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Influence of the Conditions of Exposure of Pigs' corpses (*Sus scrofa domesticus* L.) on the Diversity of Necrophagous Insects in the Guinean zone of Côted'Ivoire

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Abstract

A corpse constitutes for different species of insects a nourishing substrate, an egg-laying site, a refuge or even an ecological niche. The objective of our study is to know the influence of the conditions of exposure of pig corpses on the composition of the entomological necrophagous fauna in the Guinean zone of Côte d'Ivoire. Twelve pig corpses were exposed under four conditions at the National Agronomic Research Center of Adiopodoumé. The experimental set-up consisted of three series of four types of wire mesh cages each containing a freshly slaughtered pig body: one witness exposed on the ground, one semi-submerged, one wrapped in a shroud and one suspended from a gallows. Two orders of insects were collected: Diptera and Coleoptera represented respectively by seven and eight families. *Chrysomya albiceps* was most abundant in control and packed cadavers with 14.93 and 11.81% of total Calliphoridae numbers, respectively. Fanniidae, Piophilidae, Muscidae and Stratiomyidae, were not found on the hanging corpses. The family of Coleoptera Histeridae was the most diverse; that of Geotrupidae was not collected from the hanging corpses. The high Shannon index on witness, wrapped and semi-submerged corpses reflects a cohabitation of many species present on these corpses. The high values of Equitability at the level of these same types of cadaver, demonstrated an equitable distribution of species within the corpse ecosystem.

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Pig corpses, Exposure conditions, Necrophagous insects, Diptera, Coleoptera, Guinean zone of Côte d'Ivoire.

Introduction

A corpse constitutes for different species of insects a nourishing substrate, a laying site, a refuge or even an ideal territory (Caster *et al.*, 2007). The temporary micro-habitat created by the decomposition of dead organic matter of animal origin attracts a variety of fauna, the most specialized of which are necrophagous insects belonging mainly to the orders Diptera and Coleoptera (Catts and Goff, 1992; Hall, 2001; Hall and Huntington, 2009).

During an entomological survey to date the death, identifying the insects found on a rotting corpse is the very first step. It's therefore essential to know the composition of the entomological fauna that can colonize a corpse accessible to insects. Recent studies carried out in the Guinean zone of Côte d'Ivoire have shown that as

soon as death occurs, a corpse exposed to the open air is quickly colonized by various necrophagous insects (Koffi *et al.*, 2018; Dao *et al.*, 2019). The experimental exposure of pig corpses to the open air corresponds to the classic case of people murdered and abandoned in the wild. But in very specific cases, murderers seek to conceal their victims or the circumstances of their crimes. These can wrap their victims in shrouds before leaving them in the wild. In some cases, murderers can hide their victims by leaving them in ponds of varying size. In other cases, they may, after committing their murders, simulate a voluntary hanging of the victim in the wild. However, throughout the process of cadaveric decomposition, certain factors intrinsic and extrinsic to the corpse can influence both the behavior of necrophagous insects and the composition of the entomological fauna

(Campobasso *et al.*, 2001 ; Dao *et al.*, 2019). The objective of this study is therefore to know the influence of the conditions of exposure of pig corpses on the composition of the entomological necrophagous fauna in the Guinean zone of Côte d'Ivoire.

Materials and Methods

Study site

Our work was carried out on the site of the National Agronomic Research Center located west of the city of Abidjan, precisely in Adiopodoumé, road of Dabou (5°19'40.13'' North Latitude, 4°07'54.80'' West Longitude, Altitude 17 m). This site is limited to the South and East by the Ebrié lagoon, to the West by the road that leads to the Pasteur Institute of Adiopodoumé and to the North by the road of Dabou. It covers an area of approximately 230 hectares. There is vegetation essentially made up of a relic of primary lagoon forest covering 4/5 of the site. In its western part, a fringe of this forest relic has suffered severe degradation under the influence of man to make way for vegetation made up of grass and cassava plantations. In the midst of this forest vegetation, the National Agronomic Research Center site houses many buildings intended for the administration and accommodation of the officers who work there.

Experimental climatic conditions

Daily atmospheric temperatures and relative humidity were recorded using an "HMI - 0172SI" type thermo-hygrometer recorder. Concerning the rainfall data, they were been obtained thanks to the Airport, Aeronautical and Meteorological Exploitation and Development Company (SODEXAM - Abidjan). The daily data recorded were been used to calculate the monthly averages of temperature and relative humidity. The temperature values ranged from 25.8 to 29.9 °C. Those for relative humidity fluctuated between 75% and 87%.

Experimental device

Four wire mesh cages were been made to protect the biological material (pig carcass) and depending on the different cases studied, they had different dimensions. The cages of the first three cadaver cases (cages of cadavers exposed to the open air (control), cages of semi-submerged cadavers, cages of cadavers wrapped in a shroud had the following dimensions: L = 1.5 m, l = 1 m and h = 0.8 m. While those of corpses suspended from a gallows were: L = 0.9 m, l = 0.9 m and h = 1.5 m. The cages inside which were the control pig corpses and those wrapped in a shroud were been fixed to the ground using a tripod. The dimensions of the basin containing the semi-submerged corpse were: Length = 1.7 m ; width = 1.2 m ; depth = 0.7 m. As for the cage containing the suspended corpse, the carcass was been suspended using a nylon rope attached to a 2 m long gallows. Three repetitions were carried out for the different cases, ie 12 pigs used (Figure 2).

Slaughter and exposition of pig's cadavers

Our study required the purchase of pigs each weighing 60 kg. After verification of their state of health by a veterinarian, they were been euthanized after administration of a sedative. The date of October 29, 2019, noted J0, corresponded to the day of slaughter and exposure of the pig corpses. Within a given repetition, the corpses were been separated from each other by about 300 m. At the experimental site, the replicates were been separated from each other by about 800 m. These arrangements were been made to avoid any form of competition during the colonization process of corpses by necrophagous insects.

Harvesting, identification and counting of insects associated with cadavers

Some necrophagous Diptera were been directly harvested from pig carcasses, removing the eggs from the skin surface with a knife. These samples were taken at each stage of decomposition of the corpse. Plastic boxes containing pieces of pork liver were used for incubating the eggs and were transported to the

laboratory (Koffi, 2018; Dao *et al.,* 2019). After the eggs hatched, the larvae were been followed until the emergence of the adults. Adults of other Diptera species whose eggs were not been collected by the method explained above were obtained from larvae or pupae taken from or near decaying corpses. Regarding to Coleoptera, a flexible clamp was used to harvest adults from decaying corpses. The larvae, nymphs and adults of harvested insects were stored in labeled pill boxes containing 60 ° alcohol. Small-sized Diptera, such as Piophilidae and other flying insects, were harvested using a mower net. Around each cadaver, four yellow bins were placed in order to trap both Diptera and adult Coleoptera (Dekeirsschieter *et al.,* 2011; Koffi, 2018; Dao *et al.,* 2020).

Frequency of harvesting, identification and counting of necrophagous insects

The sedated pigs were been euthanized and exposed on October 29, 2019. The harvest of necrophagous insects was done three times a day: in the morning at 7:00 a.m., at 12:00 p.m. and at 6:00 p.m. The insects trapped by the yellow bins were collected every day at 6.30 p.m.

The identification and enumeration of these captured necrophagous insects was done under a binocular magnifying glass. The different stages of decomposition of the corpses and the number of insects identified were noted on a technical sheet prepared for this purpose.

Data processing

Statistical processing of the data was carried out using Statistical version 7.1 software. The analysis of variance (ANOVA) and the Newman-Keuls test at the 5% threshold made it possible to separate the different homogeneous groups. The diversity of the entomological fauna of the different stages of decomposition of the corpses was estimated according to 4 ecological indices :

Relative Abundance (Ar)

Relative abundance (Ar), according to Zaime and Gautier (1989), is defined as the ratio between the number of individuals of a species (Ni) taken into consideration and the total number of individuals of all species combined. (N).

Four relative abundance classes can be observed
When Ar ≥ 10%, it means that, the species are very abundant;

When 5% ≤ Ar <10%, it means that the species are abundant;

When 1% ≤ Ar <5%, it means that the species are quite abundant;

When Ar <1%, it means that the species are scarce.

Specific wealth (S)

The specific richness or total richness of a Biocenosis is defined as being the total number of all the species observed during N surveys (Ramade, 1984).

S = Sp1 + Sp2 +…. + Spn

Total number of species observed during N surveys is noted S. Sp1, Sp2, Spn corresponds to the species collected.

Indices de Shannon -Weaver (H ou H')

The Shannon index (Shannon, 1948; Shannon & Weaver, 1963), also called the Shannon-Weaver or Shannon-Wiener index, is derived from information theory. It makes it possible to quantify the heterogeneity of the biodiversity of the study environment and therefore to observe changes over time (Daget, 1979).

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Originally, Shannon used a logarithm to base 2 so that H was the average number of binary questions (yes or no answer) needed to identify an insect species (Marcon, 2010).

H is minimal (= 0) if all the individuals in the stand belong to a single species. Or if, in a stand, each species is represented by a single individual, except one species which is represented by a large number of individuals in the stand. According to Frontier (1983), H is maximal when all individuals are equally distributed over all species.

The Shannon index is often been accompanied by the Equitability index also known as the Equity distribution index (Blondel, 1979).

Equitability (E)

The regularity of a distribution is an intuitively fairly simple notion: the small difference between the real distribution and a perfectly regular distribution, verifying pi = 1 / N. An expression of Equitability is often given from the Shannon index. The maximum value of the Shannon index is obtained when the distribution is perfectly regular (Marcon, 2010). Then, Hmax = lnS. Therefore, the equitability index is defined by the relationship:

Results and Discussion

Experimental climatic conditions

The monthly temperature averages for the year 2019 fluctuated between 25.7 and 29.3°C and those for the year 2020 varied from 25.8 to 29.9°C. Two rainy seasons were been recorded in 2019, from April to June and from September to November. During this same year, two dry seasons were also been recorded from January to March and from July to August (Figure 3A and 3B). During the year 2020, two rainy seasons were been observed from April to June and from October to November. While two dry seasons were recorded from January to April and from July to September (Figure 3A and 3B). For the relative humidity for the years 2019 and 2020, the rates ranged from 75 to 87% (Figure 3C).

Necrophagous insects inventoried during the decomposition process of corpses exposed under various conditions

During the decomposition process of the four types of exposed corpses, a total of 28 species of necrophagous insects were inventoried. They have been grouped into two orders: Diptera and Coleoptera. In Diptera, 18 inventoried species were grouped into seven families, while in Coleoptera, 10 listed species were grouped into eight families. Among the Diptera, the Calliphoridae, Muscidae and Sarcophagidae families were been respectively represented by nine, one and three species collected during the fresh cadaver and active decomposition stages. Four species belonging to the Fanniidae, Piophilidae and Stratiomyidae families were been collected during the stages of advanced decomposition and skeletonization of corpses. All the species of these different families of Diptera were present on the control pig corpses, packed and semi submerged. On the other hand, on the suspended corpses, species of the Muscidae, Fanniidae, Stratiomyidae and Phoridae families were not collected. The Phoridae family was also absent from the witness corpses. In Coleoptera, almost all species were been collected during the stages of advanced decomposition and skeletonization of corpses. While the families of Geotrupidae, Silphidae and Trogidae were absent from the control and hanging corpses, those of Cleridae, Histeridae, Dermestidae, Scarabaeidae and Tenebrionidae were present on the four types of corpses exhibited (control, hanging, wrapped and semi-submerged). Furthermore, the Scarabaeidae family was represented by the species *Onthophagus taurus* which was very abundant in semi-submerged corpses (Table 1).

Richness and relative abundance of species with in families of necrophagous Diptera

Eighteen species have listed and grouped into seven families. The number of individuals present on pig corpses varied from species to species depending on the case. The total numbers of Diptera collected were 14223 individuals on the control cadavers, 5504 on the suspended cadavers, 10.097 on the wrapped cadavers and 10.059 individuals on the semi-submerged cadavers. (Table 2). *Chrysomya albiceps* was the most abundant in control, suspended, wrapped and semi-submerged cadavers with respectively 14.93, 20.38, 12.53 and 11.13% of all Diptera collected (F = 2.99446; df = 3; P = 0.095472) (Table 2). While *Lucilia sericata* was the least abundant species among the Calliphoridae with 0.47, 1.50, 0.44 and 0.41% of the total number of Diptera, respectively on control, suspended, wrapped and semi-submerged corpses (Table 2). *Chloromyia formosa*, *Fannia canicularis*, *Hermetia illucens*, *Megazella sp*, *Musca domestica* and *Piophila casei* species were absent from the hanging and wrapped corpses. *Piophila casei* was not collected from the control corpses (Table 2).

Richness and relative abundance of species with in necrophagous Coleoptera families

Eight families within which 10 species were identified represented Coleoptera. The presence of these varied from one cadaver to another depending on the type of exposure. The total numbers of Coleoptera collected were 1264, 1199, 509 and 709 individuals respectively on the control, semi-submerged, suspended and wrapped corpses. The most diverse Histeridae family was been represented by three species, namely *Hister cadaverinus*, *Margarinotus brunneus* and *Pachylister inaequalis*. On the control corpses, suspended, wrapped and semi-submerged, the mean numbers of *Hister cadaverinus*

were respectively 332.66 ± 99.48, 56.00 ± 6.42, 220.00 ± 32.86 and 301.00 ± 22.70 individuals, i.e. a relative abundance of 26.31, 11.00, 31.01 and 25.1% of the total numbers of Histeridae (F = 6.23226; df = 3; P = 0.017294). Concerning *Margarinotus brunneus*, the mean numbers obtained were respectively 218.33 ± 33.56, 83.33 ± 7.35, 55.66 ± 7.31 and 63.33 ± 5.36 individuals on the control corpses, suspended, wrapped and semi-submerged, ie a relative abundance of 17.27, 16.37, 7.84 and 5.28% of the total numbers of Histeridae (F = 18.4557; df = 3 ; P = 0.000593) (Table 3).

For *Pachylister inaequalis* on, control, hanging, wrapped and semi-submerged corpses respectively attracted on average, 163.33±7.42, 34.33±6.35, 74.33±11.85 and 189.33±54.20 individuals, i.e. 12.92, 6.74, 10.47 and 15.79% of the total numbers of Histeridae collected (F = 6.70915; df = 3; P = 0.014148) (Table 3).

In addition, the species *Geotrupes stercorarius* belonging to the family Geotrupidae was only present on wrapped and semi-submerged corpses. The mean numbers were respectively 2.43 ± 0.21 and 10.66 ± 2, 33 individuals, representing 0.34% and 0.88% of the numbers of Coleoptera (F = 2.578811; df = 3; P = 0.001855) (Table 3). A species of Silphidae belonging to the genus Silpha n 'was only identified on semi-submerged corpses with an average size of 8.00 ± 0.00 individuals (0.66%) of Coleoptera collected (Table 3).

Ecological indices

Regarding the Shannon index (H'), control, wrapped and semi-submerged corpses had the highest values, while hanging corpses had the lowest value. At the level of the Equitability index (E), the highest values were also recorded on the control corpses, wrapped and semi-submerged, while the lowest was noted on the suspended corpses (Table 4).

Of all the different exposed pig corpses, the necrophagous insects collected were grouped into two orders, namely, Diptera and Coleoptera. The order Diptera was been represented by 18 species grouped into seven (7) families and that of Coleoptera, by 10 species grouped into eight (8) families.

These results join those of Leclercq (1996) and Koffi *et al.*, (2017), the work of which was respectively carried out in France and in the Guinean zone of Côte d'Ivoire. In fact, during the decomposition process of a dead boar body that accidentally died in the forest of the national domain of Chambord, Leclercq (1996) was able to identify 30 species of Diptera and two species of Coleoptera. The inventory work carried out by Rickenbach *et al.*, (1962) on the Calliphoridae family from Haute-Volta (now Burkina Faso) and Côte d'Ivoire as well as those from Koffi (2018) in the southern Ivorian forest zone, enabled them to collect the genera *Phumosia* Robineau-Desvoidy, 1830 (*Calliphora*), *Lucilia* and *Chrysomya*.

These authors also identified other species of Diptera belonging to the Sarcophagidae, Muscidae and Piophilidae families. Our results demonstrated the presence of seven (7) families of Diptera, of which five (5) were also been collected by Leclercq (1996), Koffi (2018) and Dao *et al.*, (2019). The work carried out in Cameroon by Youmessi *et al.*, (2012) allowed the identification of five (5) families of Diptera. Moreover, Irish *et al.*, (2014) were able to identify many Afrotropical species belonging to the genus *Chrysomya*. In our study, these species were identified on corpses exposed in different situations (suspended corpses, semi-submerged corpses and wrapped corpses). These results could be been explained by the fact that many species of necrophagous Diptera are cosmopolitan and would adapt well to biotopes and summer climatic conditions that favor their development. No statistical difference was observed between the mean numbers of *C. albiceps* in cadavers exposed under different conditions. This consistency in the colonization of the various corpses by *Chrysomya albiceps* would be due to the same characteristic odors emitted by all these carcasses between the 2nd and the 10th post-mortem day (Koffi *et al.*, 2017; Dao *et al.*, 2019). Quantitatively and undifferentiatedly, the other species of Calliphoridae also colonized all four types of cadavers. This could be been explained by the fact that these other species would have the same capacities to detect various odorous molecules emitted by decomposing corpses (Dekeirsschieter, 2007). In the Sarcophagidae, the average numbers of individuals of the different species obtained from the suspended corpses were very low.

This low abundance would be due to the rapid drying out of the suspended corpses. In contrast, the prolonged humidity of the semi-submerged and wrapped carcasses favored the presence in large numbers of these same species of Sarcophagidae (Dao *et al.*, 2019). Species from the families of Fanniidae (*F. canicularis*), Muscidae (*M. domestica*), Piophilidae (*P. casei*) and Stratiomyidae (*H. illucens* and *C. formosa*) have not been recorded on the suspended corpses.

Table.1 Species of necrophagous insects collected from the various corpses exposed.

Orders	Families	Species	Control corpses	Suspended corpses	Semi-submerged corpses	Wrapped corpses
Diptera	Calliphoridae	*Calliphora vicina* (Robineau-Desvoidy, 1830)	+	+	+	+
		Calliphora vomitoria (Linné, 1758)	+	+	+	+
		Chrysomya albiceps (Wiedemann, 1819)	+	+	+	+
		Chrysomya marginalis (Wiedemann, 1830)	+	+	+	+
		Chrysomya megacephala (Fabricius, 1794)	+	+	+	+
		Chrysomya putoria (Wiedemann, 1830)	+	+	+	+
		Lucilia caesar (Linné, 1758)	+	+	+	+
		Lucilia sericata (Meigen, 1826)	+	+	+	+
		Protophormia terraenovae (Robineau-Desvoidy, 1830)	+	+	+	+
	Sarcophagidae	*Sarcophaga africa*, (Wiedemann, 1824)	+	+	+	+
		Sarcophaga carnaria, (Linné, 1758)	+	+	+	+
		Sarcophaga haemorrhoidalis (Fallen, 1817)	+	+	+	+
	Fanniidae	*Fannia canicularis* (Linné, 1760)	+	-	+	+
	Muscidae	*Musca domestica* (Linné, 1758)	+	-	+	+
	Stratiomyidae	*Hermetia illucens* (Linné, 1758)	+	-	+	+
		Chloromyia formosa (Scopoli, 1763)	+	-	+	+
	Piophilidae	*Piophila casei* (Linné, 1758)	+	-	+	+
	Phoridae	*Megazella* sp.	-	-	+	+
Coleoptera	Cleridae	*Necrobia rufipes* (De Geer, 1775)	+	+	+	+
	Histeridae	*Margarinotus brunneus* (Fabricius, 1775)	+	+	+	+
		Hister cadaverinus (Hoffmann, 1803)	+	+	+	+
		Pachylister inaequalis (Olivier, 1789)	+	+	+	+
	Dermestidae	*Dermestes maculatus* (De Geer, 1774)	+	+	+	+
	Scarabaeidae	*Onthophagus taurus* (Schreber, 1759)	+	+	+	+
	Silphidae	*Silpha* sp	-	-	+	-
	Geotrupidae	*Geotrupes stercorarius* (Linné, 1758)	+	-	+	+
	Tenebrionidae	*Tenebrio molitor* (Linné, 1758)	+	+	+	+
	Trogidae	*Trox cadaverinus* (Illiger, 1802)	+	-	+	+

Table.2 Average numbers et relative abundance of necrophagous Diptera species collected from pig cadavers exposed under different conditions.

		Control corpses		Suspended corpses		Wrapped corpses		Semi- submerged corpses	
Families	**Species**	**Average numbers**	**Ar (%)**	**Average numbers**	**Ar (%)**	**Average numbers**	**Ar (%)**	**Average numbers**	**Ar (%)**
Calliphoridae	*Calliphora vicina*	841.33 ± 87.48^{a}	5.92	731.66 ± 86.21^{ab}	13.29	732.66 ± 112.49^{ab}	7.26	392.33 ± 91.96^{b}	3.90
	Calliphoridae vomitoria	1196.66 ± 53.07^{a}	8.41	1015.33 ±165.04^{a}	18.45	817.66 ± 23.38^{a}	8.10	1188.33 ± 153.79^{a}	11.81
	Chrysomya albiceps	2124.0 ± 438.83^{a}	14.93	1122.0 ± 241.29^{a}	20.39	1192.33 ± 157,14^{a}	11.81	1120.0 ± 215.02^{a}	11.13
	Chrysomya marginalis	176.00 ± 59.63^{a}	1.24	250.66 ± 38.44^{a}	4.55	211.00 ± 53.56^{a}	2.09	268.00 ±113.85^{a}	2.66
	Chrysomya megacephala	124.33 ± 13,38^{a}	0.87	86.66 ± 4.63^{b}	1.57	77.33 ± 9.76^{b}	0.77	92.66 ± 4. 09^{b}	0.92
	Chrysomya putoria	662.00 ± 218.72^{a}	4.65	160.00 ± 39.80^{a}	2.91	563.33 ± 145.78^{a}	5.58	646.66 ± 154.32^{a}	6.43
	Lucilia caesar	1896.00 ± 358.63^{a}	13.33	1568.33±33.29^{ab}	28.49	586.33 ± 49.36^{b}	5.81	922.66 ± 170.25^{ab}	9.17
	Lucilia sericata	67.33 ± 6.69^{ab}	0.47	82.66 ± 8.08^{a}	1.50	44.66 ±9.87^{b}	0.44	41.66 ± 9.38^{b}	0.41
	Protophormia terraenovae	963.00 ± 245.09^{a}	6.77	241.33 ± 66.43^{a}	4.38	509.66 ± 105.80^{ba}	5.05	761.33 ± 49.46^{ba}	7.57
Fanniidae	*Fannia canicularis*	93.00 ± 8.02^{a}	0.65	0.00 ± 0.00^{b}	0.00	136.66 ± 20.01^{a}	1.35	171.66 ± 37.11^{a}	1.71
Muscidae	*Musca domestica*	1143.66 ± 284.34^{a}	8.04	0.00 ± 0.00^{b}	0.00	485.00 ± 149.28^{ab}	4.80	864.33 ± 68.03^{a}	8.59
Phoridae	*Megazella* sp.	0.00 ± 0.00^{b}	0.00	0.00 ± 0.00^{b}	0.00	124.12 ± 32.11^{a}	1.23	196.64 ± 44.21^{a}	1.95
Piophilidae	*Piophila casei*	2109.33 ± 181.78^{a}	14.83	0.00 ± 0.00^{b}	0.00	2107.33 ± 363.83^{a}	20.87	631.00 ± 115.27^{ab}	6.27
Sarcophagidae	*Sarcophaga carnaria*	385.66 ± 35.30^{a}	2.71	73.66 ± 12.91^{b}	1.34	268.33 ± 30.74^{a}	2.66	392.66 ± 87.60^{a}	3.90
	Sarcophaga haemorrhoidalis	530.33±103.74^{a}	3.73	120.33±89.37^{b}	2.19	372.00±94.21^{ab}	3.68	46.66 ± 12.71^{b}	0.46
	Sarcophaga africa	351.66±120.04^{a}	2.47	51.54±12.17^{b}	0.94	65.33±14.11^{b}	0.65	453.154±173.84^{a}	4.50
Stratiomyidae	*Hermetia illucens*	1388.33 ± 129.66^{a}	9.76	0.00 ± 0.00^{b}	0.00	1695.33 ± 321.99^{a}	16.79	1753.00±322.56^{a}	17.43
	Chloromyia formosa	170.00 ± 8.62^{a}	1.20	0.00 ± 0.00^{b}	0.00	107.66 ± 7.75^{a}	1.07	116.66 ± 36.02^{a}	1.16

The numbers followed by the same letter on the same line are not significantly different according to the Newman Keuls test at the level of **5%**.

Table.3 Average numbers and relative abundance of Coleoptera species collected from pig cadavers exposed under different conditions

Families	Species	Control corpses		Suspended corpses		Wrapped corpses		Semi-submerged corpses	
		Average numbers	Ar (%)	Average numbers	Ar (%)	Average numbers	Ar (%)	Average numbers	Ar (%)
Cleridae	*Necrobia rufipes*	214.33± 47.89^{a}	16.96	165.33 ±16.82^{a}	32.48	52.00± 6.35^{b}	7.33	54.66 ± 6.11^{b}	4.56
Histeridae	*Margarinotus brunneus*	218.33±33.56^{a}	17.27	83,33±7.35^{b}	16.37	55.66±7.31^{b}	7.85	63.33± 5.36^{b}	5.28
	Hister cadaverinus	332.66± 99.48^{a}	26.32	56,00± 6.42^{b}	11	220.00±32.86^{a}	31.03	301.00± 22.74^{a}	25.1
	Pachylister inaequalis	163.33±7.42^{ab}	12.92	34.33±6.35^{c}	6.74	74.33±11.85^{bc}	10.48	189.33 ±54.29^{a}	15.79
Dermestidae	*Dermestes maculatus*	180.66±54.45^{a}	14.29	110.00±16.86^{a}	21.61	52.33±8.5^{a}	7.38	90.33 ± 6.22^{a}	7.53
Tenebrionidae	*Tenebrio molitor*	66.00±6.42^{b}	5.22	4.33±1.20^{c}	0.86	5.00±1.73^{c}	0.71	84.00 ± 4.93^{a}	7.01
Scarabaeidae	*Onthophagus taurus*	84.00±13.01^{c}	6.65	55.66±5.45^{c}	10.94	202.00±38^{b}	28.44	348.66 ±58.37^{a}	29.08
Trogidae	*Trox cadaverinus*	4.66±2.40^{b}	0.37	0.00±0.00^{b}	0	45.66 ± 7.12^{a}	6.44	49.00 ± 11.15^{a}	4.09
Silphidae	*Silpha* sp.	0.00±0.00^{b}	0	0.00±0.00^{b}	0	0.00±0.00^{b}	0	8 ± 0.00^{a}	0.67
Geotrupidae	*Geotrupes stercorarius*	0.00±0.00^{b}	0	0.00±0.00^{b}	0	2.43±0.21^{b}	0.34	10.66 ± 2.33^{a}	0.89

The numbers followed by the same letter on the same line are not significantly different according to the Newman Keuls test at the level of 5%.

Table.4 Ecological indices of insect species present on the different types of corpses.

	Numbers of species	Shannon index (H')	Equitability (E)
Control corpses	26	3.7329	0.8261
Suspended corpses	19	2.8774	0.5451
Wrapped corpses	27	3.6604	0.7023
Semi-submerged corpses	28	3.6496	0.7987

Fig.1 Location of the National Agronomic Research Center site in the city of Abidjan.

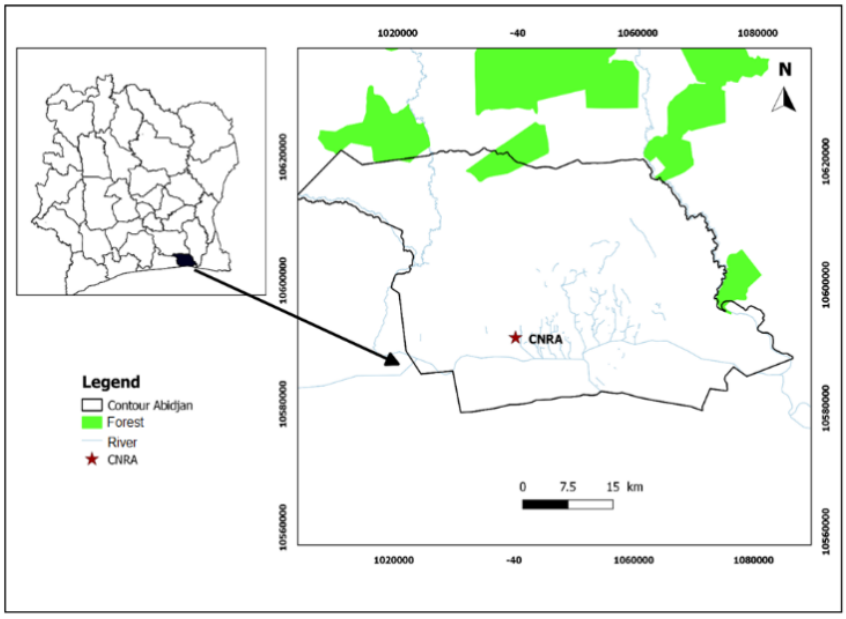
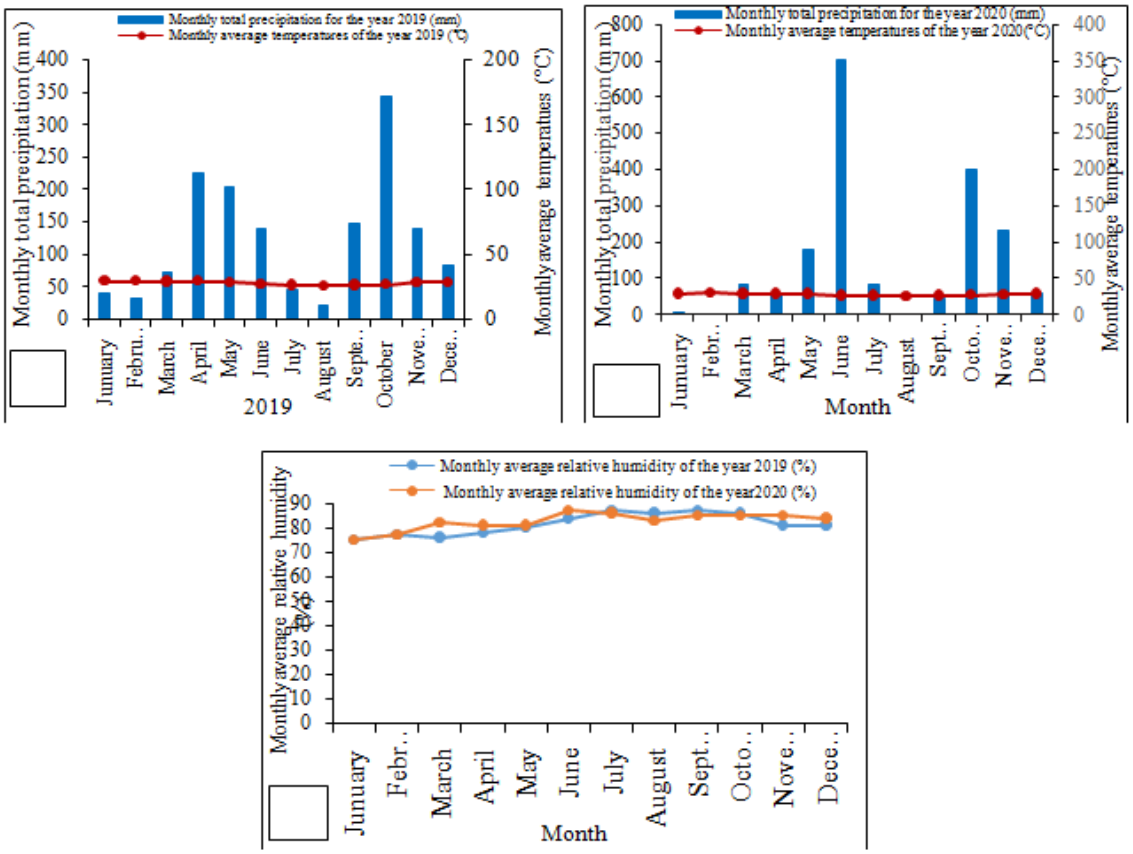


Fig.2 Exposure of the corpses in the various protection cages
A: Exposure of the Control corpse; **B**: Exposure of the semi-submerged corpse; **C**: Exposure of the suspended corpse; **D**: Exhibition of the wrapped corpse.

Fig.3 Meteorological data given by SODEXAM
A: Ombrothermal diagram 2019 of the city of Abidjan; **B**: Ombrothermal diagram 2020 of the city of Abidjan; **C**: Monthly average relative humidity recorded during the years 2019 and 2020



The early drying out of the suspended corpses is believed to be the cause of the absence of these species in these corpses (Dao *et al.*, 2019). The order of Coleoptera was been represented by eight (8) families. Of these, the Histeridae family was the richest in species.

These results agree with those of Koffi (2018) and Dao *et al.*, (2019) who respectively carried out their work on the inventory of necrophagous insects in the Guinean zone and in the Sub-sudanese zone of Côte d'Ivoire. *N. rufipes*, which was the most abundant species on the control corpses during the trapping carried out, was also been collected by Leclercq (1996) in summer in France.

In addition, Youmessi *et al.*, (2012) in Cameroon also identified five of the eight Coleoptera families resulting from our work. Most of the Coleoptera families collected have also been listed by numerous authors on the African (Farah, 2010 ; Youmessi *et al.*, 2012), European (Dekeirsschieter, 2011; Charabidzé *et al.*, 2012) and American (Byrd & Castner, 2001; Caballero *et al.*, 2014; Da Silva *et al.*, 2014). Staphylinidae species were absent from the various traps carried out, which could be explained by the fact that these species were not present in the environment where the dead pigs were exposed (Koffi, 2018). The numbers of most Coleoptera species were reduced with the exception of *O. taurus* (Scarabaeidae) and *H. cadaverinus* (Histeridae) which were present in large numbers in semi-submerged corpses with respectively 29.07 and 25.1% of the total number of Coleoptera collected.

Inventory work carried out on pig cadavers exposed under different conditions at the National Agronomic Research Center of Adiopodoume revealed a diverse entomological fauna associated with the corpses. Whatever the condition of exposure of the corpses, the necrophagous insect species inventoried were grouped into two orders: Diptera and Coleoptera. The identification of Diptera made it possible to highlight eighteen (18) species grouped into seven (7) families: Calliphoridae, Fanniidae, Muscidae, Phoridae, Piophilidae, Sarcophagidae, Stratiomyidae. The Calliphoridae species collected from the four types of pig carcasses exposed were *Calliphora vicina*, *Calliphora vomitoria*, *C. albiceps*, *C. marginalis*, *C. megacephala*, *C. putoria*, *L. caesar*, *L. sericata* and *P. terraenovae*. In the Sarcophagidae, three species have been identified. These are *S. africa*, *S. carnaria* and *Sarcophaga haemorrhoidalis*. The species *F. canicularis*, *M. domestica* and *P. casei* were present on the control corpses, packed and semi-submerged. *Megazella sp* was also absent from the witness and suspended corpses. With regard to Stratiomyidae, two species were identified: *C. formosa* and *Hermetia illucens* which were absent from the hanging corpses. Among Diptera, the Calliphoridae family was the most diverse. *Chrysomya albiceps* was abundant in control, hanging, wrapped and semi-submerged corpses. The Coleoptera identified belonged to eight (8) families: Cleridae (*N. rufipes*), Dermestidae (*D. maculatus*), the Geotrupidae (*G. stercorarius*), the Histeridae (*H. cadaverinus*, *M. brunneus*, *P. inaequalis*) Scarabeidae (*O. taurus*), Silphidae (*Silpha sp.*), Tenebrionidae (*T. molitor*) and Trogidae (*T. cadaverinus*). The Histeridae family has been the most diverse. On the other hand, *G. stercorarius* and *T. cadaverinus* species were absent on suspended cadavers, while *Silpha sp* was only found on semi-submerged cadavers. Finally, it emerges from this study that the conditions of exposure of pig corpses have, depending on the case, little or strongly influenced the scavenging entomological fauna, both in its diversity and in its abundance. However, whatever the conditions of exposure of the corpses, Diptera and necrophagous Coleoptera have always been present on the carcasses.

In addition, on all exposed carcasses, we can note the invariable presence of the main necrophagous Diptera most commonly used in entomological surveys to date deaths, namely, Calliphoridae, Muscidae and Sarcophagidae.

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Conflict of interest

The authors declare that they have no conflict of interest regarding this article.

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