Available online at http://www.ifgdg.org

Int. J. Biol. Chem. Sci. 18(5): 1803-1814, October 2024

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper http://ajol.info/index.php/ijbcs http://indexmedicus.afro.who.int

Biological parameters of *Chrysomya marginalis* (Wiedemann, 1830) and *Chrysomya albiceps* (Wiedemann, 1819) (Diptera: Calliphoridae), two necrophagous insects bred on pig substrate (*Sus scrofa domesticus* L.) in the sub-Sudanese zone of Côte d'Ivoire

Hassane DAO[1*], Prisca Gnanda EHOUNOU[2], Drissa FONDIO[1] and Louis Roi Nondenot ABOUA[3]

[1] Jean Lorougnon Guédé University of Daloa, PO BOX 150 Daloa, Côte d'Ivoire.
[2] Alassane Ouattara University of Bouaké, 01 PO BOX 633 Bouaké 01, Côte d'Ivoire.
[3] Félix Houphouët Boigny University of Cocody-Abidjan, UFR Biosciences, 22 PO BOX 582 Abidjan 22, Côte d'Ivoire.
[*] Corresponding author; E-mail: daohassane@hotmail.com, Phone : +225 07 07 48 63 85

Received: 22-07-2024 Accepted: 21-10-2024 Published: 31-10-2024

ABSTRACT

When a corpse is discovered, estimating the post-mortem interval requires knowledge of the biological parameters of the first colonizing insects. The objective of this work was to determine the biological parameters of *Chrysomya marginalis* and *Chrysomya albiceps* in an ambient environment during the dry and rainy season on pig substrate. *C. marginalis* and *C. albiceps* come from eggs laid on pig carcasses exhibited at the botanical garden of the Peleforo Gon Coulibaly University of Korhogo. Eggs collected from these pig carcasses were incubated in cylindrical breeding cages containing striated pig muscle. The larvae were fed using the same substrate. After the adults' emergence, thirty pairs of each species were introduced into breeding cages containing pig striated muscle weighing 200 g. Daily monitoring made it possible to determine the different biological parameters. The total durations of the development cycle of the two species were 245.53 ± 14.85 and 243.13 ± 19.86 hours in the dry seasons respectively for *C. albiceps* and *C. marginalis*. During the rainy season, these durations were 259.30 ± 9.33 and 270.46 ± 15.56 hours respectively for *C. albiceps* and *C. marginalis*. During these two periods, females had a longer lifetime than males. On the other hand, during the rainy season, both sexes had practically the same lifetime. These results are important tools in carcasse dating.

Keywords : Necrophagous insects, biological parameters, seasons, Côte d'Ivoire.

INTRODUCTION

The need to strengthen the criminal justice system for the effective fight against crime through modern means of investigation is a prerequisite for developing countries. Forensic entomology, a discipline related to forensic science, is one of the most reliable methods for determining the Post-Mortem Interval (PMI) (Gennard, 2007). Forensic doctors are able to accurate determine the time of death in the case of a fresh corpse, based on studying the characteristics of the body and its

DOI: https://dx.doi.org/10.4314/ijbcs.v18i5.15

state of decomposition. Beyond three days, forensic entomology remains the best means, thanks to the technique, which consists of studying the scavenging entomofauna found on the corpse in order to estimate the date of death (Benecke, 2004; Charabidze, 2008). The necrophagous Diptera are attracted to the fresh corpse a few hours after the death of the organism. The arrival of these insects on the corpse makes it possible to estimate the PMI based on calculations of the age of the larvae collected (Byrd and Castner, 2001; Wyss and Cherix, 2006). Work on the biology of certain species of necrophagous insects has carried out in Europe and the United States but few work are done in Africa (Wyss and Cherix, 2006; Szpila and Villet, 2011; Charabidze, 2012). The literature does not mention any study on the biology of *Chrysomya albiceps* and *Chrysomya marginalis* in an ambient environment. The objective of this work was to determine the biological parameters of *C. marginalis* and *C. albiceps* in an ambient environment during the dry and rainy season on pig substrate.

MATERIALS AND METHODS

Study site

The work took place in the locality of Korhogo located in the sub-Sudanese zone, northern part of Côte d'Ivoire. The botanical garden of Peleforo Gon Coulibaly University (9°26' N - 5°38' W, altitude 380m) was chosen to house the experiments. This site enjoys a sub-Sudanese type climate with two seasons: a dry season and a rainy season.

Equipment

The biological material consisted of *C. marginalis* and *C. albiceps*, scavenger flies raised on pork liver. The strain of these species was formed from individuals emerged from pig corpses exhibited at the botanical garden of the Peleforo Gon Coulibaly University. The measurement of temperature and relative humidity was possible thanks to an IHM 172SI brand thermo-hygrometer recorder. To take the samples, flexible metal forceps and pill bottles were used. The Optika LAB20 brand and model binocular magnifier carried out the observations and identifications of the different insects. Identification guides were used for the determination of flies emerging from mass breeding (Szpila, 2014; Irish et al., 2014). Breeding was carried out in Plexiglas cages fitted with mosquito net containing sand sterilized in an autoclave at a temperature of 121°C and a pressure of 1.5 bar.

Experimental climate data

The breeding was carried out at the botanical garden of Peleforo Gon Coulibaly University during the dry and rainy seasons. The experiments were carried out under ambient conditions between November-December 2018 for the dry season and between July-August 2019 for the rainy season. In the dry season, the temperature values recorded varied from 25.7 to 34.2°C with an average of 30.2 ± 1.4°C. The average relative humidity values during this period was 41.5 ± 0.7%. Regarding the rainy season, the temperature oscillated between 24 and 28.2°C with an average of 27.3 ± 0.8°C. During this same season, the average relative humidity was 83.2 ± 0.9%.

Determination of biological parameters

Mass breeding of flies

The eggs laid by the insects on the exposed pig corpses were recovered then incubated using an autoclave at 121°C and a pressure of 1.5 bar in cylindrical plastic breeding transparent cages, height 15 cm and diameter 12 cm. These cages contained sterilized sand slightly moistened to facilitate the penetration of larvae in the prepupal phase. The emerging larvae were fed pork liver and striated muscle. After pupation, the pupae were separated on the basis of morphological characters then were introduced into different emergence cages and monitored until adult flies were obtained. The technique of sorting pupae obtained by mass breeding made it possible to avoid sorting emerged adult flies. After emergence of the flies, 30 specimens were taken from each cage to be identified under a binocular microscope and using an identification guide. (Biavati et al., 2010; Szpila, 2014; Irish et al., 2014). Once the target

species were identified, they were fed with honeyed and/or sugared water for a week so that they acquired sexual maturity.

Specific breeding

Thirty pairs of flies of each species were introduced into breeding cages. To trigger vitellogenesis in females, cotton soaked in pig blood and placed in petri dishes as a protein source was made available to fly pairs (Alonso et al., 2015). Eight hours later, the petri dishes were removed and pieces of pork liver and/or striated muscle weighing 200 g were placed in each breeding cage. The time of first laying was noted. After laying, the eggs were incubated until hatching. Thirty 1st stage larvae were collected from each fly pair. The collection of these was possible thanks to the handle magnifying glass and flexible tweezers. The larvae collected from each pair were introduced into breeding cages containing the liver or striated muscle and sterilized sand and then monitored until emergence. During this monitoring, the different biological parameters of each species were determined.

Egg incubation time

Since the number of eggs was not counted, the incubation time was obtained by averaging the egg incubation times across different breeding cages for a given species.

Duration of larval development

After hatching, daily monitoring of 1st stage larvae were carried out on the decomposing pig substrate. The different stages of larval development were determined using respiratory stigmata and different larval moults.

The duration of larval development was the time separating the moment of hatching of the eggs and that of obtaining the larvae in the prepupal stage. This period is the sum of the passage time from stage 1 larvae to stage 2 larvae and that from stage 2 larvae to stage 3 larvae in the prepupal phase (**tl**) noted (**DSL)** (Tano et al., 2010).

$$DSL = \sum diki / \sum ki$$

di = tl; ki: number of stage 1 larvae

Duration of prepupal development

The time which separates the moment of obtaining the 3rd stage larva **(JL**) from that of the pupa (**Jp**) is the noted post-feeding stage (**PF**). This duration was calculated by the following relationship:

$$SPF = \sum fisi / \sum si$$

fi = Jp-JL; if: number of stage 3 larvae

Duration of pupal development

The duration of pupal development, which is the time separating pupation (**P**) from the emergence of the adult **(Ea**), denoted **SDP,** was calculated using the formular below.

$$SDP = \sum gizi / \sum zi$$

With: gi = Ea-P; zi: number of pupae

Development cycle (DC) length

The total development time, which is the period between egg laying and the adult stage (DC), was calculated. This duration is the sum of the durations of the different stages of development (Tano et al., 2010).

$$DC\ (hour) = Din + SDL + SPF + SDP$$

Flies Lifetime

Ten pairs of freshly emerged flies were each placed in a breeding box containing 100 g of pig's liver and sugar water soaked in cotton and spread in a petri dish. Every 24 hours, the liver and petri dish were removed and replaced with another until the insects died. The number of dead imagos was recorded every day until the death of the last individual. The average lifetime (Dv) of adults, expressed in days, was determined from the results obtained by establishing the ratio of the sum of lifetime products to the sum of numbers.

$$DV = \frac{\sum xini}{\sum ni}$$

xi: lifetime; ni: number of insects

Determining emergence rates

For the determination of the emergence rate at the level of each species, empty pupae and/or emerged adults were counted.

The average emergence rate (Te), ratio expressed as a percentage, of the number of adults emerged to the number of pupae obtained was calculated. The sex ratio is the ratio of the number of emerged males to the number of emerged females. The emergence rate and sex ratio were calculated for the offspring of each female and then averaged.

$$Er = \frac{Ne}{Ntp} \times 100$$

Er: Emergence rate in percentage; **Ne**: Number of adults emerged; **Ntp**: Total number of pupae.

$$\mathbf{Sex-ratio} = \frac{\mathbf{Nomber\ of\ males}}{\mathbf{Nomber\ of\ females}} \times \mathbf{100}$$

Data processing

Data processing was carried out using Statistica software version 7.1. The Student test was done to compare the different data between dry and rainy seasons. The Kruskal-Wallis test was used to compare the lifetimes of both species in the two seasons.

RESULTS

Development cycle duration

Egg incubation time

The development cycle of both species went through three larval stages and a pupal stage. In *C. albiceps*, egg incubation times were 11.13 ± 2.11 and 12.76 ± 2.09 hours, respectively during the dry season and the rainy season. The Student's t test at the 5% threshold revealed significant differences between the incubation times of this species' eggs in dry and rainy seasons (t = -3.00614; df = 58; P = 0.003906; N = 30) (Table 1). Regarding *C. marginalis*, the incubation times were 10.50 ± 01.59 and 11.83 ± 2.02 hours during the dry and rainy seasons, respectively. The Student's t test at the 5% threshold revealed significant differences between the incubation times of this species' eggs in dry and rainy seasons (t = -2.8407; df = 58; P = 0.00620; N = 30) (Table 1).

Duration of larval development

The average duration of larval stages 1 in *C. albiceps* was respectively 24.50 ± 1.85 and 26.83 ± 2.24 hours in the dry season and in the rainy season. The Student's t test at the 5% threshold revealed significant differences between the durations of the 1st larval instar of *C. albiceps* in the dry and rainy seasons (t = -4.17559; df = 58; P = 0.0001; N = 30) (Table 2). In *C. marginalis*, the durations of larval stage 1 were respectively 21.63±2.96 and 24.56±5.07 hours during the two breeding periods. The Student's t test at the 5% threshold revealed significant differences between the durations of the 1st larval instar of *C. albiceps* in dry and rainy seasons (t = -2.73558; df = 58; P = 0.00824; N = 30) (Table 2).

The durations of the 2nd larval instar of *C. albiceps* were respectively 26.16 ± 2.18 and 25.46 ± 4.36 hours during the dry and rainy seasons. The Student's t test at the 5% threshold revealed significant differences between the durations of the 2nd larval instar of *C. albiceps* in dry and rainy seasons (t = -0.785090; df = 58; P = 0.435596; N = 30) (Table 2).

Concerning the duration of development of stage 2 in *C. marginalis*, they were 27.96 ± 2.22 hours in the dry season and 26.03 ± 1.92 hours during the rainy season. The Student's t test at the 5% threshold revealed significant differences between the durations of the 2nd larval instar of *C. marginalis* in dry and rainy seasons (t = -3.60707; df = 58; P = 0.00064; N = 30) (Table 2).

The durations of larval stages 3 of *C. albiceps* were respectively 56.36±5.48 and 58.40 ± 4.91 hours during both breeding periods. The Student's t test at the 5% threshold revealed no significant difference between the durations of the 3rd larval instar of *C. albiceps* in dry and rainy seasons (t = -1.51162; df = 58; P = 0.136060; N = 30) (Table 2). In *C. marginalis*, the durations of the 3rd larval instar were respectively 49.36 ± 13.11 hours, and 57.66 ± 6.51 hours during the dry and rainy seasons. The Student's t test at the 5% threshold revealed significant differences between the durations of the 3rd larval instar of *C. albiceps* in the dry and rainy seasons (t = -3.10474; df = 58; P = 0.00294; N = 30) (Table 2).

Duration of prepupal development

After stopping feeding, 3rd stage larvae leave the substrate to pupate in the sterilized sand. The post-feeding duration (Pa), the time spent by the third instar larva to pupate in *C. albiceps*, was 22.83 ± 2.46 hours during the dry season and 26.86 ± 6.61 hours during the rainy season. Student's t test at the 5% threshold revealed significant differences between the durations of the prepupal stage of this species in dry and rainy seasons (t = 3.13108; df = 58; P = 0.002727; N = 30) (Table 3).

In *C. marginalis*, this stage lasted for 26.93 ± 4.04 hours during the dry season and

28.20 ± 4.03 hours during the rainy season. The Student's t test at the 5% level revealed no significant difference between the durations of the prepupal stage of this species in the dry and rainy seasons (t = = -1.21429; df = 58; P = 0.22955; N = 30) (Table 3).

Duration of pupal development

The average durations of pupal development for C. *albiceps* were respectively 101.20 ± 8.64 and 112.30 ± 7.22 hours during the dry and rainy seasons. The Student's t test at the 5% threshold revealed significant differences between the durations of the pupal stage of *C. albiceps* during the dry and rainy seasons (t = -5.39774; df = 58; P = 0.00001; N = 30) (Table 4). In *C. marginalis*, the durations of the pupal stage were respectively 108.66 ± 8.10 and 120.23 ± 10.24 during the two breeding periods mentioned above. The Student's t test at the 5% threshold revealed significant differences between the durations of the pupal stage of *C. albiceps* during the dry and rainy seasons (t = -4.85011; df = 58; P = 0.00001; N = 30) (Table 4).

Total development time

The total developmental cycle times of *C. albiceps* were 245.53 ± 14.85 and 259.30 ± 9.33 hours during the dry and rainy seasons, respectively. The Student's t test at the 5% threshold revealed significant differences between the durations of the pupal stage of *C. albiceps* during the dry and rainy seasons (t = -4.29799; df = 58; P = 0.000064; N = 30) (Table 5). For *C. marginalis*, the total development cycle times were 243.13 ± 19.86 and 270.46 ± 15.56 hours during the dry and rainy seasons respectively. The Student's t test at the 5% threshold revealed significant differences between the durations of the pupal stage of *C. albiceps* during the dry and rainy seasons (t = -5.93273; df = 58; P = 0.00001; N = 30) (Table 5).

Imaginal survival rate

The average imaginal survival rates of *C. albiceps* were higher in the rainy season than in the dry season (Figure 1). The Student's t test at the 5% threshold revealed significant differences between the average imaginal survival rates of *C. albiceps* during the dry and rainy seasons (t = -9.82826; df = 58; P = 0.00001; N = 30) (Figure 1). The same observation was made in *C. marginalis.* The Student's t test at the 5% threshold revealed significant differences between the imaginal survivals of *C. marginalis* during the dry and rainy seasons (t = -11.5755; df = 58; P = 0.00001; N = 30) (Figure 1).

Sex ratio

The calculated sex ratio was higher in the dry season in *C. albiceps.* The Student's t test at the 5% threshold revealed significant differences between the durations of the pupal stage of *C. albiceps* during the dry and rainy seasons (t = 3.74940; df = 58; P = 0.00041; N = 30) (Table 6). For *C. marginalis*, the sex ratio was also higher in the dry season. The Student's t test at the 5% threshold revealed significant differences between the durations of the pupal stage of *C. albiceps* during the dry and rainy seasons (t = 6.595637; df = 58; P = 0.00001; N = 30) (Table 6).

Life's time of adult flies

For the average lifetime of *C. albiceps*, a difference was observed between the lifetime of males and females during the dry season (Figure 2). During these two periods, females had a longer lifetime than males. On the other hand, during the rainy season, both sexes had statistically the same lifetimes (Figure 2). Concerning the extents, they were greater among females than males during both seasons. Analysis of variance at the 5% level (F = 4.5986; P = 0.008) revealed significant differences between the lifetime of males and females during the rainy and dry seasons (Figure 2). In *C. marginalis*, no statistical difference was observed between the lifetimes of males and females in the two seasons. However, it was also noticed in this species that the extents were higher in females than in males. Analysis of variance at the 5% level (F = 5.2676; P = 0.0041) revealed significant differences between the lifetime of males and females during the rainy and dry seasons (Figure 3).

Table 1: Incubation time (in hour) of *C. albiceps* eggs and *C. marginalis* eggs during the dry season and the rainy season.

	Incubation time (hour) *C. albiceps* eggs	**Incubation time (hour) *C. marginalis* eggs**
Dry season	11.13 ± 2.11[b]	10.50 ± 1.59 [b]
Rainy season	12.76 ± 2.09[a]	11.83 ± 2.02[a]
t	-3.00614	-2.84070
df	58	58
p	0.003906	0.00620

Note: Numbers followed by the same letters in the same column are not significantly different at the 5% threshold according to the Newman Keuls test.
Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%
Rainy season: 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

Table 2: Duration of the different larval stages (in hours) of *C. albiceps* and *C. marginalis* during the dry season and the rainy season.

	Duration of larval development of *C. albiceps* (hours)			**Duration of larval development of *C. marginalis* (hours)**		
	DSL1	**DSL2**	**DSL3**	**DSL1**	**DSL2**	**DSL3**
Dry season	24.50± 1.85[b]	25.46± 4.36[a]	56.36± 5.48[a]	21.63± 2.96[b]	26.03±1.92 [b]	49.36± 13.11[b]
Rainy season	26.83± 2.24[a]	26.16± 2.18[a]	58.40± 4.91[a]	24.56± 5.07[a]	27.96± 2.22[a]	57.66± 6.51[a]
t	-4.17559	-0.785090	-1.51162	-2.73558	-3.60707	-3.10474
df	58	58	58	58	58	58
p	0.000101	0.435596	0.136060	0.00824	0.00064	0.00294

Note: Numbers followed by the same letters in the same column are not significantly different at the 5% threshold according to the Newman Keuls test.; Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%; Rainy season: T = 27.3 ± 0.8°C ; HR = 83.2 ± 0.9%

Table 3: Duration of the prepupal stage (in hours) of *C. albiceps* and *C. marginalis* during the dry season and the rainy season.

	Duration of development of the prepupal stage of *C. albiceps* (hour)	**Duration of development of the prepupal stage of *C. marginalis* (hour)**
Dry season	22.83 ± 2.46[b]	26.93 ± 4.04 [a]
Rainy season	26.86 ± 6.61 [a]	28.20 ± 4.03[a]
t	3.131088	-1.21429
df	58	58
p	0.002727	0.22955

Note: Numbers followed by the same letters in the same column are not significantly different at the 5% threshold according to the Newman Keuls test; Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%; Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

Table 4: Duration of the pupal stage (in hours) of *C. albiceps* and *C. marginalis* during the dry season and the rainy season.

	***C. albiceps* pupal stage development time (hour)**	***C. marginalis* pupal stage development time (hour)**
Dry season	101.20 ± 8.64 [b]	108.66 ± 8.10 [b]
Rainy season	112.30 ± 7.22[a]	120.23 ± 10.24 [a]
t	-5.39774	-4.85011
df	58	58
p	0.000001	0.00001

Numbers followed by the same letters in the same column are not significantly different at the 5% threshold according to the Newman Keuls test; Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%; Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

Table 5: Duration of the development cycle (hours) of *C. albiceps* and *C. marginalis* during the dry season and the rainy season.

	Development cycle length *C. albiceps* (hour)	**Development cycle length *C. marginalis* (hour)**
Dry season	245.53 ± 14.85 [b]	243.13 ± 19.86 [b]
Rainy season	259.30 ± 9.33 [a]	270.46 ± 15.56 [a]
t	-4.29799	-5.93273
df	58	58
p	0.000067	0.00001

Note: Numbers followed by the same letters in the same column are not significantly different at the 5% threshold according to the Newman Keuls test; Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%; Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

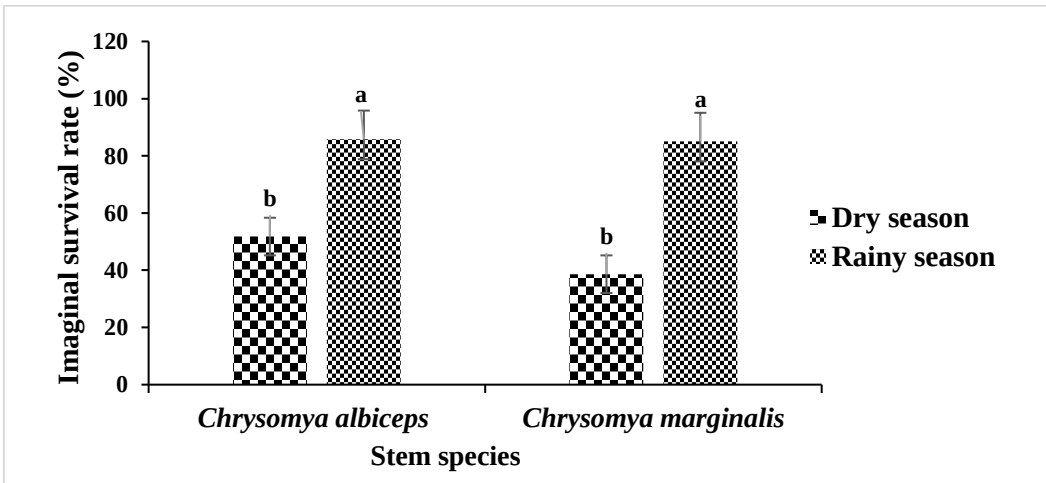

Figure 1: Emergence rate of *C. albiceps* and *C. marginalis* in dry, rainy and harmattan seasons.
ANOVA followed by the Newman-Keuls test at the 5% threshold
C. albiceps : t = -9.82826; df = 58; p<0.0001
C. marginalis : t = -11.5755; df = 58; p<0.0001
Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%
Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

Table 6: Sex ratio values of *C. albiceps* and *C. marginalis* for both the dry and rainy seasons.

	C. albiceps	*C. marginalis*
Dry season	0.74 ± 0.43[a]	0.65 ± 0.24[a]
Rainy season	0.43 ± 0.18[b]	0.34 ± 0.10[b]
t	3.74940	6.595637
df	58	58
P-value	0.00041	0.00001

Note: Numbers followed by the same letters in the same column are not significantly different at the 5% threshold according to the Newman Keuls test; Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%; Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

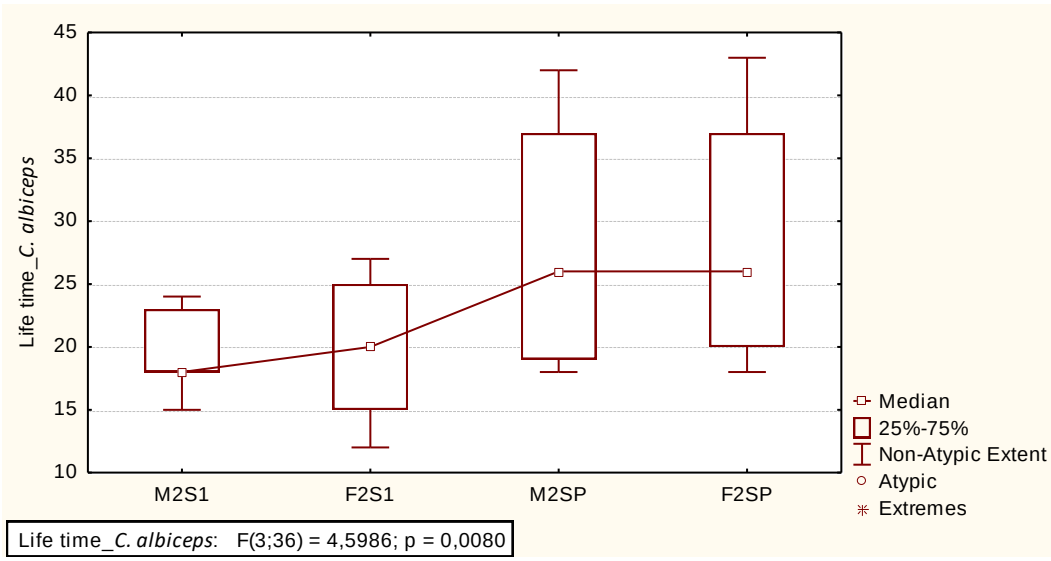

Figure 2: Lifetime of *C. albiceps* depending on sex and season.
M2: Male; F2: Female
S1: Dry season
SP: Rainy season
H: Harmattan
Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%
Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

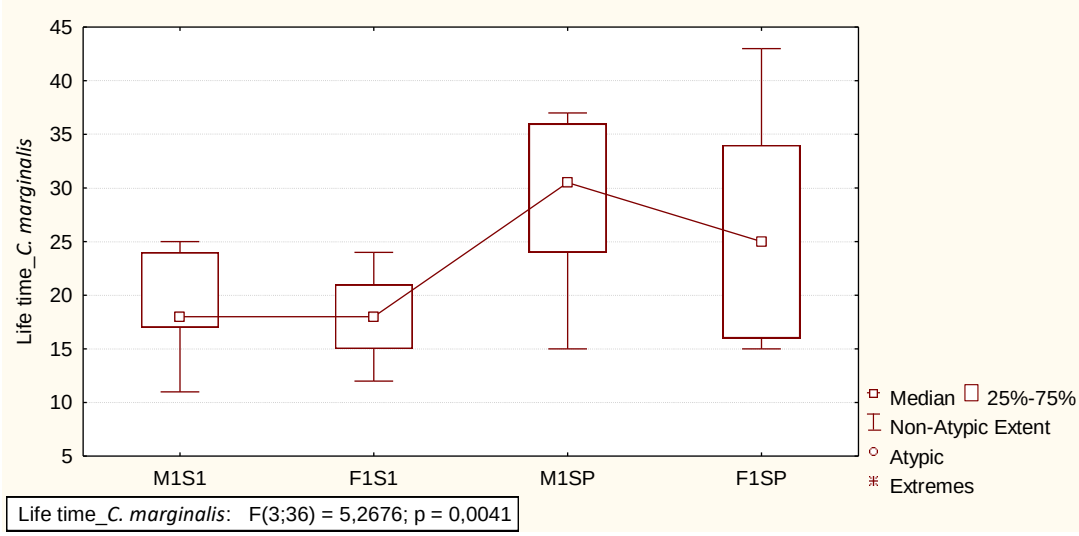

Figure 3: Lifetime of *C. marginalis* depending on sex and season.
M1: Male; F1: Female
S1: Dry season
SP: Rainy season
Dry season: T = 30.2 ± 1.4°C; HR = 41.5 ± 0.7%
Rainy season: T = 27.3 ± 0.8°C; HR = 83.2 ± 0.9%

DISCUSSION

The developmental cycles of *C. albiceps* and *C. marginalis* went through three larval stages and one pupal stage. Egg incubation times were longer in the rainy season (24 to 27°C) than in the dry season (26 to 30.7°C) in both species. This observation could be explained by the fact that in the dry season, high temperatures caused the eggs of these species to hatch quickly. This observation is similar to that of (Greenberg and Kunich, 2002). According to Wells and Kurahashi (1994), the development time of the egg of *C. albiceps* is between 12 and 18 hours at 27°C. Barros and Pujol-Luz (2010) found that the hatching times of these species were between 14 and 15 hours at 26°C. Richards and Villet (2009) found hatching times for *C. albiceps* eggs between 19 and 21 hours for 22°C and 12.5 hours for 25°C.

The development of stage 1, 2 and 3 larvae of *C. albiceps* and *C. marginalis* was also shorter in the dry season than in the rainy season and this could be due to the high heat that the climate provided during this season. An increase in temperature would favor the growth of larvae due to the increase in their metabolism rate (Dao et al., 2019). In addition, the rapidity with which the larvae developed in the dry season can be explained by the drying out of the breeding substrate (Dao et al., 2019). Indeed, when the breeding substrate is lacking, the physiology of the larvae changes by promoting rapid development allowing the larvae to be able to complete their development cycle (Higley and Haskell, 2001). In Côte d'Ivoire during the rainy season, the relative humidity can be high as 75 - 90% and the temperature values can be between 26 and 30.7°C. These data allow the conservation of nutrients contained in the breeding substrate (Anderson, 2011; Clark et al., 2006). Preserving it allows the larvae to have nutrients. Indeed, when larvae have a large quantity of nutrients, they take plenty of time to feed before pupating (Kouamé et al., 2018). The post-feeding duration (Pa), the time spent by the third instar larva to pupate in *C.*

albiceps, was 26.86 ± 6.61 hours in the dry season and 22.83 ± 2.46 in the rainy season. In *C. marginalis*, this stage lasted 26.93 ± 4.04 hours in the dry season and 28.20 ± 4.03 in the rainy season. According to Gomes et al. (2006), temperature can modify the burrowing behavior of larvae before pupation. At low temperatures, the metabolism of post-feeding stage larvae can be significantly reduced, which would explain the longer prepupal time in the rainy season than in the dry season (Grassberger and Reiter, 2001).

The average durations of pupal development of *C. albiceps* and *C. marginalis* were longer in the rainy season than in the dry season. The total durations of the development cycle of both species were longer in the rainy season than in the dry season. On the other hand, the development cycle of *C. albiceps* is shorter than that of *C. marginalis.*

The emergence rate of *C. albiceps* was higher in the rainy season than in the dry season and this could be explained by the fact that in the rainy season, the breeding substrates that remained moist provided nutrients necessary for good development of these. Indeed, when food is lacking, as in the case of drying out of the substrate in the dry season, pupae form early. This early formation of pupae does not promote the proper development of the insect's constituent organs. This observation is similar to that of Kouamé et al. (2018). In both species (*C. albiceps* and *C. marginalis*), the sex ratio was higher in the dry season than in the rainy season. A difference was observed between the lifetime of males and females of *C. albiceps* during the dry season. During the dry and rainy seasons, females had a longer lifetime than males. On the other hand, during the rainy season, both sexes had practically the same lifetime. In *C. marginalis*, no difference was observed between the lifetimes of males and females in both seasons. However, it was also noticed in this species that the extents were higher in females than in males.

Conclusion

The development of *C. albiceps* and *C. marginalis* consists of three larval stages and a pupal stage. Significant differences were observed between the incubation times of these two species in the dry and rainy seasons. The total durations of the development cycle of the two species were 245.53 ± 14.85 and 243.13 ± 19.86 hours in dry seasons respectively for *C. albiceps* and *C. marginalis* at an average temperature of 30.2 ± 1.4°C and an average humidity of 41.5 ± 0.7%. During the rainy season, these development times were 259.30 ± 9.33 and 270.46 ± 15.56 hours respectively for *C. albiceps* and *C. marginalis* at an average temperature of 27.3 ± 0.8 °C and an average humidity of 83.2 ± 0.9%. During both seasons , females had a longer lifetime than males . The determination of the biological parameters of these two fly species in the ambient environment during the dry and rainy season is an important tool in carcasse dating.

COMPETING INTERESTS

The authors declare that they have no competing interest with respect to this article.

AUTHORS' CONTRIBUTIONS

This work was carried out with the collaboration of all the authors**.** The corresponding author of the article HD conducted the work, analyzed the data and drafted the manuscript. DF and PGE contributed to the interpretation of the data and the critical revision of the content of the article. LRNA, initiator of the research activity read and corrected the manuscript. All authors approved the final manuscript.

ACKNOWLEDGMENTS

We thank the Director of the Faculty of Biological Sciences of Peleforo University Gon Coulibaly for allowing us to carry out our work at the botanical garden.

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