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Checklist of Insects on Asphyxiated Carrion and Their Forensic Importance in Southern Nigeria

قائمة مرجعية للحشرات المتواجدة على الجيف المختنقة وأهميتها الجنائية في جنوب نيجيريا

Maduamaka Cyriacus Abajue
Department of Animal and Environmental Biology, University of Port Harcourt, Port Harcourt, Nigeria

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Abstract

Insects associated with vertebrate carrions play an important role in forensic investigations, especially in estimating post-mortem interval (PMI). Unfortunately, baseline data on local insect species associated with carrions in southern Nigeria is still limited. In this study, a checklist was compiled of insects associated with asphyxiated pig carrion was carried out in a grassland habitat. The study was conducted across both dry and rainy seasons of 2023, 2024, and 2025. Fresh pig carrions of 21kg were humanely euthanized by asphyxiation and exposed in wire-mesh cages to exclude vertebrate scavengers but allowed insects access. Insect sampling on the carrions was carried out throughout the decomposition stages. Adult and immature insects were collected, preserved, and identified to species using standard morphological keys. Four stages of carrion decomposition were observed for both seasons, but tissue depletion was faster during the rainy season than the dry season. Insect species collected on the carrions were 25 in 19 families, and 6 orders. The dipterans were the earliest and most dominant colonizers, starting from the fresh to wet stages. The coleopterans became prominent during dry stages throughout the skeletonized remains. Seasonal and interannual variations in species composition were also

Keywords: forensic sciences, forensic entomology, pig carrion, insect species, seasonal variations, southern Nigeria

المستخلص

تلعب الحشرات المرتبطة بجيف الفقاريات دوراً هاماً في التحقيقات الجنائية، لا سيما في تقدير «الفترة ما بعد الوفاة» (PMI). ولسوء الحظ، لا تزال البيانات الأساسية حول أنواع الحشرات المحلية المرتبطة بالجيف في جنوب نيجيريا محدودة. في هذه الدراسة، تم إجراء حصر (قائمة مرجعية) للحشرات المرتبطة بجيف الخنازير المختنقة في بيئة عشبية.

أُجريت الدراسة خلال موسمي الجفاف والأمطار للأعوام 2023، 2024، و2025. تم القتل الرحيم لجيف خنازير طازجة تزن 21 كجم عن طريق الاختناق، ووُضعت في أقفاص سلكية لاستبعاد الحيوانات الفقارية الكاسحة مع السماح بدخول الحشرات. تم أخذ عينات من الحشرات الموجودة على الجيف طوال مراحل التحلل؛ حيث جُمعت الحشرات البالغة وغير البالغة، وحُفظت، ثم جرى تصنيفها وتحديد أنواعها باستخدام مفاتيح مورفولوجية (شكلية) قياسية.

تم رصد أربع مراحل لتحلل الجيف في كلا الموسمين، إلا أن استنزاف الأنسجة كان أسرع خلال موسم الأمطار مقارنة بموسم الجفاف. بلغت أنواع الحشرات التي جُمعت من الجيف 25 نوعاً تنتمي إلى 19 فصيلة و6 رتب. كانت رتبة "ثنائيات الأجنحة" (Dipterans) هي المستعمر الأول والأكثر هيمنة، بدءاً من المرحلة الطازجة وحتى المراحل الرطبة. بينما أصبحت رتبة "غمديات الأجنحة" (Coleopterans) بارزة خلال المراحل الجافة وصولاً إلى بقايا الهيكل العظمي.

الكلمات المفتاحية: علوم الأدلة الجنائية، علم الحشرات الجنائي، جيف الخنازير، أنواع الحشرات، التباينات الموسمية، جنوب نيجيريا

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* Corresponding Author: Maduamaka Cyriacus Abajue
Email: maduamaka.abajue@uniport.edu.ng

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observed across the three-year study period. The findings provide a comprehensive checklist of carrion-associated insects in a grassland habitat in southern Nigeria and contribute baseline data for forensic entomology in the region. This study emphasizes the importance of localized entomological data for improving the accuracy of PMI estimation and forensic investigations in tropical environments.

كما لوحظت تباينات موسمية وسنوية في تكوين الأنواع خلال فترة الدراسة التي استمرت ثلاث سنوات. توفر هذه النتائج قائمة مرجعية شاملة للحشرات المرتبطة بالجيف في الموائل العشبية بجنوب نيجيريا، وتساهم ببيانات أساسية لعلم الحشرات الجنائي في المنطقة. تؤكد هذه الدراسة على أهمية البيانات الحشرية المحلية لتحسين دقة تقدير فترة ما بعد الوفاة والتحقيقات الجنائية في البيئات الاستوائية.

1. Introduction

Vertebrate carrions, when accessible to insects, provide a unique transient ecosystem that can be useful in the forensic evaluation of questionable death. Insects such as flies and beetles in the orders of Diptera and Coleoptera, respectively, are regular and primary agents of carrion decomposition. They are obligate necrophagous and are capable of reproducing on carrions [1,2], hence can provide a valuable post-mortem interval (PMI) of the carrion. Interestingly, these groups of insects do not visit at random but in a predictable sequence, which usually commences immediately after death. Their arrival time ought to synchronize with distinct carrion decomposition stages [3], thus providing a clue to forensic entomologists in predicting PMI of the carrion. The use of insects in criminal investigation and the prosecution of homicide cases dates back to China in the 13th century [4] but has been more popular recently in the judicial systems of the developed world [5].

Despite the relevance and growing importance of forensic entomology in Europe and America, bordering on homicide and drug-related abuses, there is still a paucity of such in Africa, especially in Southern Nigeria. This is attributed to a few empirical studies relating to carrion decomposition and its associated insects. It has therefore made this crucial aspect of the judicial system a very distant one from meeting up with the current global practices in homicide and related criminal investigations, especially for deceased bodies that are infested with insects.

Recently, a dry and rainy season study of pig carcasses in Southeast Nigeria reported six insect orders and 16 families across five decomposition stages [6]. The study highlighted seasonal differences in insect diversity, with a higher number of families and individuals in the wet season compared to the dry season, reflecting climatic influence on insect activity. Similarly, Abajue et al. [7-9] in Southeast Nigeria reported flies and beetle taxa that are relevant to the decomposition ecology of pig carrion. The reports submitted early colonization of pig carrions by Sarcophagids and Calliphorids, and later supplemented by dermestids, clerids, and stratiomyids, which emphasizes broader insect community involvement beyond core forensic taxa. In Warri, Southern Nigeria, [10] reported arthropods of forensic importance on decomposing pigs, which showed dipterans, coleopterans, and hymenopterans orders in ten families across decomposition stages. In the report, dipterans dominated the early stages, while beetles increased later and were consistent.

Despite the progress made so far in pig carrion decomposition and its associated insect, forensic entomology data from Southern Nigeria remains limited. For instance, the available data on pig carrion ecosystems are from Anambra, Akwa Ibom, Delta, and Edo States. It therefore requires broader sampling across Southern States with a long-term

multi-year study to capture interannual changes and other ecological variables. This study, therefore, is set to have a checklist of insects associated with decomposing pig carrion in Southern Nigeria. The objectives include determining the time taken and the insects found on the pig carrion till the tissues decompose completely, and ascertaining the insect species with unique PMI traits. Hence, the findings of this study will enrich the database of local insect species that will be useful in forensic investigations relating to the death of vertebrate carrions infested with insects at the time of the carrion discovery in Southern Nigeria. Despite its limitations, the significance of this study, if carefully evaluated, can be extrapolated to human cadavers when the need arises.

2. Materials and Methods

2.1. Study Area

The study was conducted in a grassland ([4°907.54N and 6°923.64 (±1m Altitude 34m) habitat at University of Port Harcourt (UPH), Rivers State, Southern Nigeria. The University lies within the humid tropical rainforest zone, characterized by high temperatures, high relative humidity, and a yearly distinct dry and rainy seasons. The grassland habitat is relatively open, slightly disturbed, free from pesticide application, and with reduced routine human and animal activities. The study was carried out across both the dry and rainy seasons in 2023, 2024, and 2025, respectively.

2.2. Experimental Design, Source and Preparation of Pig Carrion

A field-based observational design was adopted to document the insect species associated with pig carrions for each year. The study assesses seasonal variations in the decomposition of the pig carrion and their insect assemblages. Fresh pig carrions were used as animal models due to their anatomical and physiological similarities to humans and their widespread use in forensic entomology studies.

Twelve healthy domestic pigs (*Sus scrofa Linn.*) with an average weight of 21 kg were obtained from the University of Port Harcourt livestock farm (Faculty of Agriculture). The pigs were humanely euthanized by asphyxiation to ensure a uniform cause of death and to avoid external trauma that could influence insect colonization patterns. Four pigs were used each year, 2 per season. Immediately after the pig's death, the carrions were transported to the study site (grassland habitat) and placed on the soil surface. To prevent scavengers while allowing unrestricted access to insects, each carcass was enclosed in a wire mesh cage. The mesh size was large enough to permit insect entry but excluded rodents and other vertebrate scavengers.

2.3. Decomposition Monitoring, Insect Sampling, Collection, and Identification

The pig carrions were observed daily throughout the decomposition process, and photographs were taken from the fresh stage until the dry decay stage. Decomposition stages were categorized as fresh, bloated, wet decay, and dry decay based on physical changes such as bloating, odor, tissue breakdown, and desiccation of the body.

Ambient environmental parameters (temperature and relative humidity) were recorded daily using a digital thermo-hygrometer positioned near the carrions. Rainfall data for the study period were obtained with a manual rain gauge calibrated in millimeters.

Insects associated with the pig carrion were sampled daily from the early stages of decomposition until the later stages. Adult flying insects were collected with a sweep net, while crawling insects were collected with forceps. Immature stages (eggs, larvae, and pupae) on the body orifices, and

beneath the carrions were collected with either a plastic spoon or forceps.

The representative samples of fly larvae were killed with hot water and preserved in 70% ethanol for further evaluation, while some live larvae were reared in the laboratory on beef liver to allow adult emergence for accurate species identification. Adult insects were also preserved in labeled specimen bottles containing 70% ethanol.

The preserved insect specimens were identified to species level using standard morphological keys [11] and identification guides relevant to African and tropical insects. A checklist of insect taxa associated with the pig carrion was compiled for each year.

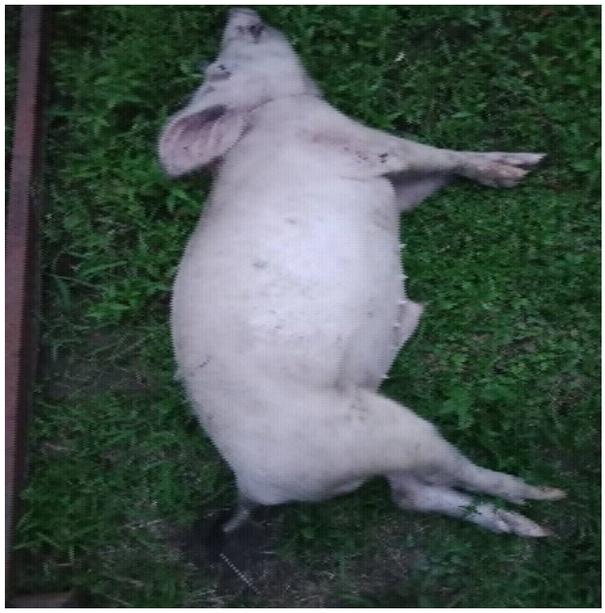
2.4. Ethical Considerations

Ethical approval for the use of animal models was obtained from the Research Ethics Committee, University of Port Harcourt, Rivers State, Nigeria. All procedures involving animal use in research were conducted in accordance with the internationally accepted ethical guidelines to minimize unnecessary cruelty and environmental impact.

3. Results

There were four distinguishable stages (fresh, bloated, wet, and dry) of tissue decomposition observed in this study, with each of the stages (Plate 1) taken varying durations depending on the yearly season. The fresh stage began immediately after the pig was confirmed dead, and lasted approximately 23 hours (1 day) until the body began to stiffen and showed discoloration changes, irrespective of the season. The bloated stage was noted when the body began to swell, most evident in the abdominal region due to trapped gases. This stage lasted for 2 days in the dry season and 3 days in the rainy season. The wet decay stage was marked with copious liquefaction preceding deflation of the bloated body. The stage varied considerably during the seasons and the years. In 2023, it lasted for 4 days in the dry season and 9 days in the rainy season. In 2024, it was 5 days in the dry season and 8 days in the rainy season, while in 2025, it was 3 days in the dry season and 7 days in the rainy season. Similar observation was noted for the dry decay stage, which commenced with dryness of fluids from the tissues, visible exposition of bones and remnants of cartilages, tough skin (upper surface), and furs. The stage lasted for 9 days in the dry season and 1 day in the rainy season in 2023. In 2024, it was 12 days in the dry season and 2 days in the rainy season, while in 2025, it was 10 days in the dry season and 2 days in the rainy season (Figure 1). After this stage was skeletonized remains (bones without tissues) that lasted beyond 60 days in all seasons and years.

Apparently, the decomposition pattern, processes, and stages of the asphyxiated pig carrions remained the same throughout the years, irrespective of the seasons at the grassland habitat in UPH, Nigeria. However, the depletion of the tissues varied according to seasons (Figure 2) as the tissues (except cartilages and upper skin) were completely decomposed in 16 days in the dry season and 14 days in the rainy season for 2023. In 2024 and 2025, it was 20 and 16 days, respectively, in the dry season, and 14 and 13 days, respectively in the rainy season. The temperature, relative humidity, and rainfall (Figure 2) at the study site varied considerably according to seasons but remained slightly unchanged over the years. The ambient temperature, relative humidity, and rainfall were 30.3 ºC, 60.9 %, and 1.8 mm in the dry season, and 28.2 ºC, 73.4 %, and 108.7 mm in the rainy season of 2023. In 2024, they were 32.2 ºC, 56.1 %, and 1.8 mm in dry season, and 28.1 ºC, 76.3 %, and 142.3 mm in rainy season, while in 2025, they were



Fresh

Wet decay

Bloated

Dry decay

Figure 1- *Decomposition stages of the asphyxiated pig carrions in a grassland at UPH, Nigeria*

29.8 ºC, 62.2 %, and 3 mm in dry season, and 26.7 ºC, 83.8 %, and 247.8 mm in rainy season.

The list of insects on the asphyxiated pig carrions showed 25 insect species in 19 families, and in 6 orders. However, the number of insect species varied considerably in each of the years, as 18, 22, and 14 species were recorded in 2023, 2024, and 2025, respectively. Among the insect species, the dipterans (Chrysomya albiceps (Wied.), Chrysomya chloropyga (Wied.), Chrysomya megacephala (Fab.), Hermetia illucens (Linn.), Chrysomyza africana (Hendel) were consistent on the carrions between the fresh and wet decay stages. The Necrobia rufipes (Deg.), Dermestes maculatus (De

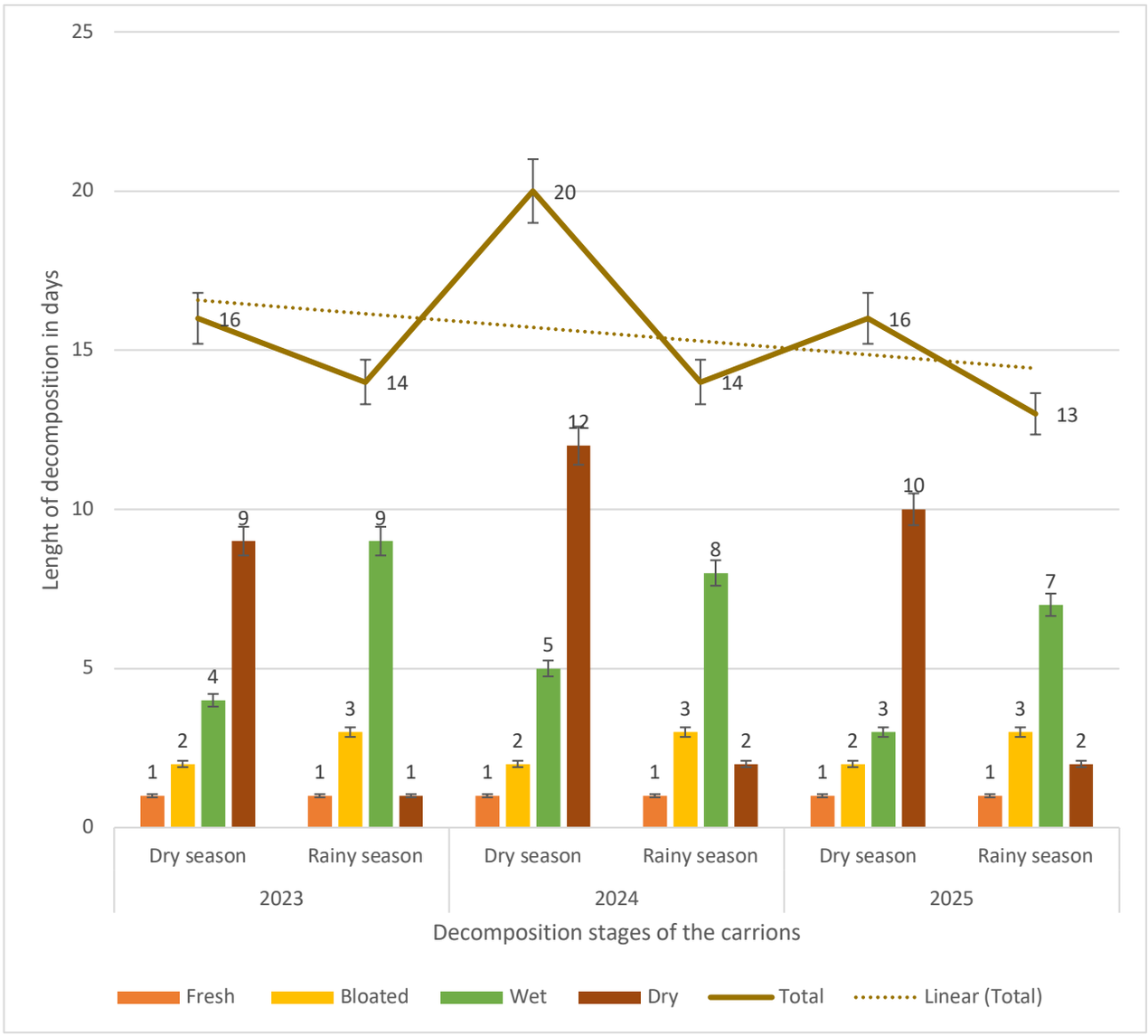


Figure 2- *Decomposition duration of asphyxiated pig carrions at UPH, Nigeria*

G.), Hister unicolor (Linn.), and Hister sp., among the coleopterans, also showed consistency on the carrions between the wet decay and skeletonized remains, depending on the season. The dipterans and coleopterans showed PMI values of 3-20 days on the pig carrion. Other insects include: Musca domestica (Linn.), Sarcophaga sp., among the dipterans, Carpophilus sp., Staphylinus sp., among the coleopterans, and Camponotus perrisi (For.), and Dorylus affinis (Fab.) for hymenopterans, showed a dependable level of consistency on the carrions without reliable PMI values. The other insect species, such as Harpalus sp., Onthophagus sp., Scarite sp., Tenebrio molitor (Linn.) among the coleopterans, the hemipterans, Megalotomus sp., Melanolestes sp., the hymenopterans, Camponotus acvapimensis (Mayr), Delta sp., and Sympetrum sp. (odonatan), and Euchorthippus sp. (orthopteran), were not consistent on the carrions, and hence are of no forensic value (Figure 3).

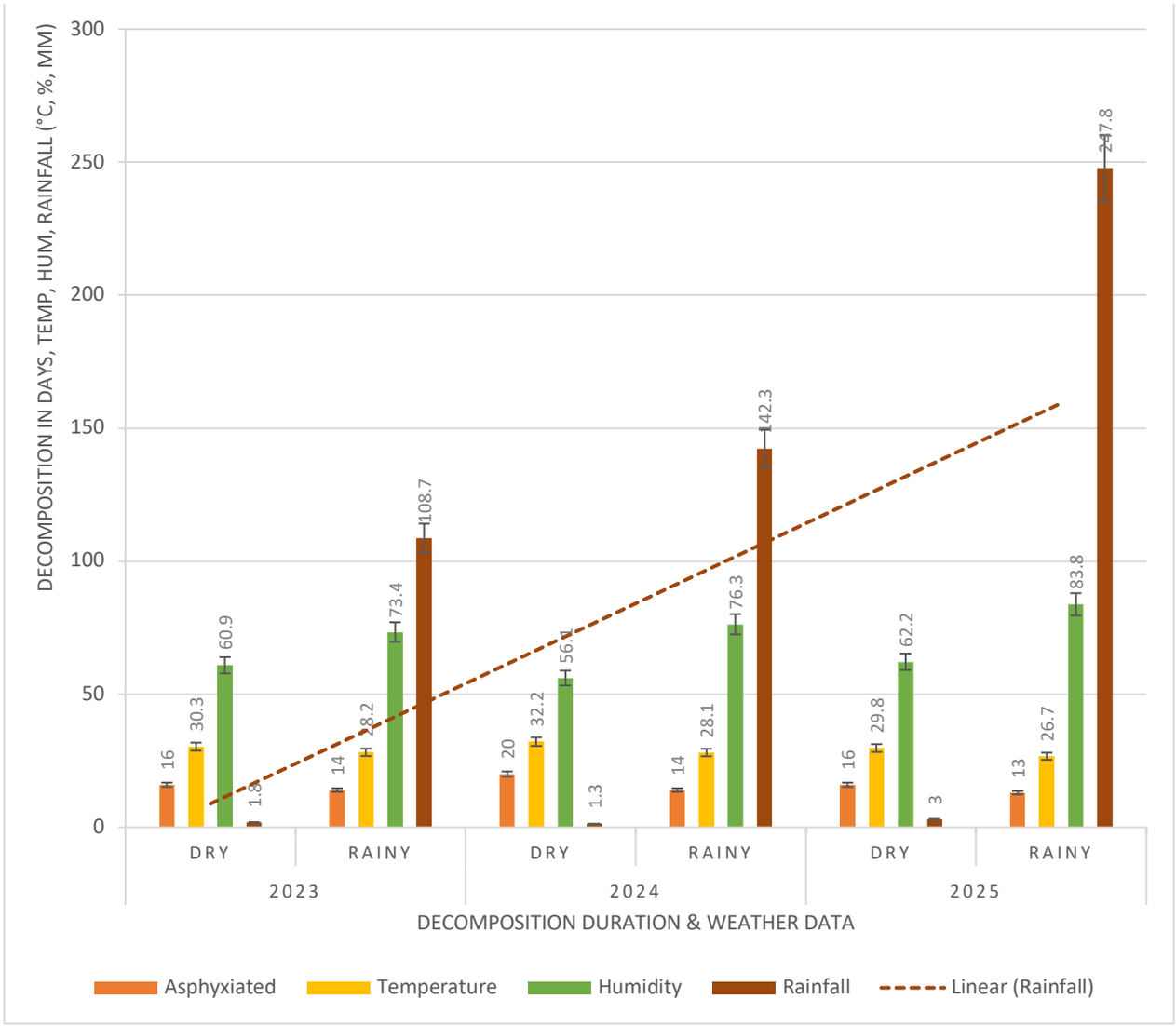


Figure 3- *Weather data & decomposition duration of asphyxiated pig carrions at UPH, Nigeria*

4. Discussion

It is apparently inevitable for organic matter to evade decomposition processes once it is dead, except when it is exposed to preservatives. Vertebrate carrion, irrespective of its cause of death, becomes a transient ecosystem immediately after its death. It usually passes distinct stages of decay and will be infested with insects and other invertebrates irrespective of seasons. In this study, the asphyxiated pig carrion was infested with a diverse group of insects. They were dominated by dipterans and coleopterans as early and late decomposers, with exceptional consumption preferences for soft and dry tissues, respectively. The decomposition stages (fresh, bloated, wet, and dry) presented in this study are usually phases of carrion decomposition peculiar to tropical conditions, where each year is distinctly marked into dry and rainy seasons respectively.

The stages of the carrion decomposition are empirically synonymous within the ambient of forensic entomology in Nigeria, with pigs as the

animal model. However, the choice of carrion decomposition stages by authors are usually for explicit analogy, hence the four stages of decomposition reported herein is in tandem with that of the pig carrion study in Uyo and Benin [12, 13] in Southsouth Nigeria. Meanwhile, five stages of decay were reported for pig carrion in Abakiliki and Nibo [14, 6] in Southeast Nigeria. These authors distinguished the main putrefaction phase of the carrion into active, advanced, and dry stages in addition to fresh and bloated stages, which are in contrast to the stages of decay recorded in this present study.

The effect of ambient temperature, relative humidity, and rainfall for the yearly seasons showed a remarkable difference on the decomposition duration and insect assemblages. On average, the tissue decomposition duration in the dry season was longer (18 days), probably due to moderately higher ambient temperature, lower relative humidity, and near absence of rainfall against that of the rainy season (13.5 days). According to Ekanem and Dike [12], higher ambient temperature and lower relative humidity could cause quicker chemical reaction in carrions, hence, leading to accelerated tissue decomposition. In this study, decomposition was faster during the rainy season despite recording a slightly lower temperature in comparison to that of the dry season. This may probably be as a result of copious rainfall, which may have contributed to higher humidity and aided in softening the tissues throughout the stages of decomposition. This scenario may be the reason why the dry decay stage was shorter during the rainy season, hence making the tissues continuously soft and palatable for insects to consume them with ease and faster. On the contrary, the wet decay stage was shorter in the dry season, hence drying the tissues faster, contributing to slower tissue consumption and depletion by insects.

According to Villet [15], descriptive observations on carrion decomposition stages as presented in this study are unilateral benchmarks, and not a unanimously accepted paradigm. Therefore, the contradictions in relation to carrion decompositions are not barriers to the homogeneity of the same carrion ecology, but semantics in the designation of carrion stages. Interestingly, carrion ecosystems globally show the same kind of fauna assemblages at the family level, which infers biological surrogateship [15]. Perhaps, a diverse group of insects on the same carrion resource at different stages of decay suggests community assemblage with inherent ecological niches that could intersect with core values of forensic entomology.

Carrion decomposition is usually dominated by insect species [16-18], thus emphasizing their usefulness in forensic entomology, especially for PMI estimation of a victim infested with insects. In this study, insect species of forensic importance include Chrysomya albiceps, Chrysomya chloropyga, and *Chrysomya megacephala*, which are the local calliphorids of Southern Nigeria, in agreement with earlier reports of carrion ecosystem researchers in Nigeria [7, 12, 13, 19]. These calliphorids are primary colonizers of the pig carrion between fresh and wet decay stages, and maintain a predictable appearance on carrions [20]. Their immature stages were visible from the bloated stage, and formed a conspicuous larval mass during the wet decay stage, but dispersed as prepupae at the peak of dry and wet decay stages in dry and rainy seasons, respectively. Their emergence as young adults was during the peak of the dry decay stage irrespective of the season. Other dipterans of forensic importance sparsely found on the carrion, include Chrysomyza africana (Ulidiidae) and Hermetia illucens (Stratiomyidae), but were equally predictable and consistent on the carrion at bloated

Table 1- Checklist & yearly distribution of insects on asphyxiated pig carrions at UPH, Nigeria

	Insect Group			2023	2024	2025
	Order	**Family**	**Species**	**Yearly Distribution**		
1	Coleoptera	Carabidae	*Harpalus* sp.		X	
2			*Scarite* sp.		X	
3		Cleridae	*Necrobia rufipes* (Deg.)	~~X~~	~~X~~	~~X~~
4		Dermestidae	*Dermestes maculatus* (De G.)	~~X~~	~~X~~	~~X~~
5		Histeridae	*Hister unicolor* (Linn.)	~~X~~	~~X~~	~~X~~
6			*Hister* sp.	~~X~~	~~X~~	~~X~~
7		Nitidulidae	*Carpophilus* sp.	~~X~~	~~X~~	~~X~~
8		Scarabaeidae	*Onthophagus* sp.		X	
9		Staphylinidae	*Staphylinus* sp.	~~X~~	~~X~~	~~X~~
10		Tenebrionidae	*Tenebrio molitor* (Linn.)		X	
11	Diptera	Calliphoridae	*Chrysomya albiceps* (Wied.)	~~X~~	~~X~~	~~X~~
12			*Chrysomya chloropyga* (Wied.)	~~X~~	~~X~~	~~X~~
13			*Chrysomya megacephala* (Fab.)	~~X~~	~~X~~	~~X~~
14		Muscidae	*Musca domestica* (Linn.)	~~X~~	~~X~~	~~X~~
15		Sarcophagidae	*Sarcophaga* sp.	~~X~~	~~X~~	~~X~~
16		Stratiomyidae	*Hermetia illucens* (Linn.)	~~X~~	~~X~~	~~X~~
17		Ulidiidae	*Chrysomyza africana* (Hendel)	~~X~~	~~X~~	~~X~~
18	Hemiptera	Alydidae	*Megalotomus* sp.	X		
19		Reduviidae	*Melanolestes* sp.	X		
20	Hymenoptera	Formicidae	*Camponotus acvapimensis* (Mayr)		X	
21			*Camponotus perrisi* (For.)	~~X~~	~~X~~	~~X~~
22			*Dorylus affinis* (Fab.)	X	X	
23		Vespidae	*Delta* sp.		X	
24	Odonata	Libellulidae	*Sympetrum* sp.		X	
25	Orthoptera	Acrididae	*Euchorthippus* sp.	X		
Total	**6**	**19**	**25**	**18**	**22**	**14**

Note

X Consistent

~~**X**~~ Consistent without PMI value

~~**X**~~ Consistent with PMI value

and wet decay stages, respectively. Unfortunately, the larval stage of C. africana was not implicated in this study as to the earlier report by Abajue et al. [21], who sampled the larvae during the dry decay stage in the Southeast Nigeria. The reason for the difference could not be ascertained in this report, but the contrast in the study locations may provide a clue, as the former was in a fallow land dominated by herbs and shrubs against the later in open grassland. The larval stages of H. illucens were found sparsely beneath the carrion during the skeletonized remains in rainy season. This suggests that H. illucens, in addition to exuviae of calliphorid flies, will be forensically important on skeletonized remains in the rainy season in the study area.

Similarly, Necrobia rufipes, Dermestes

maculatus, Hister unicolor, and Hister sp. are the coleopterans that are predictable and consistent as regards their arrival time and activity on the pig carrions at both seasons. They constitute the major carrion fauna during the dry and skeletonized remains, in addition to larval stages of H. illucens. None of the larval stages of these coleopterans were implicated in this study, which contradicts the reports of Abajue et al. [21], were the larval stages of clerid and dermestid were implicated in decomposing pig carrion. Apparently, the dipterans and coleopterans that are predictably consistent in their arrival time and reproductive activity on the pig carrions between 3 and 20 days are designated insects of forensic importance.

Other insects contained in this list include Musca domestica, Sarcophaga sp. (dipterans), Carpophilus sp., Staphylinus sp. (coleopterans), and Camponotus perrisi, and Dorylus affinis (hymenopterans) are equally consistent on the carrions but without PMI potentials. However, they are reliable and predictable local insect species in the list of carrion insects in Southern Nigeria. The other insect species, such as Harpalus sp., Onthophagus sp., Scarite sp., and Tenebrio molitor for the coleopterans, the hemipterans (Megalotomus sp., Melanolestes sp.), the hymenopterans (Camponotus acvapimensis and Delta sp.), Sympetrum sp. (odonatan), and Euchorthippus sp. (orthopteran) were not consistent on the carrion, and thus completely lack forensic values, but could serve as local insects of the study area.

5. Conclusion

The decomposition process of the pig carrions in Southern Nigeria is the same, and attracts the same group of insect species in predictable order, despite the yearly seasonal differences. It is therefore concluded that higher humidity as a result of copious rainfall in the rainy season, contributed to the prolonged wet decay stage and shorter tissue decomposition. It hastened chemical reactions in the carrion tissues and propelled insects to invade the tissues and speedily consume them with ease. On the contrary, the absence of rainfall in the dry season prolonged tissue decomposition due to lower humidity, which facilitated the dryness of tissues. The dipteran and coleopteran species that are highly consistent during the early and late decompositions, respectively, with certain predictability of arrival time are designated as insects of forensic importance of this study. The data herein are part of the databases that can aid in estimating PMI of carrions infested with insects in Southern Nigeria, considering seasonal variations, carrion size, and other circumstances.

Conflict of Interest

The author declares no conflicts of interest.

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