International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 10-06-2026, Accepted: 10-07-2026, Published: 25-07-2026
Volume 11, Issue 3, 2026, Page No. 147-153

Survey and descriptive study of carrion-associated insects of forensic importance in Southern Nigeria

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Abstract
Insects associated with carrions are crucial in nutrient recycling and are of substantial importance in forensic entomology in the estimation of post-mortem intervals. This study presents an all-inclusive checklist of insects associated with slaughtered pig (*Sus scrofa* Linn.) carrions deposited in a grassland habitat at the University of Port Harcourt, Nigeria, over three consecutive years (2023–2025). Freshly euthanized (slaughtered) pig carrions were deposited during dry and rainy seasons and observed throughout decomposition stages (fresh, bloated, wet, and dry). Insects on the carrions were sampled with a sweep net and hand-picking techniques, preserved, and identified to the species level. The insect community comprises 22 species, 15 families, and 4 orders (Diptera and Coleoptera, Dermaptera, and Hymenoptera) with their arrival time matching unique decomposition stage(s). Calliphoridae, Muscidae, Sarcophagidae, and Ulidiidae families (Diptera) were the earliest and most abundant colonizers, while Staphylinidae, Histeridae, Cleridae, and Dermestidae families (Coleoptera) predominated during later stages. Seasonal variation influenced species richness, activity, and abundance, especially in the rainy season. The insect checklist of this study provides baseline data for the Southern region of Nigeria, and augments the growing body of forensic entomology in the tropics.

Keywords: Pig-carrion, Diptera, Coleoptera, descriptive-survey, forensic-entomology, Nigerian

Introduction

Insect-facilitated decomposition of a vertebrate carrion is naturally an important ecological process that enables nutrient-ladened carrion to enrich the soil, as well as contributing to energy transfer in terrestrial ecosystems [1]. A vertebrate carrion forms a transient ecosystem resource that is usually rich to enrich mostly invertebrate fauna diversity [2]. Amongst the invertebrates, insects remain the ones at the forefront in breaking down the carrion tissues [3], and they uniquely arrive in predictable orders that synchronize with stages of tissue decomposition in relation to local environmental conditions [4]. The predictability of insects' arrival on carrions in successional order, is the logical basis to incorporate them to forensic science, and is referred to as forensic entomology.

Forensic entomology centers on the application of insect knowledge to legal investigations relating to death, mostly to estimate the post-mortem interval (PMI) of a carrion infested with insects [5]. It also helps to determine if a carrion was relocated after death, and or recreate the circumstances that led to the questionable death [6, 7]. Among the insects useful in this task; are flies (Diptera) and beetles (Coleoptera) that could provide reliable biological evidence matching the competence of medical pathologists in estimating PMI. These insects are more dependable to utilize especially when the carrion is badly decomposed or found long after death [8]. Flies and beetles are recognized necrophagous groups that are capable of developing their immature stages on carrions [9] depending on anthropocentric variabilities. Their pattern of succession and ecological activities on carrions provides valuable time-based information that can assist homicide investigators in ascertaining the PMI of the deceased [10].

Domestic pig carrions (*Sus scrofa* Linn.) are commonly used as experimental analogous animals for human cadavers in forensic entomology research because of their closer similarities (body mass, skin composition, hair coverage, and decomposition processes) [11, 12]. In Nigeria, many studies have used pig carrions, and hence have significantly accentuated the understanding of insects on carrion decomposition, and PMI estimation principles at different environmental habitats. Though most of the empirical studies on forensic entomology with pig carrions have been conducted in south-east region [13, 15], it therefore, raises concerns about the extrapolation of such data to the south-south region.

There are remarkable climatic variables (temperatures, humidity, and seasonal rainfall patterns) that characterize tropical regions, which are perhaps have a strong influence on insect activity, richness, and growth rates [16, 17]. The climatic conditions in southern Nigeria may enhance swift insect development and colonization, hence, accelerate decomposition of deceased bodies. The conditions remarkably accentuated the year into dry and rainy seasons [18, 19]. It therefore, entails that region-specific forensic entomology datasets is paramount to guarantee an accurate understanding of insect evidence. This averts total reliance on non-local data, which may lead to substantial errors in PMI estimation and crime scene demonstration.

Rivers State in Southern region of Nigeria, is strategically unique with some level of security loopholes leading to some questionable deaths that are usually infested with insects at the time of their discoveries. Nevertheless, literature of forensic entomology pertaining to ambient of insect species of forensic importance is not rich. Some pockets of previous reports are in Port Harcourt, however, they were based on short-term studies, and were not on pig models [20, 21]. Hence, long-term and multi-year investigations that include arrays of insect species, decomposition stages, and forensic understanding remain scarce. The University of Port Harcourt, Nigeria, offers a representative grassland habitat within the Southern region,

which is suitable for premeditated carrion insect studies that apply to common outdoor forensic scenarios.

Therefore, this study was planned to produce a comprehensive, three-year (2023[5]–2025) dataset on insects associated with decomposing pig carrions deposited in a grassland habitat at the University of Port Harcourt, Nigeria. The objectives include: determination of decomposition stages and duration of pig carrions, compilation of a detailed checklist of carrion-associated insects in relation to decomposition stages, and assessment of seasonal and inter-annual variation in insect assemblages within the ambient of forensic entomology in a tropical grassland environment. This study will provide southern region-specific baseline data that can strengthen the use of forensic entomology in Nigeria, and add to the broader understanding of carrion ecology in tropical Africa.

Materials and Methods

1. Study Area

The study was carried out in a grassland habitat within the University of Port Harcourt (UPH), Rivers State, Southern Nigeria (approximately 4°907.54N and 6°923.64). The habitat represents a tropical climatic condition with a distinct rainy season (June–October) and dry season (November–May). Mean daily temperatures are between 25 and 32 °C, with high relative humidity above 50 % throughout the year.

2. Experimental Design and Animal Model

The experimental design adopted in this study was a field-based observational approach to document carrion decomposition patterns and insect community assemblages. The investigation was carried out during 2023, 2024, and 2025[5, 15] using 12 domestic pigs (*Sus scrofa* Linn.) as animal models. The pigs were obtained from the livestock farm, Faculty of Agriculture, UPH, Nigeria. They were humanely sacrificed by euthanization to avoid external trauma. In each year, four pigs weighing approximately 21 kg were used. During the dry seasons of each year, 2 pig carrions were immediately transported to the study location at the grassland habitat, and were placed on the soil surface. During the rainy season, another 2 pig carrions were used, repeating the procedural processes, hence making it 4 pig carcasses per year. To prevent vertebrate scavengers from accessing the carrions while allowing unrestricted access to insects, each carrion was enclosed in a wire mesh cage.

3. Decomposition Stages, Insect Sampling, Preservation, and Identification

The pig carrions were visually categorized into four stages of decomposition, namely: fresh, bloated, wet decay, and dry decay with skeletonized remains. Daily observations and photographs were carried out to document body changes in the carrions and their associated insect activity. Insects found on the carrion bodies were collected either by hand-picking with forceps or a sweep net, depending on the stage, and species of the insects. Observations and insect sampling were done daily during the decomposition stages (fresh, bloated, wet decay, and dry decay). Adult stages of the insects were placed in screw cap containers and preserved with 70 % ethanol. The larval stages of suspected flies were reared to the adult stage under laboratory conditions to help with accurate identification.

The field sampled and reared adult insects were sorted taxonomically, identified with standard keys and reference collections. Identification of the insects to the species level was based on their morphological features, with the aid of a dissecting microscope.

4. Ethical Considerations

The use of the pigs as animal models was ethically approval by 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 unkindness to the pigs and environmental impact.

Results

The decomposition of the pig carrions followed a consistent sequence of four stages; fresh, bloated, wet decay, dry decay cum skeletal remains for the three years. However, the duration of each stage, especially during wet and dry decay stages varied between seasons (Figure 1). The fresh stage was approximately 1 day throughout the seasons and years, while the bloated stage was approximately 3 days in all the years except in the dry season of 2025, with a bloated stage of 2 days.

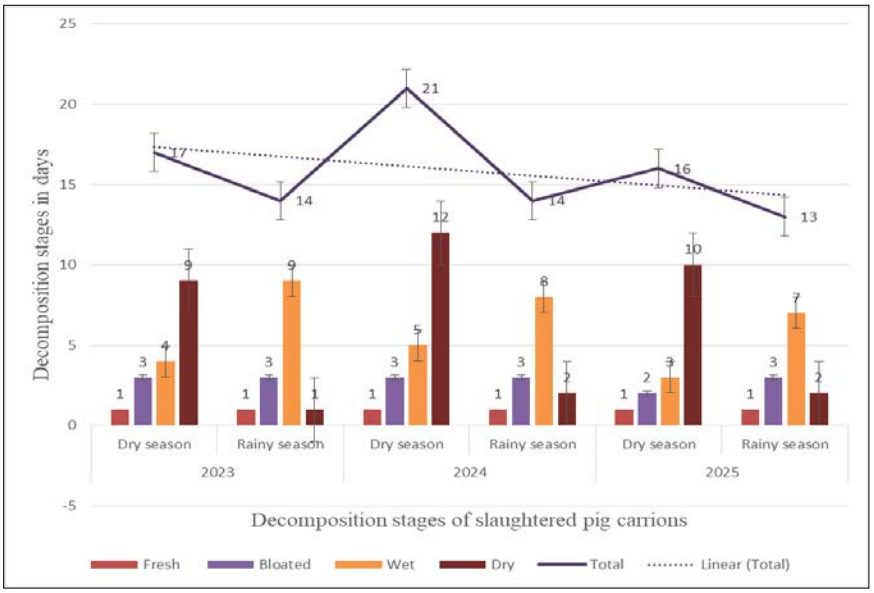

Fig 1: Decomposition durations of pig carrions at UPH, Nigeria

The morphological changes as observed on the pig carrions are shown (plate 1). During the fresh stage, the carrions showed no visual signs of bloating and were basically characterized by the arrival of adult flies (dipterans). The bloated stage was marked by abdominal swelling and strong odour emission that attracted huge numbers of blow flies (calliphorids), spotted flesh flies (sarcophagids), house flies (muscids), and ulidiid flies. The wet decay stage was prolonged during the rainy season (7-9 days) but was rapid during the dry season (3-5 days).

Plate 1: Decomposition stages of pig carrions at UPH, Nigeria

The wet decay stage was characterized by blister-like lesions on the distended body, ruptures and collapse of the body with intense fly larvae feeding on the tissues, and visible islands of carrion fluids. This stage maintained the highest insect assemblages dominated by dipteran larvae and some predatory beetles (coleopterans), and ants (hymenopterans). The dry decay stage was rapid during the rainy season (1-2 days) but was extended during the dry season (9-12 days), in contrast to the wet decay stage. During this stage, most of the tissues have been removed by dipterans during the rainy seasons or dried up during the dry season without islands of carrion fluids. Insect activity at this stage, drifted toward coleopterans and ants. The skeletal remains are a continuum of dry decay, with the carrion skin, gut contents, bones, and hair being the visible evidence of the carrion. Clerids and dermestids (coleopterans), and the larvae of stratiomyid (dipteran) are most visible at this stage, and lasted beyond 60 to 90 days in the dry and rainy seasons, respectively.

The mean ambient temperature in both seasons was high at 30.76 °C and 27.66 °C for dry and rainy seasons, respectively. Similarly, the relative humidity was optimal at 56.73 % and 77.83 % while rainfall showed contrasting records at 2.02 mm and 166.26 mm for the dry and rainy seasons, respectively (Figure 2). These climatic changes, except for rainfall, were consistent through the years but variably impacted the decomposition duration of the pig carrions across the seasons.

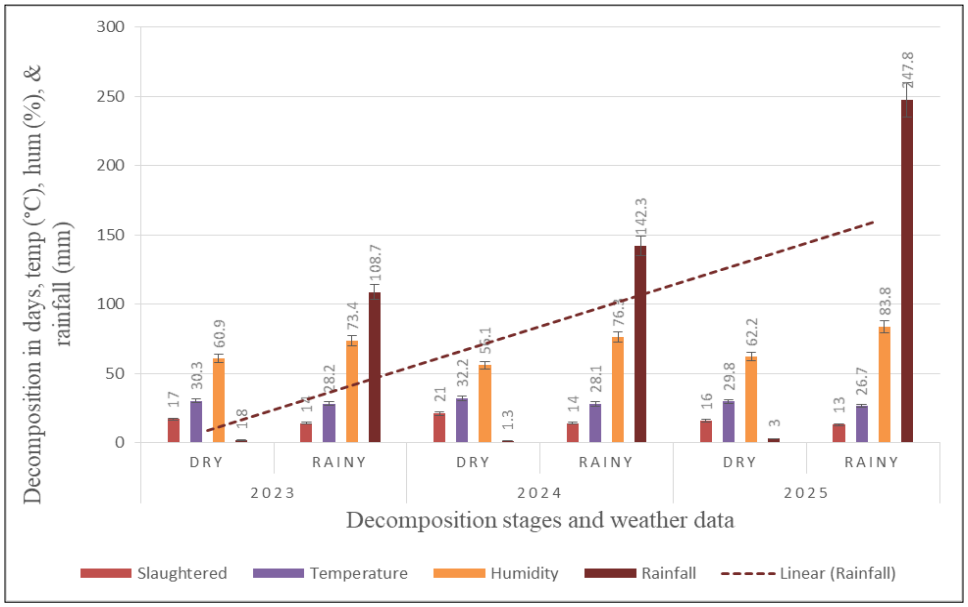

Fig 2: Decomposition durations of pig carrions and their weather variables at UPH, Nigeria

There was a rich assemblage of insects in 4 orders (Diptera, Coleoptera, Dermaptera, and Hymenoptera), 15 families, and 22 species recorded throughout the study period (Figure 3). Diptera was the dominant order in terms of abundance and early colonization, but the Coleoptera dominated in terms of richness. Insect abundance and feeding activity were usually higher during the rainy season across the three years, with the major groups (dipterans and coleopterans) remaining consistent from 2023[26] to 2025.

S/No.	Insect Group			2023	2024	2025
	Order	**Family**	**Insect Species**	**Slaughtered**	**Slaughtered**	**Slaughtered**
1	**Coleoptera**	Cleridae	*Necrobia rufipes* (Deg.)	X	X	X
2		Dermestidae	*Dermestes maculatus* (De G.)	X	X	X
3		Histeridae	*Hister unicolor* (Linn.)	X	X	X
4			*Hister* sp.	X	X	X
5		Lycidae	*Calopteran terminale* (Say)		X	
6		Nitidulidae	*Carpophilus* sp.	X	X	X
7		Ptinidae	*Lasioderma* sp.			X
8		Scarabaeidae	*Maladera holosericea* sp.	X		
9		Staphylinidae	*Staphylinus* sp.	X	X	X
10	**Diptera**	Calliphoridae	*Chrysomya albiceps* (Wied.)	X	X	X
11			*Chrysomya chloropyga* (Wied.)	X	X	X
12			*Chrysomya megacephala* (Fab.)	X	X	X
13		Muscidae	*Musca domestica* (Linn.)	X	X	X
14		Sarcophagidae	*Sarcophaga* sp.	X	X	X
15		Stratiomyidae	*Hermetia illucens* (Linn.)	X	X	X
16		Ulidiidae	*Chrysomyza africana* (Hendel)	X	X	X
17	**Dermaptera**	Anisolabididae	*Euborella* sp.		X	
18	**Hymenoptera**	Formicidae	*Apis mellifera* (Linn.)			X
19			*Camponotus acvapimensis* (May	X		
20			*Camponotus nigriceps* (Smith)	X		X
21			*Camponotus perrisi* (For.)	X	X	X
22			*Pheidole* sp.	X		
Total	**4**	**15**	**22**	**18**	**16**	**17**

Fig 3: Checklist and yearly distribution of insect species on pig carrions at UPH, Nigeria

Discussion

The seasonal difference between the dry and rainy season observed in this study has unique interpretations for forensic exercise in southern Nigeria. The faster decomposition of the carrion tissues and higher insect feeding activity during the rainy seasons were clues for shorter PMI ranges, while extended decomposition during the dry season suggests prolonged PMI timelines. Remarkably, the consistency of core forensic taxa across the three-year study timeline indicates relative stability of the carrion insect community,

and strengthens the reliability of the checklist as a regional reference data.

The carrion decomposition and pattern of the insects' arrival in this study offer robust forensic values that are applicable to outdoor death investigations in tropical grassland and related terrestrial environments. In agreement with the reports of Effiong *et al*. [21], the predictability of arrival and developmental indices of dipteran flies during the early decomposition stages of the pig carrions emphasizes their critical role in estimating PMI of the carrions. In agreement with the review reports of Obafunwa *et al*. [22], the calliphorid flies (blow flies), especially *Chrysomya* species, were consistently observed during the fresh to wet decay stages, hence serving as reliable earlier indicators for early PMI estimation of carrions infested with fly eggs, larvae, or pupae. Other dipteran flies (sarcophagids and muscids) are somewhat consistent; however, their larval absence during the earlier decomposition stages in this study questions their recognition as early PMI indicators. This finding is contrary to that of Abajue *et al*. [23], where sarcophagid adults deposited first-instar larvae on pig carrions, which has serious forensic implications that may lead to overestimation of PMI when they are wrongly evaluated. Similarly, Barton *et al*. [3] reported that muscids are early carrion invaders, which contradicts the observations in this report. In this study, muscids were actually spotted in all the observable decomposition stages, but became more visible during the peak of wet decay in the rainy season, and in the dry decay stage during the dry season. Their larvae were sparsely seen later on the undigested gut contents, when all the calliphorid larvae have dispersed. Again, the stratiomyid larvae were conspicuously seen under the dried remains during the skeletal stage in the rainy seasons only, while the ulidiid flies, though in fewer numbers, consistently arrived during bloated stages and usually disappeared during the peak of wet decay stages. Unfortunately, ulidiid larvae were not seen in this study against their implication on pig carrions at Okija, Southeast Nigeria, as reported by Abajue *et al*. [23]. The absence of their larvae in this study may be linked to larval competition with the calliphorids, which are known to feed in aggregation and deprive other fly larvae from participating in the feeding rivalry on carrions [24].

In advancing the relevance of carrion insects for PMI estimates, it is evident that fresh and bloated stages are relatively short, particularly during the rainy seasons, indicating a rapid insect response to colonize carrion under humid tropical conditions. Forensically, when considering the use of dipterans, their arrival, colonization, and development on carrions, it is necessary to adjust for seasonality. In this study, the wet decay stage is the most forensically revealing, characterized by large fly larval biomass and other insect species. Hence, PMI estimation during this phase relies heavily on the age of fly larvae, developmental rates, and accumulated degree-day designations according to previous reports [25, 26]. Interestingly, the prolonged wet decay observed during the rainy season suggests that PMI estimates derived from larval biomass alone may be lengthier compared to dry-season scenarios. The dry decay stage that culminates in skeletal remains is dominated by the coleopterans (clerids and dermestids), which are forensically relevant in cases involving extended PMI and skeletonized remains. The presence of these two coleopterans could serve as indicators of dry decay stages, particularly during the dry seasons, and in skeletonized remains during the rainy seasons.

The interactions and behaviors of carrion-associated insects, in view of showcasing their forensic value, may be perplexed if the ecological linkages are not intuitively understood. Thus, the ants (Formicids), which were present throughout the decomposition stages, constituted a notable carrion insect community. In particular, the *C. perrisi* continually predated on calliphorid larvae, which, according to Goodbrod and Goff [27], can lead to a reduction in larval density. It therefore means that this can slow tissue breakdown and introduce ambiguity in relation to PMI estimates according to Nappi [28]. The predatory activity of *C. perrisi*, as observed in this study, was glaring but poses no serious threat to slowing down tissue breakdown due to the biomass load of calliphorid larvae on the carrions. However, for other ants, their feeding activity, according to Bonacci *et al*. [29], can produce fake post-mortem marks that could resemble ante-mortem injuries and pose some challenges for post-mortem interpretation if such insect activity and characteristics are not properly evaluated.

Similarly, according to Weidner and Merritt [30], predatory beetles such as histerids and staphylinids may alter dipteran larvae populations on carrions, and can indirectly influence decomposition durations and PMI estimations. This notion ought to be critically evaluated on carrion-associated insects in the tropics. In this study, the predatory behaviour of these coleopterans arguably did not pose a serious threat to delaying the decomposition durations of the carrions. Therefore, these interspecific interactions as opined by previous authors [31, 32], underscore the necessity of all-inclusive insect collection and identification in real-case scenarios to accommodate empirically carrion-fauna studies. Hence, it is pertinent to always integrate the carrion decomposition stages with patterns of insect arrival, activity, and succession to enhance accurate PMI estimation and site modelling in tropical environments such as grassland habitats. It further necessitates region-specific forensic entomology data that could provide an unbiased and logically intuitive outline for applying entomological evidence in investigations relating to deceased bodies infested with insects.

Conclusion

This three-year study presents an all-inclusive entomological survey of carrion-associated insects in a grassland habitat at the UPH, Nigeria. The carrion decomposition stages and the patterns of insect associations were plainly described. The dipteran fauna provided a critical indication of early PMI estimation, and the coleopterans offered appreciable evidence for advanced PMI estimations. Seasonal variation, heightened by rainfall, primarily influenced decomposition stages and insect activity. However, the core carrion insect species (flies and beetles) remained the same all through the seasons, which underscored their value for locally described insects of forensic importance.

The carrion decomposition-stage analysis, insect checklist, and forensic descriptions presented in this study provide a reliable resource material for forensic experts, scientists, and law enforcement agencies working in tropical environments. The findings empirically contribute to the database of forensic entomology in Nigeria, and add to the quest to commence consideration of the application of insects'

evidence in homicide investigations. Further studies should consider inculcating structured statistic-based finding to aid regionally-harmonized based findings.

Conflict of Interest

The author declares there are no conflicts of interest.

Source of Funding

The authors received no financial support for this research, authorship, or its publication.

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