsite scoring and the use of photographs were employed to get the total body score. The visible postmortem body score was done at every visit to the research site and pictures taken. During the daily observation, the three main parts of the carrion was assigned points depending on how fast they have decomposed. The total body score is based on the three regions of the carrion, that is, head and neck, trunk and limbs. This protocol was done was done in line with the established method by Megyesi *et al.,* (2005).

Soil Samples

The soil samples from the research site were collected before and after the study duration of 30 days period to carry out soil physico-chemistry, exchangeable bases as well as volatile fatty acids of the study area and their impact on decay rates, in line with earlier protocol published by Simmons*et al*., (2010). The soil before and after decomposition of the carrions were collected and the soil physicochemical analysis, exchangeable bases and volatile fatty acids were analysed in the Department of Soil Sciences, University of Uyo.

Research Analysis

This study involved a series of analysis including, statistical, total body score, temperature and entomological analysis were done. Statistical Package for Social Sciences SPSS) Version 21 was used for statistical analysis. The results of the total body was analyzed and the outcome presented in table for the four modes of death, as well as graphs were plotted Total body score (TBS) and accumulated degree days (ADD). Similarly the insects collected were analyzed and identified by Forensic Entomologist at the University of Uyo, Department of Animal Science.

RESULTS

The graphical correlation between ADD and TBS for burnt carrion (Figure 1) shows directly and strong relationship between accumulated degree days and total body score. As the ADD increases with days, the TBS also increases.

The graphical correlation between ADD and TBS for blunt trauma carrion (Figure 2) is linear presentation that depicts directly proportional increase in the two parameters.

Accumulated Degree Days (ADD) Y-axis and Total Body Score (TBS) on X-axis of poisoned pig (Figure 3), showed a progressive increase in both TBS as well as total body score the carrions, as the decomposition increases.

Present data for ADD vs total body score for drowned carrion (Figure 4) as ADD increased over time for 30 to show progression in TBS skeletonization.

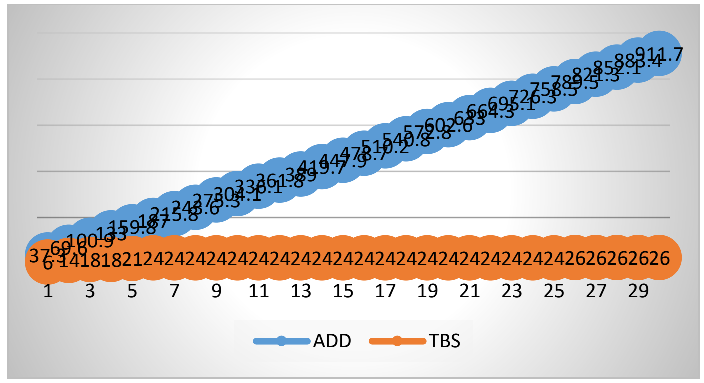

Figure 1: The relationship between accumulated degree days and total body score of burnt carrion.

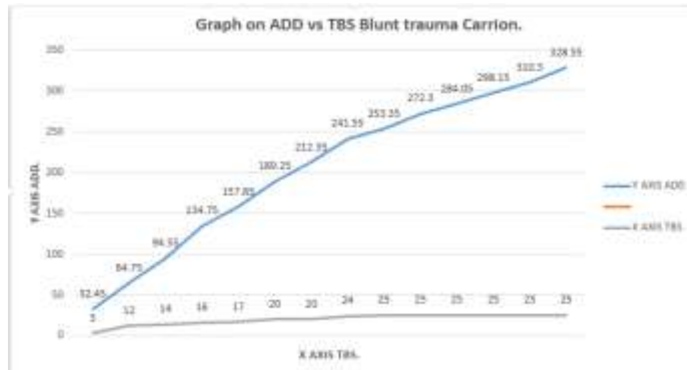

Figure 2: The graphical correlation between accumulated degree days (ADD) and total body score (TBS) of blunt trauma carrion.

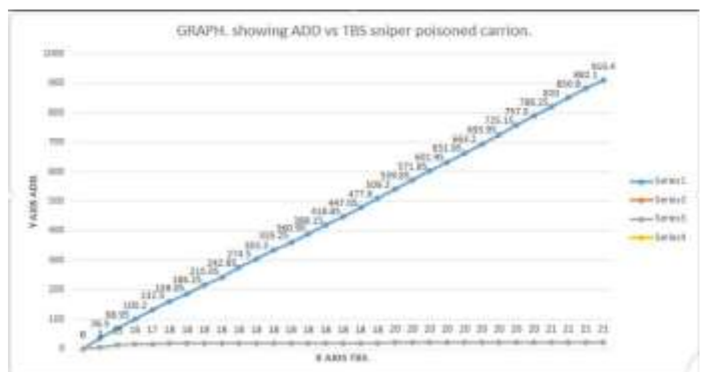
Figure 3: The result of Accumulated degree days (ADD) versus total body score (TBS) for poisoned carrion.

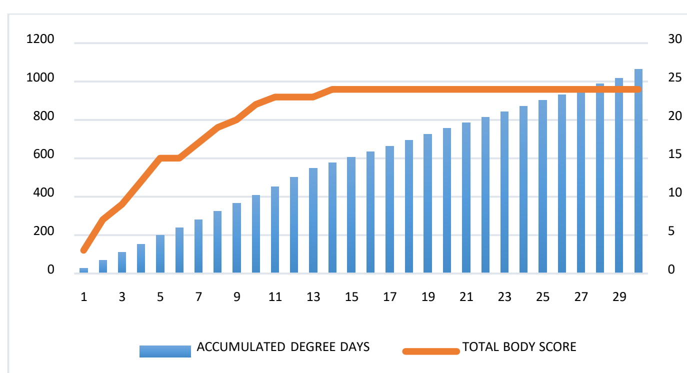

Figure 4: Accumulated degree days vs Total body scores (strangulated carrion)

From the results presented in table 1 which depicts that different modes of death have different decomposition timelines, as blunt trauma carrion decompose faster than other followed by the burned carrion and the slowest decomposing carrion was poisoned carrion all values varies data set P<0.01 respectively.

Presentation for physical postmortem changes based on modes of death.

The burnt carrion underwent physical postmortem changes that showed that the hairs were burned, some areas of the skin were peeled and darkened (Figure 5A), there was epidermal flaking and redness in the flaked region (the trunk and scrotum); extreme desiccation and blistering of the skin was also present, autolysis was almost complete, and the red areas were darkening, but the carrion was still in a fresh stage of decay.

The carrion that had been strangled (figure 5B) was at a clearly early stage of decomposition.

The physical outcome of cervical blunt carrion (figure 5 C) showed tight muscle properties together with obvious blood fluids flowing from the orifice.

Day one of the poisoned carrion (figure 5D), still in the early stages of decay, showed pallor mortis setting in for the first ten minutes, the presence of the first bloat flies, eyes open for the first thirty minutes, then later closed beginning at forty minutes, the onset of rigor mortis from smaller muscles to larger muscles, a foamy-like substance coming from the mouth and nose (orange red in colour), clear fluid coming from the anus, minor colour changes.

There was a rise in the desiccation of the skin, insect activity, and persistent fluid flow from the eyes, mouth, and nose, according to the burnt carrion (figure 6A). There were also apparent maggot larvae and skin sagging indicators, such as an inguinal eruption and forelimb blisters.

The strangled carrion (figure 6B) was characterized by a greenish hue and fluid leakage from the inguinal area. It was at an advanced state of bloating. Additionally, it was clear that there were maggots in the larval stage in the eyes, mouth, and fore and hind limbs that were in direct contact with the ground, causing complete decomposition and being replaced by pupae maggots as well as the caving in of the eye.

Day two cervical blunt trauma carrion (figure 6C) exhibits brown staining and drying of the fingers, elongation of the forelimbs, and purging of fluids from the orifice. Rigor mortis is characterized by a greenish tint on the head and neck as well as rectal protrusion.

The poisoned continued to show symptoms on day two (figure 6D), and inspections showed a larger trunk, reddish frothy fluid emerging from the nose, greenish staining of the anus and mammary region, an early onset of bloating characterized by rigidity of the abdomen, and protrusion of the anus.

The carrion decomposition island (CDI) was 6 inches at the south pole, the burned carrion (figure 7A) showed an explosion of abdominal content that persisted throughout day three, active decay had mostly started in the thoracic and abdominal parts while the head, neck, and forelimbs were still relatively fresh (15cm). The pig's skin desiccation, loss of body mass, complete collapse of the hind limbs, noticeably increased number of blisters, and growth of the mouth with protruding tongue were likely caused by the larvae and pupae stage of maggots. The bloated stage of the strangled carrion (figure 7B) did not extend to the limbs, and the color of the carrion changed from pink to dark brown or black primarily in the head, neck, limbs, and anterior abdominal wall (lividity). There was also an increase in skin slippage, fluid discharge from the inguinal region, the emergence of a foul smell, and sagging of the flesh. The anterior abdominal wall in the lower inguinal region was. The anterior abdominal wall's flesh sagged as evidenced by drained blisters, and there was only mild maggot activity in the oral cavity.

According to the findings of the physical postmortem changes of poisoned carrion (figure 7D), there was an increase in the dead pool of insects, a lack of smell, fresh blood discharge from the eyes and nostrils, a continuous rise in lividity indicated by a continuous fluid of a black sac filled with blood, and internal decomposition of all the muscles.

The physical postmortem changes of the burnt carrion (8A) at day 4 showed a continuous regional active decay, and increase in advanced decomposition featured by invagination of the maggots in the lower surface of the carrion; there was a visible decrease in body mass associated, purging of fluids from the abdominal content with excess carrion decomposition island, there was also desiccation of the anus characterized by tough leather like appearance and reduction in size of head and neck.

The lower abdominal wall and inguinal region of the strangulated carrion (8B) protruded leatherier and more exhibited considerably enhanced insect activity, complete collapse of limbs and purging of fluids.

The cervical bunt trauma carrion (8Cs) is present in the head area of the northpole and the southpole, with the rear limbs completely collapsed and skin and hair coming away from the carrion.

On the fourth day (8D), the poisoned pig was observed. It was found to have a dead pool of insects, a total gradual replacement of the body with fluids, continuous fluid discharge from the orifices, increased lividity, fluid accumulation in the ear lobules, and evidence in the soft texture of the carrion.

The burnt carrion shown in figure 10A showed a loss of body mass, and it was found that the lumbar spine and fore and hind limbs had exposed bone. Less than half of the body had been scored, and the inguinal and head regions had been purged of a dark green wax-like fluid. Mature adult maggots were active in the mouth, and the lower part of the head had advanced decay by this point.

The strangulated carrion (9B) had a mild putrid odor and noticeable maggot activity in the inguinal region on day 5, as well as additional trunk distension, ongoing flesh sagging, and a reduction in carrion size. The rate of active decay was slow, and there was significant fluid expulsion from the anus and inguinal region. The texture of the skin resembled leather, and adipocere gradually began to form in the lateral half of the carrion.

The decomposition of the head and neck following cervical blunt trauma (9C) at day 5 is progressing and is characterized by maggots (poppa stage), as well as the presence of mixed maggots. Complete skin distension with leather-like covering, rapid hair loss from the head and neck region, and lack of a faint rotting odor.

By day five, the poisoned carrion (9D) shows increased skin transparency, a lack of foul odor, more separation of the skin from the soft tissues, a dead pool of insects connected to an increase in insects, and continuous fluid discharge from the mouth.

The burnt carrion (figure 10A) was observed to progress in mummification of the carrion along with progress in skeletonization at day seven (7). Extreme desiccation of skin, increased bone exposure of the hind limb and the entire spine, mild putrid odor, noticeable breakage of thin transparent skin with presence of fenestrae in the mouth.

Physical postmortem changes of strangled carrion (Figure 10B) at day seven (7) had a noticeable purging of grease-like fluid from the oral cavity, anterior abdominal, inguinal, and anal region, along with progress in decomposition, characterized by increase in maggot activity in the anterior abdominal wall and limbs, further collapse of the carrion, progress in the mummification of the neck, and bone exposure of the mandible and fore and hind limbs in continuous motion. Increased carrion decomposition island.

Further separation of the head and neck are observed after cervical blunt trauma, and this carrion is characterized by mature insect activity (figure 10C). Blunt force exposure of the spinal bones causes modifications and occurrences that speed up the breakdown process. The poisoned carrion (10D) at day seven showed presence of dead pool of insects, absence of odor, insect activity characterized by burrowing of soil around the entire carrion, still in a fixed state, discharge of fluid from the posterior region of the neck, presence of carrion decomposition island, dead pool of beetles, further increase around the abdominal wall, and presence of carrion decomposition around the neck.

The charred carrion in figure 11 displayed full moisture loss and disarticulation of the upper hind limb from the other limbs. Mummification has advanced significantly, giving carrion a lustrous aspect. In the lowest part of the carrion, more bones were exposed.

The strangled carrion (figure 11B) was seen to exude a strong choking odor, to lose hair continuously, to progress in mummification and desiccation of the head, neck, and limbs, to have a generally greasy appearance, to have increased palpability of the carrion's bones, to have relative decreased insect activity, to purge fluid from the oral cavity, and to completely collapse. As the decomposition of the cervical blunt trauma carrion (11C) progressed, there was a moderate putrid smell, the limbs, particularly the hind, were dry, and the bones were disarticulating from the trunk.

On day 14, the poisoned carrion (figure 11D) continued to exude an oil-like fluid, there was some light insect activity, the skin was continuously transparent, and it had begun to drizzle that evening.

The physical postmortem changes of the burned carrion (figure 12A) at day 21 were advanced, with the skin of the posterior part of the trunk folding up. It was also noted that the inguinal region had a bulge due to the pelvis bone protruding beneath it. The carrion was still mummifying and the skin was desiccating at this point. Black ants dominated insect activity, and there was no smell, which shows more progress in mummification, desiccation of skin, and further exposure of nasal bone and skull. Given how desiccated and fragmented the cervical blunt trauma carrion (figure 12C) appeared, it was determined that it was in the dry stage of decay (skeletonization) at age twenty-one.

Day 21 observations of the poisoned remains show that the bones are still palpable, the skin is still transparent, there has been mild insect activity as evidenced by a dead pool of insects, the carrion has continued to collapse, the spine's bones have continued to be exposed, ridges have continued to form, and the carrion has continued to be buried in the ground after being severed from the scapula. This stage was the carrion's home from day 15 to day 21.

The burned carrion (figure 13A) at day twenty-eight revealed that the thoracic region's bones were still becoming exposed, with more than half of the area being scored and exfoliated. The mummified hide was also continuing to fold upward.

The suffocated traces (figure 13B), there were insect colonists present, and skeletonization was occurring, mummification and desiccation were progressing, the state of the carrion appeared to be fixed, there was a slight putrid smell, increasing fenestration, and there was grease in the mouth cavity.

The strangled carrion was still in the skeletonization stage by day 28 (Figure 13C), the skin had further mummified, black ants were present, the weathering and exfoliation of the bones had advanced, and there were misplaced bones as a result of insect burrowing.

Head and Neck: The frontalis bone and lateral half of the skull are exposed, the ear has been severed and is lying in touch with the ground, the neck has been mummified, and the mandible has not been exposed. Trunk: The bones of the spine, rib cage, and sacrum are exposed, and more than half of them are being scored. Skin desiccation and mummification, the presence of fenestrae and the pelvic bone's disarticulation from the sacrum and lumbar spine. Limbs: The limbs' exposed bones (the tibia and fibula), dry tissue from mummification and skin desiccation, and severed bone joints from the hind limbs. Fenestrae, especially in the hind limbs, get larger. At day 30, minimal insect activity, no foul odor, and Rain made the mummified skin of the trunk more pliable.

Day 30 saw the strangulated carrion (Fig. 14C) reach the skeletal stage of decomposition, which is marked by complete tissue decomposition, apart from mummified skin in the spinal region, complete dismemberment of the limbs, head, neck, and trunk, complete desiccation of the entire remnant of the carrion, and the presence of weathering, bone exfoliation, and bone bleaching. The poisoned carrion (figure 14D) at day 30 observations of the poisoned pig show mild putrid smell, bone exposure of the neck, fore limb, spine, and rib cage, dismemberment of the pelvic bone, flapping of the mummified skin of the neck region and trunk, detachment of the ear in contact with the soil, and continued mummification of the carrion.

Table 1: Descriptive Statistics of Modes of Death Total Body Score

Mode of Death	Minimum	Maximum	Mean±SEM
Burned	6	32	26.06±0.12
Poisoned	3	22	18.08±0.27
Strangulated	3	28	22.02 ±0.23
Blunt Trauma	3	35	30.21+0.12

Mean values across modes environments are statistically significant different at P<0.01.

Table 2: Distribution of Insects succession attracted to Burnt, Strangulated and blunt force carrions at different stages of decay.

Decomposition Stage	Associated Insect	Developmental Stage
Fresh	Muscidae (Diptera)	Adult
	Formicidae (Hymenoptera)	Adult
	Sarcophagioae (Diptera)	Adult
	Calliphoridae (Diptera)	Adult
Bloated	Calliphoridae (Diptera)	Adult and Larvae
	Muscidae(Diptera)	Adult and Larvae
Decay	Calliphoridae (Diptera)	Adult and Larvae
	Histeridae (Coleoptera)	Adult
	Phoridae (Diptera)	Adult
	Formicidae (Hymenoptera)	Adult
	Scarabidae (Coleoptera)	Adult
	Dermestidae (Coleoptera)	Adult
Mummification/Skeletal	Silphidae (Coleoptera)	Adult
	Braconidae (Hymenoptera)	Adult
	Calliphoridae (Diptera)	Adult and Larvae
Dry	Cleridae (Coleoptera)	Adult
	Anobiidae(Coleoptera)	Adult
	Dermestidae(Coleoptera)	Adult and Larvae

Depicted in table 4, above is the out of insects' successional pattern associated with each stage of decay. It is observed that the insect's species are attracted differently to the carrions across the five stages of decay.

Necrophagus insects identified and recorded at various stages of decay showed that varying species of insects are attracted to the decomposing carrion at different stages of decay.

Fig 5: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 1. All carrions at fresh stage of decay.

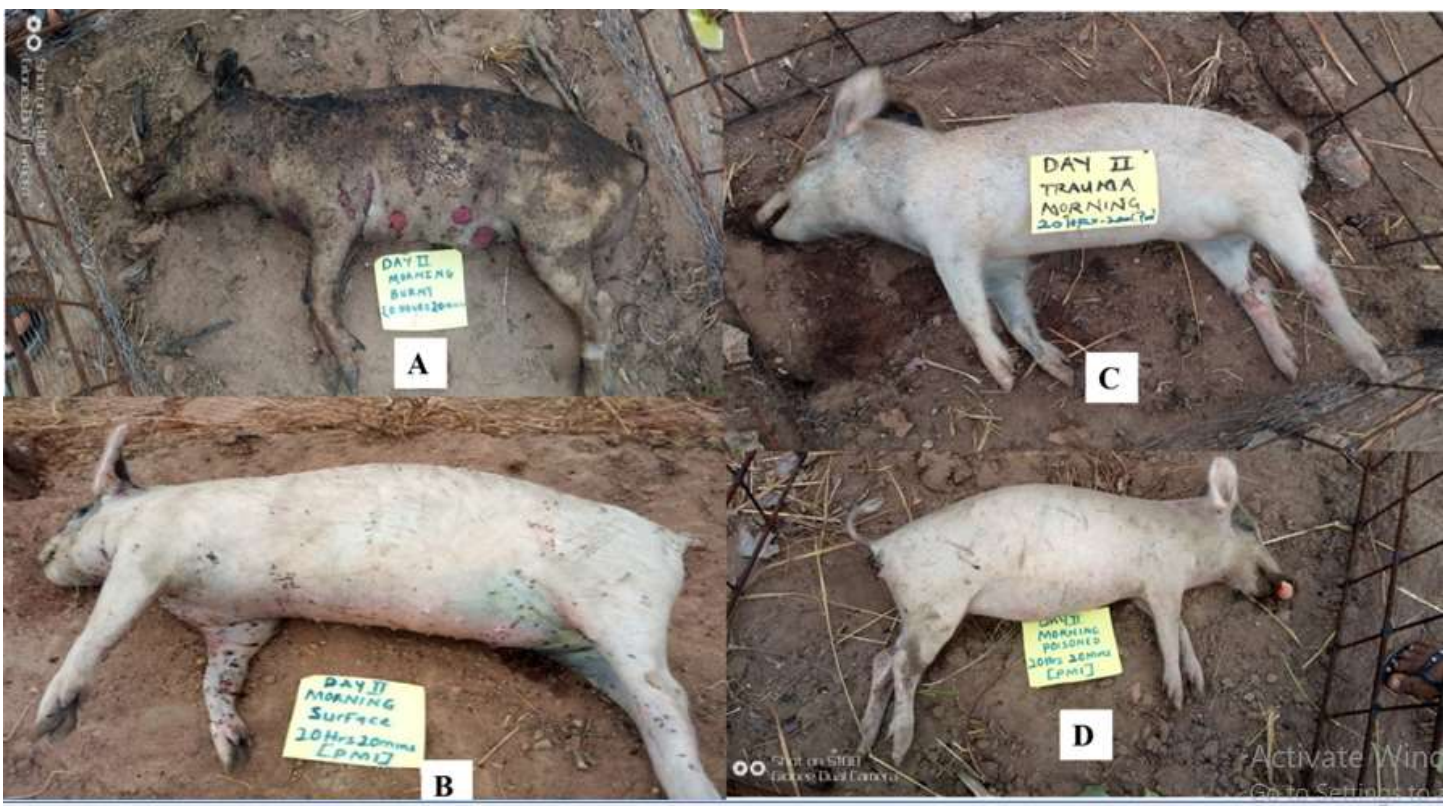

Fig 6: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 2. All carrions at bloated stage of decay.

Fig 7: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 3.

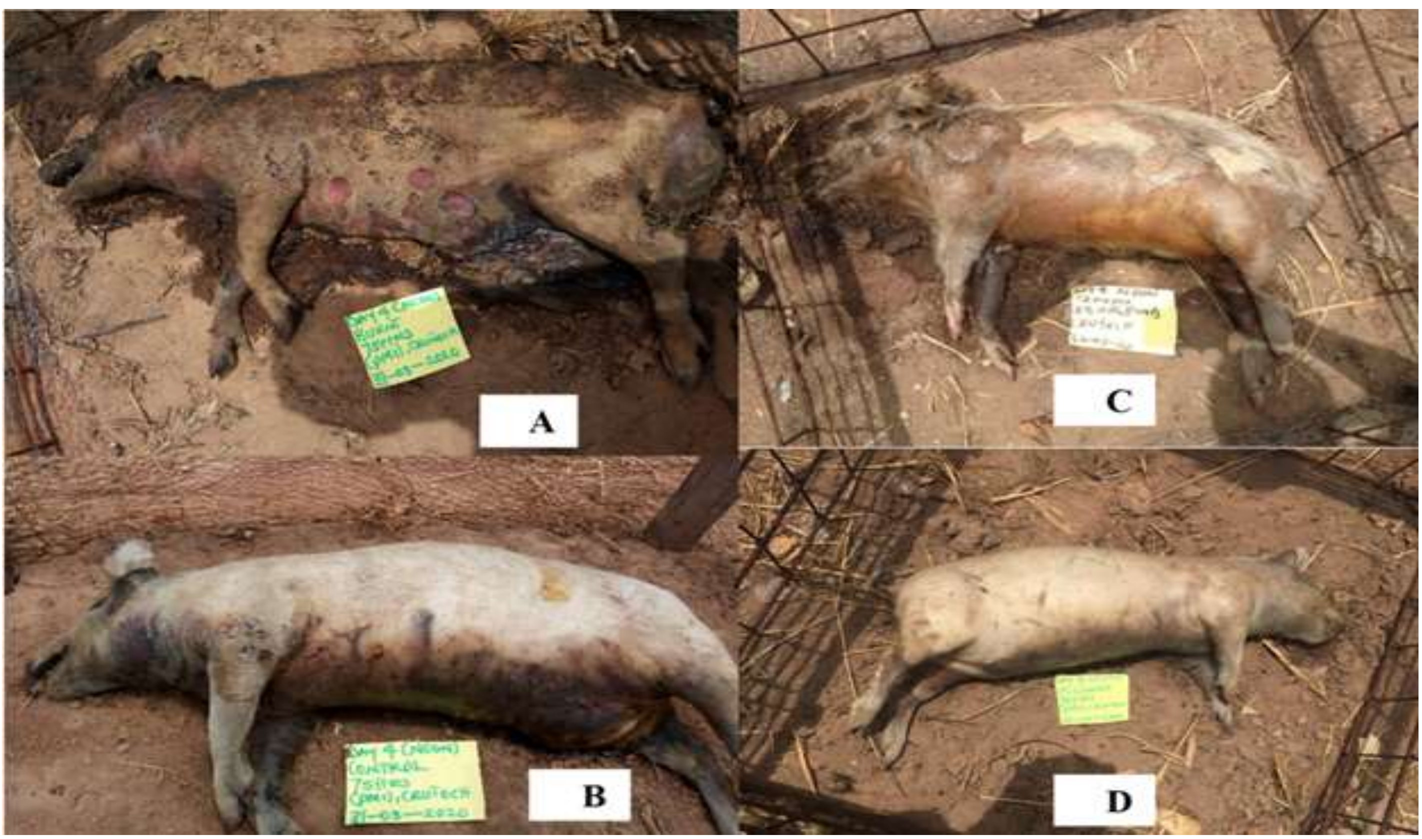

Fig 8: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 4.

Fig 9: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 5

Fig 10: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 7

Fig 11: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 14

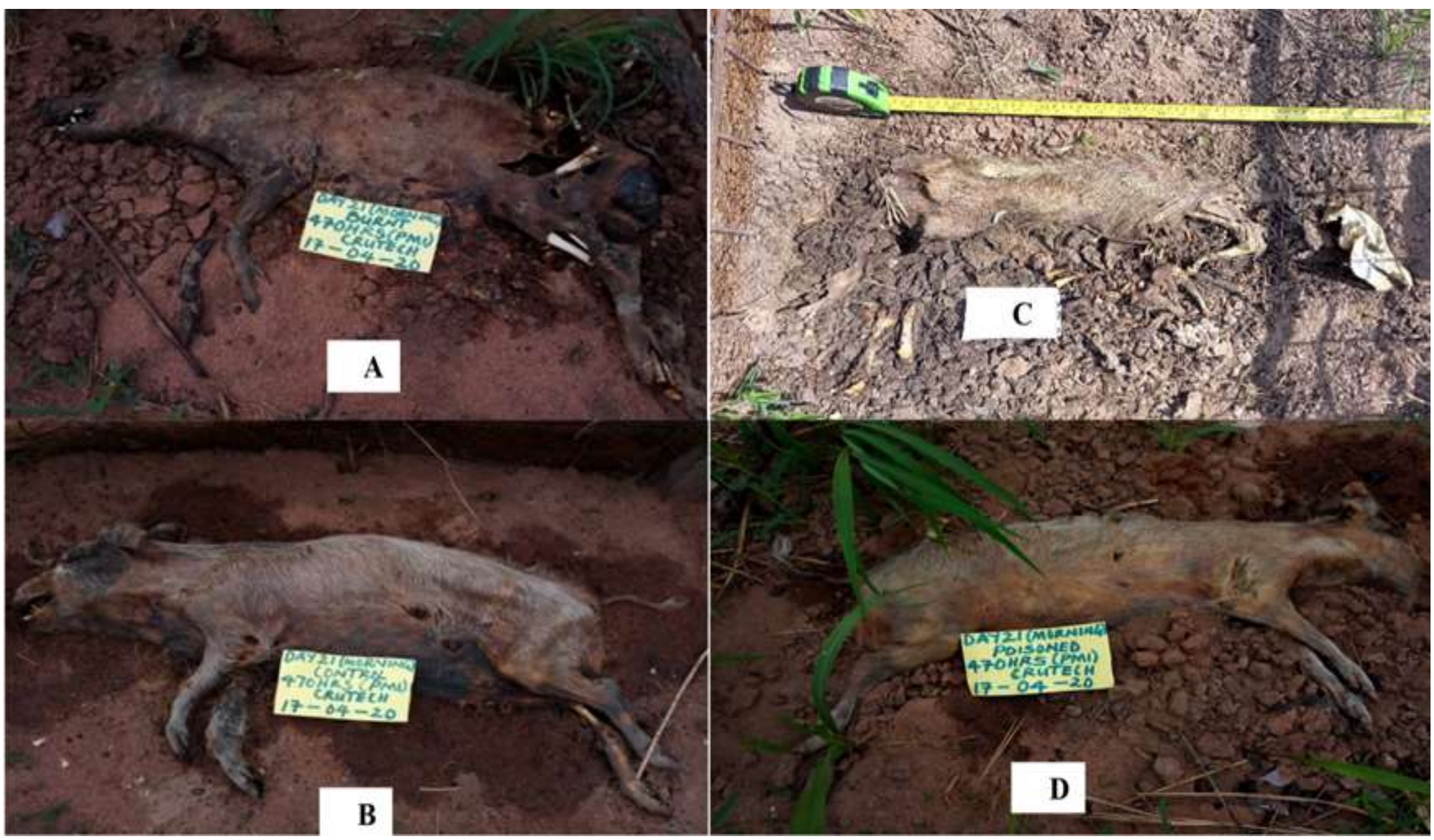

Fig 12: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 21.

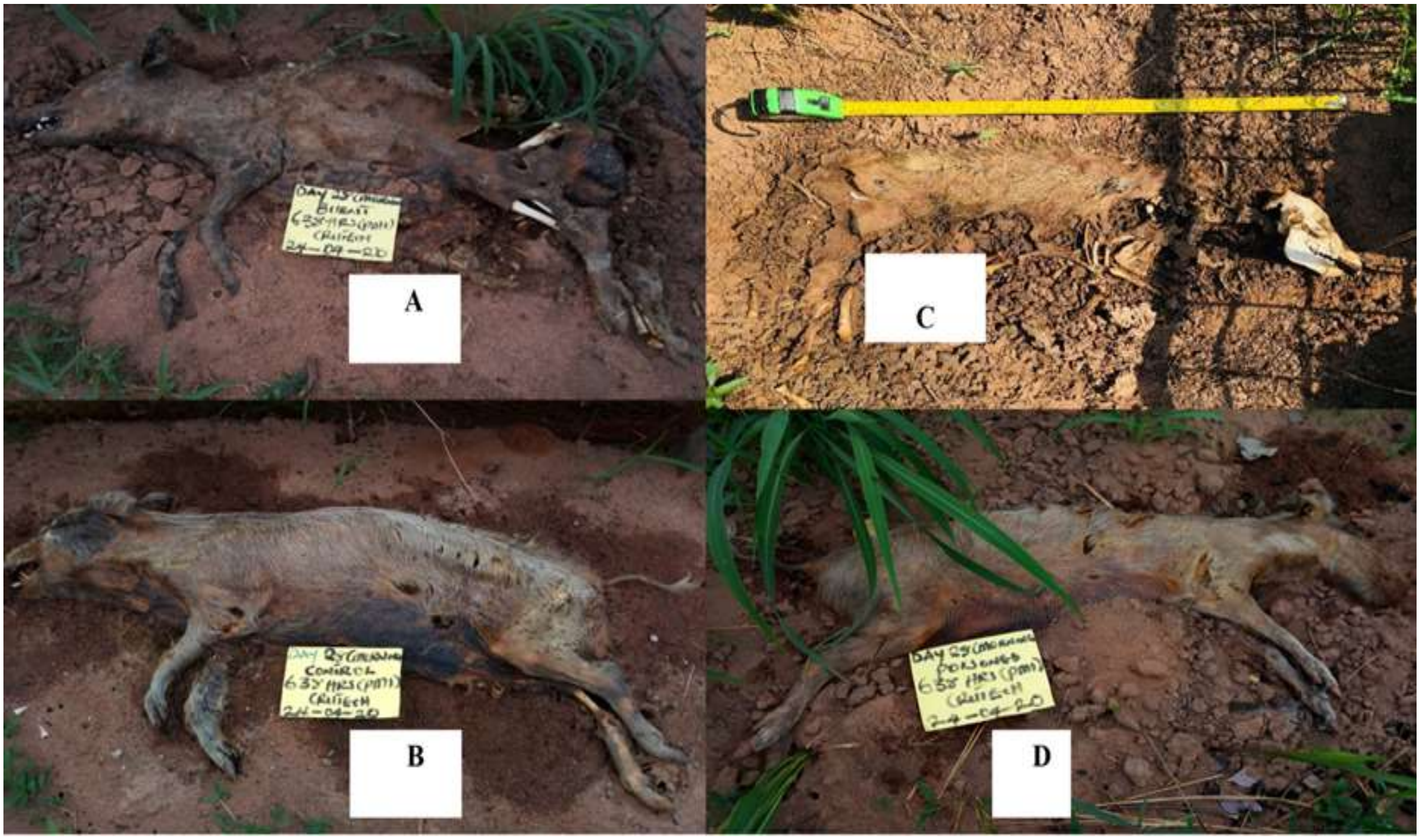

Fig 13: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 28.

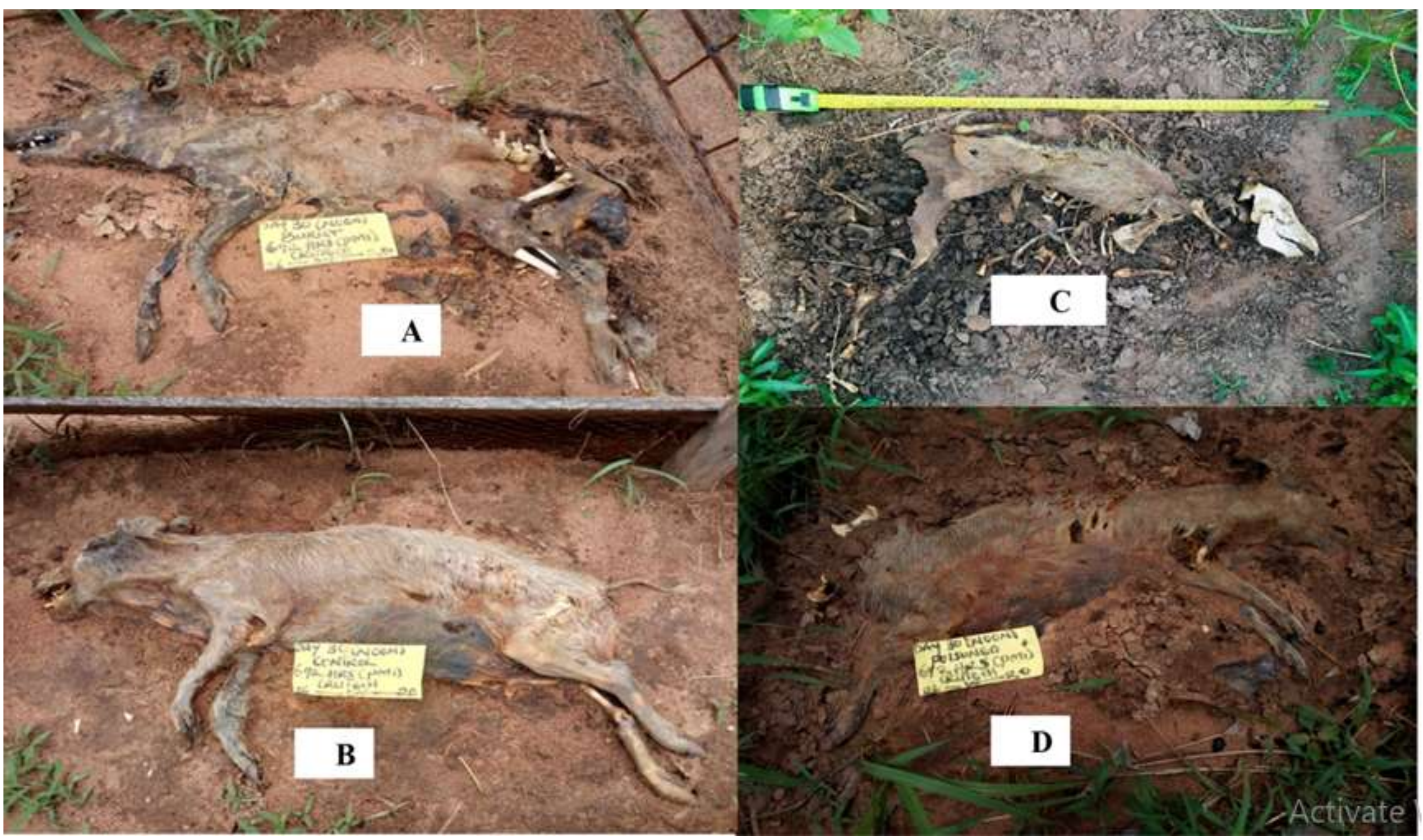

Fig 14: A-D showing visible postmortem changes of burnt (A), strangulated (B), blunt neck trauma (C) and poisoned (D) carrions at day 30.

DISCUSSION

Modes of Death

One of the tactics used by those who commit crimes involving deaths to hide evidence is to subject victims to clandestine methods of death. This study used four common modes of death ((strangulation, charring, blunt trauma and poison) to examine the rates and patterns of gross breakdown as well as the effects of these methods on decay timelines. The results are discussed comparing the strangulated carrion (control) with other modes of death.

Burnt versus strangulated (control) carrions

As early as 1989, Galloway et al., carried out this comparison and later updated by Megyesi et al., (2005). According to this studies observations, the burnt carrion demonstrated a quicker early decomposition because of the use of fire, but the strangled carrion displayed less significant postmortem changes.

A few hours into the first day of the study, pallor mortis and rigor mortis in the orbit, neck, and upper limbs began to manifest. On the other hand, during the fresh stage, the burnt pig developed blisters with flaking skin. The bloating stage of the strangled pig began on day 1 (fig.5) and continued through day 3 (fig 7), when it began to diminish along with fluid leakage and a greenish tinge. The bloating had reached a significant level by the end of the second day of the study.

By day 2, an inguinal eruption had significantly lessened and eventually stopped the ballooning in the burned pig. On day 3, the strangled pig began to exhibit fresh rot symptoms, such as sagging flesh, fluid leakage, and an unpleasant odor. Skin seemed to move noticeably. At the end of day three, the strangled pig had progressed to the late stage of fresh deterioration but still relatively fresher than burnt carrion.

The strangled pig started actively decomposing on day four characterized by shrinkage of carrion size, the carrion seemed to be in a fixed state for two days.

On day 6, the strangled carrion bones that were in contact with the ground for the skeletonization stage started to become visible, along with the nose bone. After a few days of the study, the bones of the forelimbs started to fall off and at one point, the rib cage's bones were quite palpable. By day 25, the rapid regional skeletonization had advanced. In the burnt pig, bone exposure started on day 5 with the fore and hind limbs, with less than half of the area being scored. The charred, mummified skin delayed the skeletonization process, which took place concurrently with dry degradation. The study's exposed bones were severed after which they started to separate from one another. As the research went on, it was found that the burned pig continued to mummify rather than decomposing, whereas the strangled pig's pace of decomposition was faster.

The fresh pig's total body score started out at the lowest point, which is a total of 3 (Fresh stage), and then advanced quickly over the course of the following two days before becoming largely stable from days 4 to 22. Following this, the total body score increased once more over the course of the final eight observational days. The charred pig's total body score was as high as 6 on the first day of observation due to the effects of the fire, and it rose dramatically over the following several days before it began to remain at the mummification stage of decomposition. The total body scores of the carrion stayed constant from day 5 to day 28, and it didn't appear that anything would change until day 29, when they rose once more.

The mild insect activity that the burnt carrion underwent helped to speed up the process of decomposition. About 8 hours after the carrion's death, a Musca species of the Diptera order was the first animal to arrive at the scene. Typically, the fresh stage lasts for about 2 days before bloating of the abdomen is seen. It has been noted that dipiterous maggots that were present during the active stage follow the invasion of the muscids. The inflated stage of the carrion was accompanied by the adult and larval Calliphoridae and Muscidae of the dipteral order. Silphidae or Braconidae were among the few insects present during the mummification/skeletal stage, and Anobiidae and Dermestidae joined them during the dry stage (Campobasso *et al.,* 2001; Goff *et al*., 2010).

Estimating the postmortem interval from decomposed human remains is just one application of the information obtained from the accumulated degree days in relation to ADD (Megyesi *et al.,* 2005). The purpose of this study was to examine the decomposition times of burnt and strangled carrion. It is crucial to remember that decomposition depends not only on the moment of death but also on the total number of degree days (Megyesi *et al*., 2005). Both carrions had exponential increase in ADD, which eventually reached a temperature of 910.3^{0}C.

Another significant element that may influence the rate of decomposition is the soil. Although soil is essential in solving forensic cases, its effects are infrequently researched despite the fact that huge amounts of nutrients are released into the soil when vertebrate corpses decompose (Szelecz *et al.,* 2000) Prior to the start of the experiment, the soil in the location of the burnt carrion had lower concentrations of K, MG, and Mg due to the carrion's decomposition. The soil around the charred carrion had a sandy texture prior to the experiment, but by the time it was over, it had changed to a clay loamy texture. After breakdown, the quantity of nitrogen rose by 0.01 percent.

When soil samples from the control carrion site were examined, it was found that the sand included higher concentrations of Mg, K, Na, and Ca. After the carrion's breakdown, the concentration of these components decreased. The fluid generated in the island's carrion decomposition caused the soil's texture to change from sandy to clay loamy during the pre-experiment phase. After the carrion's decomposition, the level of certain elements, notably nitrogen, went up by 0.03 percent. At the start of the experiment, there is an extraordinary increase in the total amount of nitrate (Szelecz *et al.,* 2000).

Poisoned Versus Strangulated (control) carrions.

Forensic science has been interested in the Postmortem Interval (PMI) or period since death for many years. To fill in a vacuum in the literature and compare the decomposition processes of a pig model that has been poisoned and strangled, this research considers the fact that the vast research has largely been restricted to analyzing a single species.

It is impossible to stress the critical role that PMI estimation plays in every death inquiry. When blowfly larvae are collected and aged to determine the time since colonization, which can be used to extrapolate a time since death, forensic entomology can be used. However, many outside factors can affect this estimation. In situations where insects are not present, we use a qualitative evaluation of the degree of decomposition of the body.

The results of the strangled and poisoned pigs were different after the animals were sacrificed. Poison as a chemical substance naturally slows down the process of natural breakdown, which explains why. The strangled pig displayed early commencement of rigor mortis, a significant increase in core temperature, and the onset of lividity. Rigor mortis starts to set in from smaller muscles to larger muscles. The poisoned pig, in contrast, displayed early signs of rigor mortis, an increase in core temperature, and the beginnings of lividity. It also showed early signs of pallor mortis and a progression of the disease from smaller to larger muscles (gradual drop in body temperature).

The visible observations from this experiment showed that the strangled carrion had a regular decomposition schedule, but the poisoned porcine corpse had halted decomposition. This study discovered that different poisoned and strangled pigs had different decomposition patterns. The strangled carrion decomposed more quickly than the former because of the intense insect activity that afflicted it.

The three factors identified by Galloway (1989), Adlam and Simmons (2007), Nawrocki (2009), and Simmons *et al.* (2010) as influencing the rate of decomposition are temperature, insect accessibility, and moisture or humidity, with temperature having the most impact. All of the aforementioned elements contributed significantly to the decomposition of the strangled carrion, but the poisoned pig's decomposition rate was slowed down by the toxin (sniper), which caused a death pool of insects that came into contact with the carrion. Beetles helped form ridges around the carrion, which caused the pig to burrow into the soil.

According to Megyesi *et al*. (2005), a Total Body Score chart was used to determine the stage of decomposition for the head and neck, trunk, and leg regions. The strangled pig displayed evidence of brown to black discoloration on its head and neck during the swollen stage, brown to black discoloration on its trunk after the expulsion of gases, and skin that looked leathery on its limbs. For the poisoned pig, discoloration, and brownish shades, particularly at the edges of the limbs, purging of decompositional fluids from orifice, bloating of the head and neck, bloating with green discoloration, and purging of decompositional fluids from the trunk. The strangled pig displayed moist decomposition during the active decay stage with bone exposure less than a quarter of the area being scored for the head, decomposition of tissue causing sagging flesh in the trunk, and moist decomposition with bone exposure less than a quarter of the area being scored.

The strangled pig's advanced decomposition stage included moist decomposition with bone exposure less than a half of the area being scored for the head, tissue decomposition that caused the flesh to sag in the trunk, and mummification with bone exposure less than a half of the area being scored for the limbs.

For the poisoned carrion, observed a lower TBS with little caving in of the flesh and tissues of the eyes and throat for the head and neck, moist decomposition with bone exposure less than 12 that of the area being scored, and moist decomposition with bone exposure less than 12 that of the area being scored for the limbs. The strangled pig displayed mummification at the stage of bone scoring, with less than half of the area being scored for the head and neck, less than half of the area being scored for the trunk, and less than half of the area being scored for the limbs showing through.

Forensic Forensic anthropologists, notably in North America, have started to employ ADD to estimate the Postmortem Interval (Vass *et al*., 1992; Parsons, 2009; Megyesi *et al*., 2005; Cogswell and Cross, 2021). The Megyesi *et al*. (2005) approach has so far been replicated in a variety of geographic areas, including west central Montana (Parson, 2009). With the usage of ADD, variables like temperature are taken into account. The accumulation of temperature within a certain season should be constant in that season, as employed during the dry season of the tropical climate of Okuku, Yala local government region. Megyesi *et al*. (2005) and Cogswell and Cross (2021) identified similar variations in pig decomposition in this investigation and ADD.

Rainfall affects the rate of decomposition because it indirectly affects insect activity and temperature, according to authors (Reed, 1958; Mann *et al*., 1990; Lopes De Carvalho and Linhares, 2008). On day 10, when the poisoned and strangled pigs were re-moisturized and re-infested with insects in the tropical climate during the dry season, it was discovered that rainfall is a factor that impacts the rate of decomposition. Fresh and recently decomposed remains were moldy because of the downpour.

Humans and other dead animals start to decay shortly after they pass away. This happens as a result of the rapid cessation of physiological processes, which causes tissue putrefaction. Insects are drawn to this physically undetectable degeneration as they are the first to observe the changes (Abajue *et al*., 2013).

According to the stages of carrion's decomposition, the insects are known to arrive in a regular order. The pig carrions underwent four distinct stages of decomposition: fresh, bloated, active decay, and advanced decay. Each of these stages features a different bug species' life cycle.

For the poisoned (Caliphoridae and Muscidae) and strangled (Musca Species), respectively, in their adult stage as their carcasses were exposed, PMI of the carrions can be measured during the fresh stage by the complete absence of eggs or blow flies and first instars of flesh flies. It is clear from this observation that the first-instar flesh fly that touched the poisoned pig died immediately due to fluids leaking from its orifices.

The PMI of the carrions can be calculated during the bloating stage utilizing the adult stage Formicidae and Coleoptera for the strangled carrion and the adult and larva stage of Caliphoridae for the poisoned carrion that was discovered dead after coming into touch with orifice fluids. These insects were discovered at the height of the bloating phase. The adult stages of formicidae, sarcophagidae, scarabaeidae (Coleoptera), Muscidae and Histeridae (Coleoptera) can be used to determine PMI of the carrions during the active decaying stage for the strangled animal and for the poisoned pig. House flies, meat flies, and a disproportionately large number of hide and bone beetles are among the insect taxa.

During the advanced/drying or mummification decay stage, PMI of the carrion can be estimated using Grylloblata species, Coleoptera, Agathisaciculatus, Chrysomya, Megaseliascalaris, Atherigonaorientalin Fannia species for the strangulated carrion and Dermestidae (Coleoptera), Staphylinidae (coleoptera), Cheridae (coleoptera) and Scarabaeidae for the poisoned carrion. The insects gathered for this study are crucial to the ecology of carrions because they use the carcasses as both food and a breeding ground for at least one generation of their offspring (Abajue *et al*., 2014). The study's results are therefore consistent with those of other forensic researchers in Nigeria (Ekanem, 2008; Okiwelu *et al.,* 2008; Ekanem and Duke, 2010; Abajue *et al*., 2013; Abajue et al., 2014) and comparable to those of researchers in other nations (Goff and Catts, 1992; Lord et al., 1993 and Gill, 2005), as the insect genera are substitutes for their reported insects.

The ability to estimate the minimal Postmortem Interval (PMI) of corpses that can be used in forensic research is made possible by an understanding of these insects in connection to the decomposition of carrions. In this investigation, it was observed that the strangulated pig decomposed more quickly than the poisoned pig, indicating that microbiological, environmental, soil, and insect succession have a part in the form in which the decomposition process happened.

Cervical Blunt Trauma versus strangulated (control) carrions

Most cervical blunt and strangulation injuries occur in homicidal and suicide incidents, and these incidents are on the rise globally. Moreover, if the crime included several weapons, the manner and cause of death (Small et.al 2016). Utilizing insect successional pattern, TBS, ADD, Megyesi *et al*. (2015), and other techniques Yadav *et al*. (2021).

There have been conflicting results when comparing cervical blunt injuries to strangled carrion in several studies (Carter *et al*., 2010; Otero *et al*., 2019). Primary postmortem alterations were noticed in the strangled pig right away, and these took the form of a reduction in body temperature and the early beginning of pallor mortis on day one Byard *et al*. (2011).

In contrast to the cervical blunt trauma carrion, which demonstrated an early commencement of pallor mortis, rigor mortis starts to set in from smaller muscles to larger muscles due to temperatures at the bloat stage on day two, followed by rigor mortis, which started from the smaller muscles to larger muscles (Adlam and Simmons 2007).

The visual characteristics from this investigation demonstrated that the cervical carrion was enormous in stage of decomposition in contrast to the strangulated pig that had a regular decomposition timeline. The pattern of decomposition in cervical blunt trauma and strangulated carrion differed. The attraction of flies and maggots is what caused the decomposition rate and pattern in the strangled pig to be slower than that of the cervical blunt trauma pig, according to Galloway *et al.* (1989), Kontopoulos et al. (2016) and Simmons *et al*. (2010).

Accumulated degree days (ADD) is measured by taking the cumulative average daily temperature from the time of death to the time of final measurement. When a given amount of thermal energy is put into a carcass the same amount of reaction should occur (Small, *et al.,* 2016; Simmons *et al*., 2010), such that the same body score for decomposition will be seen, the recorded pattern for this comparison was that strangle ADD was 910.3 while that of cervical blunt was 328.55, at the last interval: and their TBS was 1, 1= 3 for both at day one (1). Because the use of ADD automatically incorporates adjustments for yearly, seasonal, and within season variation, the study proves evidence of variation from day 23 showing 13-12-10=35 for cervical blunt trauma while strangle carrion was 9-8-7= 24. It has many advantages over a model based on a count of days alone. To estimate PMI, the ADD is calculated using temperature readings from the nearest weather stations; this is not without problems as the nearest weather station may not reflect the temperature at the site (Dabbs, *et al.,* 2010 and Megyesi, *et al.,* 2015).

The accumulated degree days (ADD), stands for the heat energy units available to fuel a biological process. Since biological processes come to an end at freezing temperatures, Megyesi *et al.,* (2005) chose 0C as the study's base temperature. Megyesi *et al.,* total body Score chart was employed to determine the stage of decomposition for the head and neck, trunk, and leg regions (2015).

The Total body Score of the research outcome, showed that blunt force trauma carrion decomposed faster than the strangulated carrion used as control model. Carrion, caving in of the flesh and tissues of the eyes and throat for the head and neck, decomposition of tissue causing sagging of flesh in trunk, brown to black discoloration with skin having a leathery appearance of the limbs being Total Body Score- 6,8,6= 20 are all symptoms of cervical blunt trauma. The strangled pig's advanced decomposition stage included moist decomposition with bone exposure less than half that of the area being scored for the head, tissue decomposition that caused the flesh to sag in the trunk, and mummification with bone exposure less than half that of the area being scored for the limbs, giving the body a total score of 8, 6, and 7 for 21.

Carrion from cervical blunt trauma, caving in of the flesh and tissues of the eyes and throat for the head and neck, moist decomposition with bone exposure less than half that of the area being scored, and moist decomposition with bone exposure less than half that of the area being scored for the limbs are all included in the Total Body Score of 8, 9, 7, which equals 24.

The strangled pig displayed mummification at the stage of bone scoring, with less than half of the area being scored for the head and neck, less than half of the area being scored for the trunk, and less than half of the area being scored for the limbs showing through. Total Body Score of 24 is made up of 9, 8, and 7.

For the cervical blunt carrion, the total body score is 7, 11, 7, which equals 25, and the moist decomposition with bone exposure less than 12 that of the area being scored for the head and neck, limbs, and moist decomposition with bone exposure less than 12 that of the area being scored for the cervical blunt carrion.

CONCLUSION: This study indeed provided insight into the various factors affecting rates of decomposition in porcine models, which are considered to be good models for human decomposition under four modes of death: burning, poisoning, strangulation and blunt trauma. The research explains the role of environmental, biological, and entomological variables in determining the dynamics of decomposition and their implication in forensic taphonomy and PMI estimation.

The outcome of this research showed that charring and cervical blunt force trauma had more rapid decay rates compared to poison and strangulated modes based on the figures recorded in total body score, this differential decomposition science is important to a forensic scientist when carrying out investigations.

This research will add to the existing knowledge in the area of forensic science by providing baseline data on decomposition rates and patterns across different modes of death, improving the accuracy of PMI estimations and identification of victims in clandestine modes death. The research also indicated the need for capacity-building in forensic science, especially the integration of forensic taphonomy into criminal investigations. This study provides substantial proof that decomposition dynamics is important in furthering forensic taphonomy and, subsequently improving criminal justice with regard to complicated investigations into death. The research lights up the way forward for subsequent studies in enhancing forensic capabilities in addressing medico-legal jurisprudence. Knowledge gaps have been filled; workable insights have also been provided.

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