Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2016; 4(1): 181-188

Received: 19-11-2015
Accepted: 20-12-2015

Meriem Taleb
Laboratory of Biotechnologies, Environment and Health, Faculty of Natural and Life Sciences, University of Blida 1, B.P. 270, 09000 Blida, Algeria

Ghania Tail
Laboratory of Biotechnologies, Environment and Health, Faculty of Natural and Life Sciences, University of Blida 1, B.P. 270, 09000 Blida, Algeria

Fatma Zohra KARA
Laboratory of Biotechnologies, Environment and Health, Faculty of Natural and Life Sciences, University of Blida 1, B.P. 270, 09000 Blida, Algeria

Brahim Djedouani
Laboratory of Entomology, Department of Legal Medicine, National Institute for Criminalistics and Criminology B.P. 194, 16002 Cheraga, Algeria

Moussa Toumi
Laboratory of Entomology, Department of Legal Medicine, National Institute for Criminalistics and Criminology B.P. 194, 16002 Cheraga, Algeria

Correspondence
Meriem Taleb
Laboratory of Biotechnologies, Environment and Health, Faculty of Natural and Life Sciences, University of Blida 1, B.P. 270, 09000 Blida, Algeria

A preliminary study of the effects of environmental variables on early Diptera carrion colonizers in Algiers, Algeria

Meriem Taleb, Ghania Tail, Fatma Zohra KARA, Brahim Djedouani, Moussa Toumi

Abstract
Necrophagous insects usually colonize cadavers within a short period after death, but can be influenced by weather conditions. Their activity may vary which affects the *post-mortem* interval (PMI) estimation.
In order to study the effect of environmental variables on necrophagous Diptera visiting corpses, two field surveys were conducted in July 2012 and March 2013 at the National Institute for Criminalistics and Criminology (NICC) using rabbit carcasses (*Oryctolagus cuniculus* L.). The trials were designed to identify the necrophagous Diptera fauna of Algiers, Algeria and examine their variations according to environmental variables.
Four hundred and eighteen Diptera adults belonging to five families were captured during this study. Although seasonal variations of the species were observed, their abundance did not significantly vary between the two seasons. In addition to seasonal effects, the ambient temperature, the wind speed, and precipitation affected the number of trapped flies.
These conclusions highlight the necessity of considering the environmental factors at a scene to estimate the *post-mortem* interval accurately. It is hoped that these findings provide basic information regarding the necrophagous Diptera fauna of Algeria.

Keywords: Forensic entomology, necrophagous Diptera, *post-mortem* interval, abiotic factors, Algeria.

1. Introduction

Forensic entomology is the use of insects and their arthropod relatives to aid legal investigations by interpreting information regarding a death [1-4]. The main purpose of forensic entomology is to establish the *post-mortem* interval (PMI), which is the elapsed time since death or, more exactly, how long a dead body has been exposed to the environment [1, 5-9]. Three days after death, estimating the PMI using insect evidence is often the most accurate and the only method [6, 9, 10]. If the corpse is accessible to insects and the weather conditions are favourable, colonization by necrophagous species is fast, and the pre-appearance interval (*i.e.* the delay before insect colonization) is reduced to minutes or hours [9, 12]. For this reason, insects are used by forensic entomologists to estimate a minimum *post-mortem* interval (PMI) [13]. However, the necrophagous insect populations continuously vary according to different time scales [18]. These variations are especially noticeable during the winter months, when only a few flies are usually observed, and they can affect the PMI estimation by forensic entomologists [13-15].
Rain and humidity levels in the area where the body is found can affect the time for insect development. In most species, large amounts of rain will indirectly cause slower development due to drop in temperature. Light rain or a very humid environment, acts as an insulator, permits a greater core temperature within the maggot mass, resulting in faster development [16].
Domestic rabbits were chosen as the cadaver for this study as these have been satisfactorily used as animal models to study carrion ecology and insect activity in different habitats and geographic locations [19-21]. Rabbits are small enough to handle easily during the observation and sampling of carrion insects. In addition, they are large enough to support long-term studies and a considerable number and diversity of carrion insects.
In this context, the present study is aimed to identify the necrophagous Diptera fauna of Algiers, Algeria on rabbit carrions (*Oryctolagus cuniculus* L.) and determine the effects of season and climatic parameters on the activity of early colonizers during the summer and winter/spring seasons.

2. Materials and Methods

The present study was conducted at the Laboratory of Entomology, Department of Legal Medicine, National Institute for Criminalistics and Criminology of the National Gendarmerie (NICC-GN), Algeria. A site inside the campus of the NICC-GN situated at an altitude of about 114 m above mean sea level was selected (36°76'14'' N, 2°89'38'' E). The area is characterized by a loamy soil and a Mediterranean climate with hot, dry summers and mild, wet winters. This research complied with all relevant national guidelines, regulations, legislation, and codes. Two domestic rabbit *Oryctolagus cuniculus* (Linnaeus, 1758) specimens, weighing approximately 1.5 kg each, were selected as the animal models.

The rabbits were sacrificed on July 8, 2012 and March 10, 2013 after their neck was cut. A trap designed to catch flying insects was placed on the carcass. The trap consisted of a frame measuring 60 x 30 x 20 cm that was covered with a net surrounded by several cone-shaped holes. A mesh size of 1.2 x 1.2 mm was large enough for air circulation and insolation. In addition, the carcass and the trap were protected by a metal cage measuring 90 x 70 x 60 cm which was covered with welded wire mesh measuring about 2 cm (Fig. 1). This kept the scavengers away without interfering with the ingress and egress of the insects.

The trapped insects were carefully collected once daily using a bin liner. They were killed immediately by ethyl acetate vapours ($C_4H_8O_2$) and pinned using enamelled pins. Each individual specimen was then morphologically identified in the laboratory by at least three specialists with the help of dichotomous keys [22-26].

The numbers of male and female flies were recorded. The temperature and relative humidity data around the rabbit carcass were registered several times each day with the help of a temperature data logger. Wind speed was recorded using an anemometer and precipitation rates were measured by a standard rain gauge.

Trapping during the first field survey lasted 20 days and the second lasted 52 days until no Diptera was observed.

The Mann-Whitney *U-test* was performed at the 0.05 level of significance to evaluate the differences of the abundance of necrophagous Diptera between the two seasons. Pearson correlation analysis was used to assess the relationship between the abundance of initial colonizers and recorded weather data during the first 12 days. Correlation was considered significant at $p<0.05$.

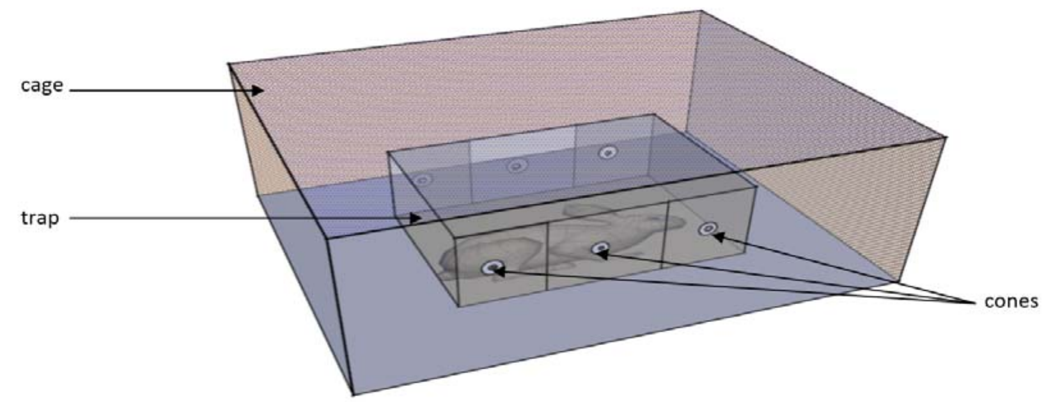

Fig 1: Diagram of the insect trap and the metal cage.

3. Results and Discussion

A total of 418 Diptera adults belonging to five families were captured during the trapping periods. The identified species and their absolute and relative abundance are listed in Table 1. The main forensically important species of Diptera are widely represented among the sampled populations, and their relative abundance is in concordance with the earlier observations on animal carcasses in natural environment [13, 19-21, 27, 28] or during criminal cases [15, 29].

At the 5% significance level, the Mann-Whitney test shows that there is no significant difference in the abundance of necrophagous Diptera fauna between the two seasons (U=9; Z=4.5; p=0.814). In contrast, in Europe, many authors have found significant changes in the number of captured necrophagous insects during the different seasons, in summer, their abundance is much higher [9, 13, 28]. This may be due to the European climate which has a cold winter and spring.

During the summer season in Algiers, the most representative dipteran families were the Calliphoridae and the Sarcophagidae, representing 44.34% and 32.58%, respectively, of the total number. These two families were followed by the Muscidae (23.08%) (Fig. 2A). The most abundant species was *Sarcophaga africa* (Wiedmann) (26.24%), followed by *Lucilia sericata* (Meigen) (22.17%) and *Chrysomya albiceps* (Wiedmann) (18.55%) (Fig. 3).

During the winter/spring period, the most frequent dipteran families in Algiers were the Muscidae (31.47%), followed by the Calliphoridae (24.87%), the Fanniidae (21.83%), and the Anthomyiidae (17.26%) (Fig. 2B). The Calliphoridae are represented mainly by *Calliphora vicina* (Robineau-Desvoidy) (18.27%). However, *Fannia* sp. and *Muscina stabulans* (Fallén) were also abundant, representing 21.83% and 18.27%, respectively (Fig. 3).

Our observations clearly indicate that necrophagous Diptera populations survive the cold season. Thus, sarcophagous fauna is abundant even during the coldest periods [9, 30]. Moreover, other species come to replace those that were active during the summer season.

The Calliphoridae family was abundant during the study period. Similar observations were also reported in Switzerland by Wyss and Cherix [9], in France by Charabidzé *et al.* [13] and in the Iberian Peninsula by Martínez-Sánchez *et al.* [31]; Arnaldos *et al.* [32, 33]; Baz *et al.* [34]; Prado e Castro *et al.* [28]; Farinha *et al.* [35].

Table 1: The absolute and relative abundance of Diptera species sampled during the experimental periods.

Diptera Family	Species	Summer		Winter/Spring	
		number	%	number	%
Calliphoridae	*Chrysomya albiceps* (Wiedmann, 1819)	41	18.55	5	2.54
	Lucilia sericata (Meigen, 1826)	49	22.17	8	4.06
	Calliphora vicina (Robineau-Desvoidy, 1830)	-	-	44	21.46
Sarcophagidae	*Sarcophaga carnaria* (Linnaeus, 1758)	14	6.33	4	2.03
	Sarcophaga africa (Wiedmann, 1824)	58	26.24	5	2.54
Muscidae	*Muscina stabulans* (Fallén, 1817)	51	23.08	36	18.27
	Hydrotaea (ophyra) capensis (Wiedmann, 1818)	-	-	26	13.20
Fanniidae	*Fannia* sp.	-	-	43	21.83
Anthomyiidae	*Delia* sp.	-	-	34	17.26
Total		213		205	

Both Calliphoridae and Muscidae species which were collected in the present study were also collected on pig carcasses in Lisbon and chicken carcasses in Murcia, Southeast Spain [32, 33], environmental conditions of which are similar to those of Algeria.

In addition, present results revealed that the respective proportions of trapped species were not constant. Important seasonal variations were observed regarding *Lucilia sericata*, *Chrysomya albiceps*, *Sarcophaga carnaria*, *Sarcophaga africa*, and *Calliphora vicina*. *Lucilia sericata* is a heliotrope fly common during the summer. We notice that the captured individuals represented 22.17% of the seasonal catches during the summer compared to only 4.06% of the seasonal catches during the winter/spring season. Conversely, *Calliphora vicina*, a species well adapted to the cold, was captured only during the winter/spring period in a high number, representing 21.46% of the total seasonal captures. These results confirm the previous observations regarding the biology of these species [9, 13, 21, 36, 37].

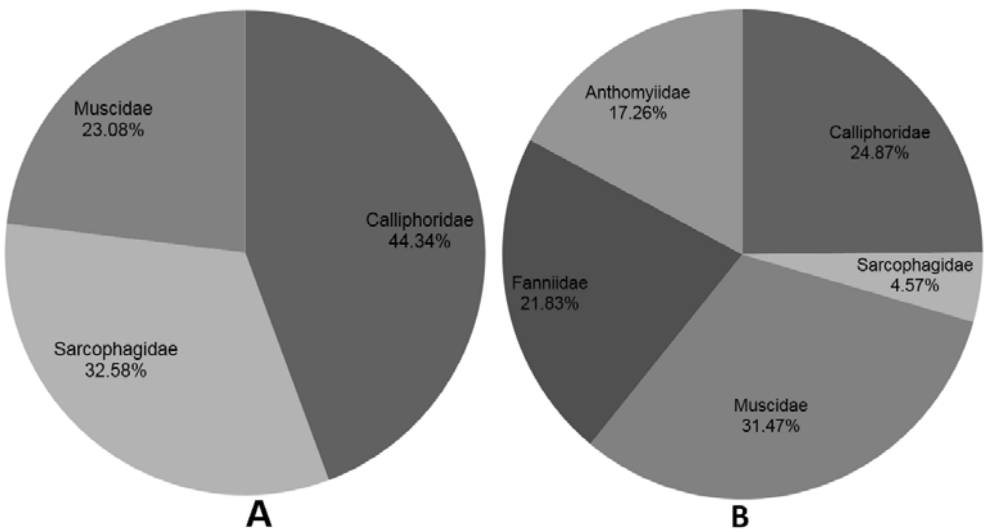

Fig 2: The distribution of the Diptera species captured during the trapping periods: (A) summer and (B) winter/spring.

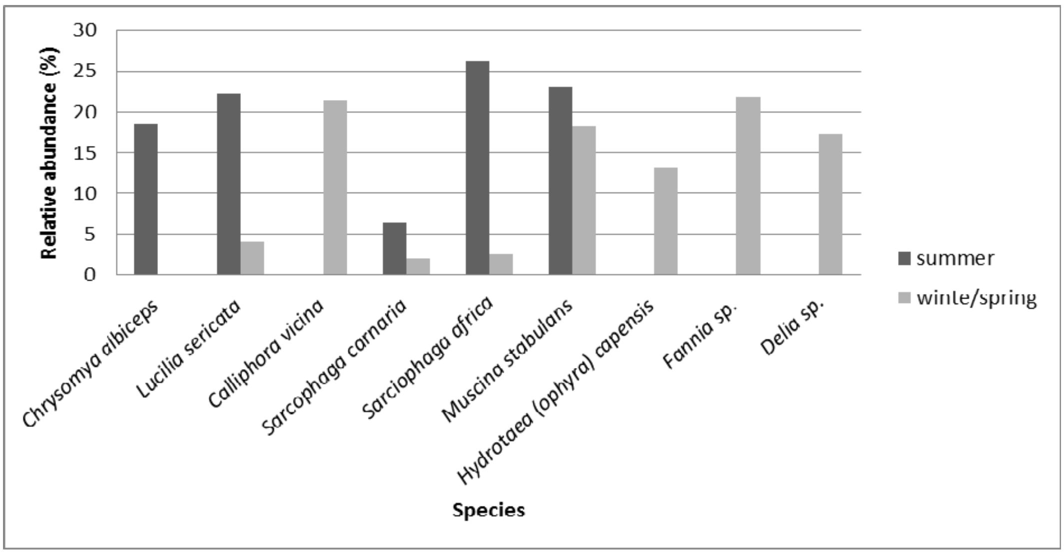

Fig 3: The relative abundance of the Diptera species caught during the two seasons.

For both of the seasons, the sex ratio of the captured flies was significantly female biased. Females represented 96% and 98% of the total catches, respectively. This result is in agreement with the values cited by other authors [9, 13, 38, 39]. This may be explained by the fact that females require protein-rich food for egg maturation or oviposition. Thus, we can confirm the dual use of the corpses by necrophagous insects as a food resource and a spawning substrate [9, 13, 40].

Climate has a profound effect on the distribution and abundance of invertebrates such as insects since they are cold-blooded animals [41-44]. The presence of a link between captured Diptera and the different recorded climatic parameters has been verified by the Pearson correlation test. The results of this test are summarized in Table 2.

Table 2: The results of the Pearson correlation test based on the different climatic data recorded during the two studies.

Tested correlation	**Summer**			**Winter/Spring**		
	alpha	*p*	R^2	*alpha*	*p*	R^2
Number-Temperature	0.05	0.019	0.665	0.05	0.006	0.7380
Number-Wind speed	0.05	0.013	0.681	0.05	0.018	0.6670
Number-Humidity	0.05	0.870	0.282	0.05	0.034	0.0589
Number-Precipitation	-	-	-	0.05	0.002	0.7920

Correlation between the climate data of the first survey (summer) with the number of trapped Diptera confirms a link between the number of the captured individuals and the daily average temperature (Fig. 4), and the average wind speeds (Fig. 5). We notice that the catches increased with an increase in temperature and decreased when the wind speed increases (Fig. 4 and Fig. 5). Regarding the relative humidity, there is no relationship between this parameter and the number of captured individuals during the summer (Fig. 6).

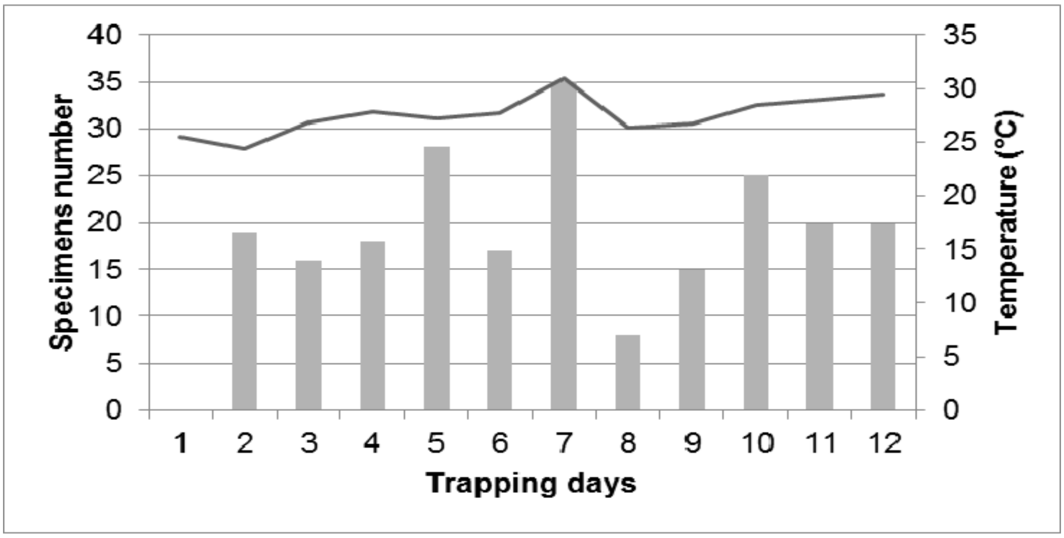

Fig 4 The daily Diptera number (histogram) and the average daily temperature (°C) (curve) (July 2012). Pearson correlation test, *p-value*=0.019; R^2=0.665.

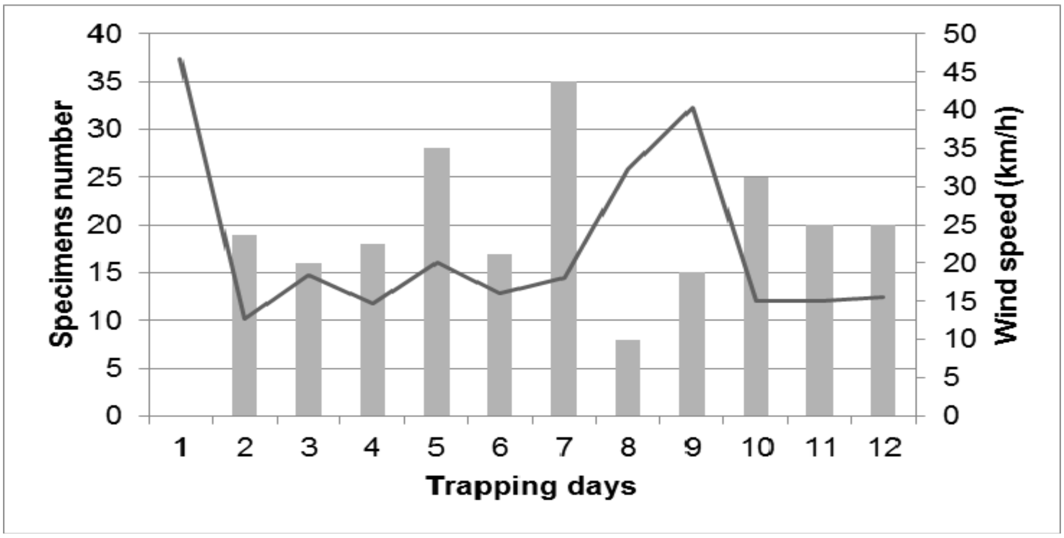

Fig 5: The daily Diptera number (histogram) and the average daily wind speeds (km/h) (July 2012). Pearson correlation test, *p-value*=0.013; R^2=0.681.

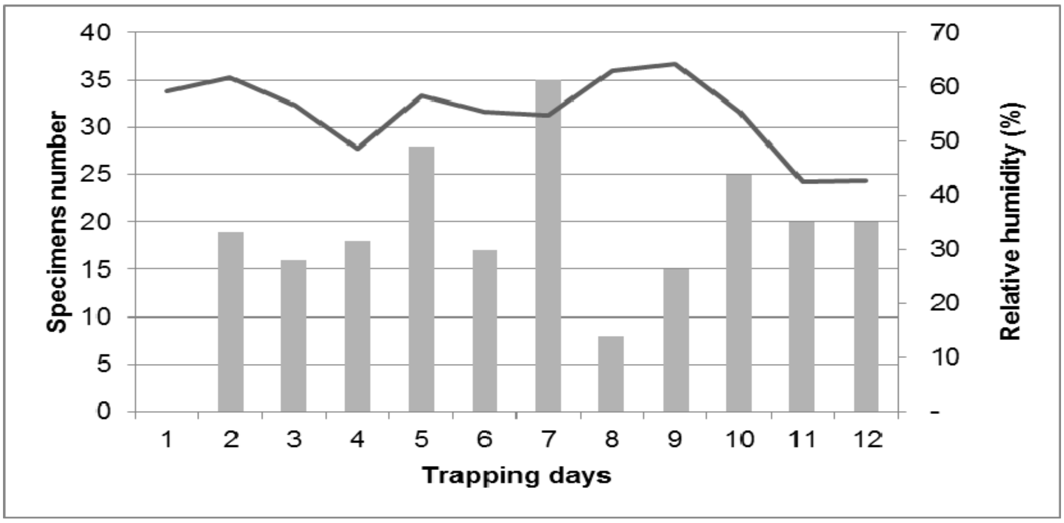

Fig 6: The daily Diptera number (histogram) and the average daily relative humidity (%) (Curve) (July 2012). Pearson correlation test, *p-value*=0.870; R^2=0.282.

For the second trial, the matching of the daily climate data with the number of trapped Diptera also confirmed a link between the number of captured individuals and the daily average temperature (Fig. 7), the average wind speed (Fig. 8), and precipitation (Fig. 9). We notice the increase of catches as the temperature increased and the decrease of catches when the wind speed and precipitation increased. Regarding the relative humidity, there is a weak correlation between this parameter and the number of catches (Fig. 10).

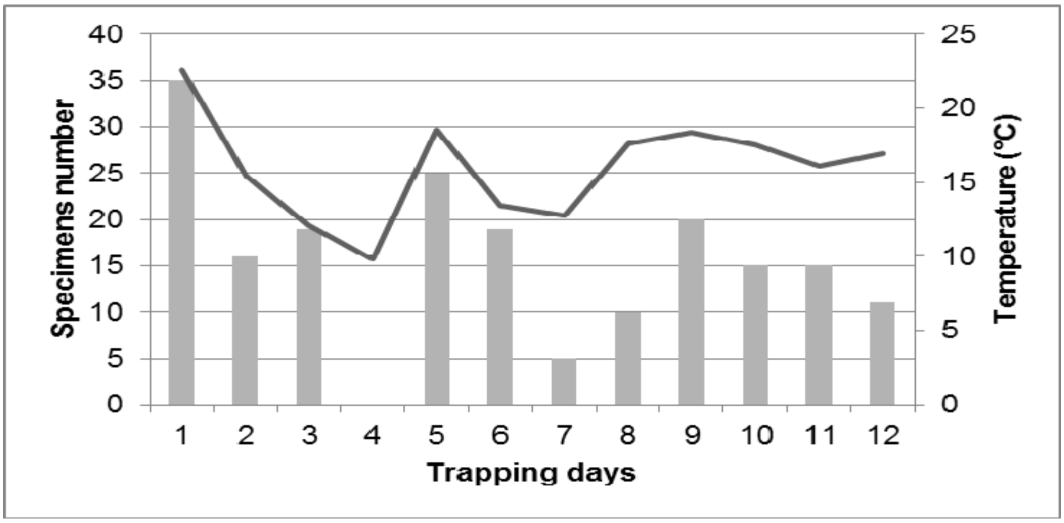

Fig 7: The daily Diptera number (histogram) and the average daily temperature (°C) (curve) (March 2013). Pearson correlation test, *p-value*=0.006; R^2 = 0.738.

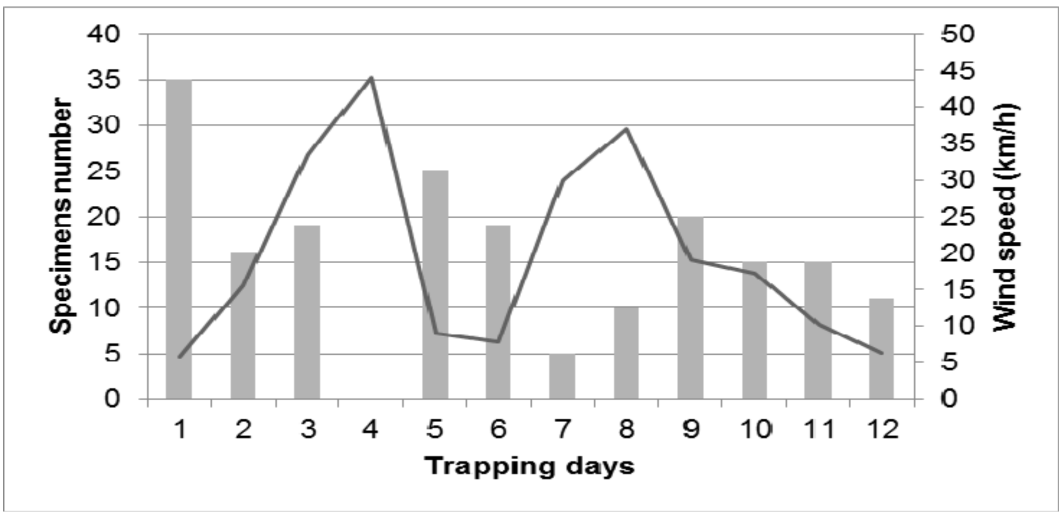

Fig 8: The Daily Diptera number (histogram) and the average daily wind speed (km/h) (curve) (March 2013). Pearson correlation test, *p-value*=0.018; R^2=0.667.

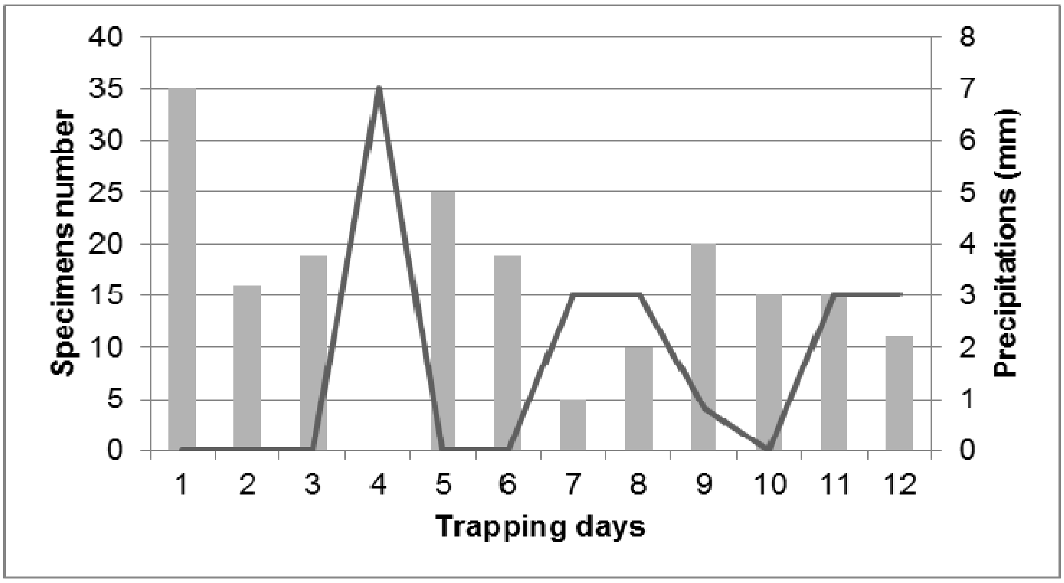

Fig. 9. The daily Diptera number (histogram) and the daily precipitation (mm) (curve) (March 2013). Pearson correlation test, *p-value*=0.002; R^2 = 0.792.

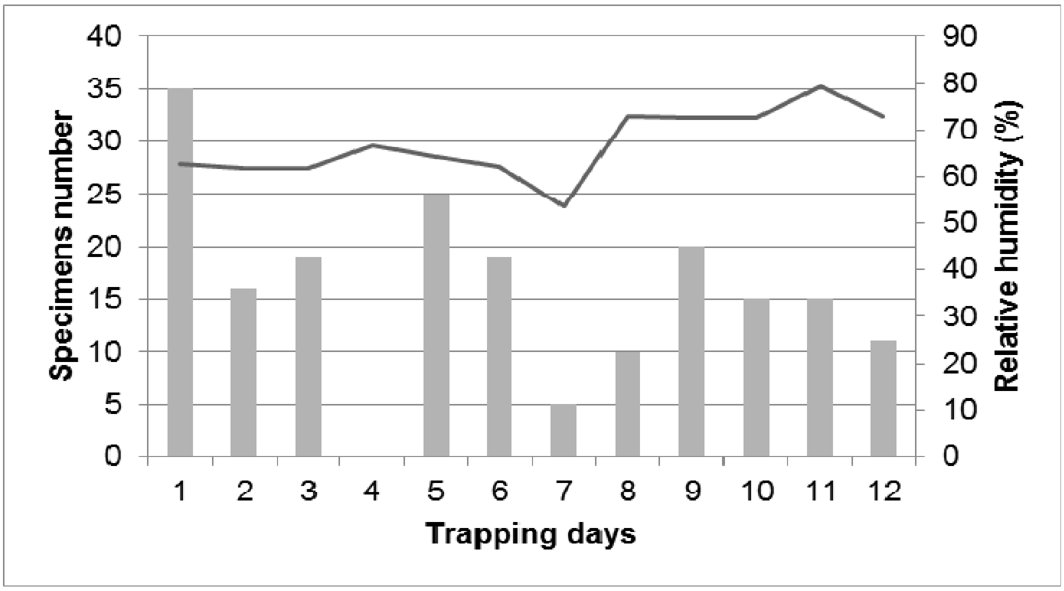

Fig 10: Daily Diptera number (histogram) and daily relative humidity (%) (curve) (March, 2013). Pearson correlation test, *p-value*=0.034; R^2=0.0589.

In a study on abiotic factors influencing the colonization of the Calliphoridae in Australia, George *et al.* [45] recorded the same kind of relationship between the number of insects and the climatic factors investigated during our study except relative humidity.

The existence of a relationship between the number of trapped insects and temperature has been highlighted in France by Charabidzé *et al.* [13]. In another study, Wall *et al.* [46] reported that temperature is a significant predictor of activity level for a variety of species, explaining up to 67% of variation in *Lucilia sericata* (Meigen) trap counts. Regarding wind speed, Digby [17] studied the effect of this factor on the flight activity of a population of the blowfly *Calliphora erythrocephala* (syn. *Calliphora vicina*) in a small wind tunnel. Under the experimental conditions wind has an activating effect up to about 0.7 m/sec, above which it inhibits flight. Mohr and Tomberlin [47] observed that precipitation and high winds affected winter-active *Calliphora vicina*. These observations are in agreement with our findings.

4. Conclusion

The climatic conditions are crucial factors for the process of the decomposition of a corpse and the appearance of necrophagous insects. It is necessary to consider the average temperature, the wind speed, and precipitation to estimate the periods of activity of necrophagous Diptera correctly.

The data obtained from this study may also be used as preliminary information on necrophagous fly diversity and relative abundance and occurrence of forensic dipterans of Algeria.

5. Acknowledgment

Authors are thankful to Prof. S. Doumandji, Department of Agricultural and Forest Zoology, Higher National School of Agronomy, Algeria, for confirming the identification of the specimens and for his valuable advices.

6. References

1. Catts EP, Goff ML. Forensic Entomology in Criminal Investigations. Annual Review of Entomology 1992; 37:253-272.
2. Tabor KL, Fell RD, Brewster CC. Insect fauna visiting carrion in Southwest Virginia. Forensic Science International 2005; 150:73-80.
3. Hall RD, Huntington TE. Introduction: Perception and Status of Forensic Entomology. In: Forensic Entomology: the Utility of Arthropods in Legal Investigations. Byrd JH, Castner JL (Eds). CRC Press, Boca Raton, Florida, USA, 2009, 1-16.
4. Frederickx C, Dekeirsschieter J, Verheggen FJ, Haubruge E. L'entomologie forensique, les insectes résolvent les crimes. Faunistic Entomology 2011; 63(4):237-249.
5. Benecke M. Forensic entomology: Arthropods and Corpses. In: Forensic Pathology Reviews. Tsokos M (Ed.). Humana Press, Totowa, New Jersey, USA, 2004, 207-240.
6. Gaudry E, Dourel L, Chauvet B, Vincent B, Pasquerault T. L'entomologie légale : lorsque insecte rime avec indice. Revue Francophone des Laboratoires 2007; 392:23-32.
7. Turchetto M, Vanin S. Forensic entomology and climatic change. Forensic Science International 2004; 146:207-209.
8. Charabidzé D. La biologie des insectes nécrophages et leur utilisation pour dater le décès en entomologie médico-légale. Annales de la société entomologique de France 2012; 48:239-252.
9. Wyss C, Cherix D. Traité d'Entomologie Forensique: Les insectes sur la scène de crime. 2nd ed. Presses Polytechniques et Universitaires romandes, Lausanne, Switzerland, 2013, 70-326.
10. Anderson GS. Practical Exercise in Forensic Entomology. Gazette 1996; 58:3-6.
11. Roberts J, Márquez-Grant N. Forensic ecology handbook: From crime scene to court. Wiley-Blackwell, Chichester, UK, 2012, 76-81.
12. Marchenko ML. Medicolegal relevance of cadaver entomofauna for the determination of the time of death. Forensic Science International 2001; 120:89-109.
13. Charabidzé D, Hedouin V, Gosset D. Que font les mouches en hiver ? Étude des variations hebdomadaires et saisonnières des populations d'insectes nécrophages. La Revue de Médecine Légale 2012; 3:120-126.
14. Cruickshank I, Wall R. Population dynamics of the sheep blowfly Lucilia sericata: seasonal patterns and implications for control. Journal of Applied Ecology. 2002; 39:493-501.
15. Schroeder H, Klotzbach H, Puschel K. Insects' colonization of human corpses in warm and cold season. Legal Medicine (Tokyo) 2003; 5:372-374.
16. Vilet MH, Richards CS, Midgley JM. Contemporary precision, bias and accuracy of minimum post-mortem intervals estimated using development of carrion-feeding insects. In: Current concepts in forensic entomology. Amendt J, Campobasso CP, Goff ML, Grassberger M (Eds). Springer, Heidelberg, Germany, 2010, 109-137.
17. Digby PSB. Flight activity in the blowfly Calliphora erythrocephala, in relation to light and radiant heat, with special reference to adaptation. Journal of Experimental Biology. 1958; 35:1-19.
18. Anderson GS. Factors that influence insect succession on carrion. In: Forensic Entomology: The Utility of Arthropods in Legal Investigations. Byrd JH, Castner JL (Eds). CRC Press Inc, Boca Raton, Florida, USA, 2009, 201-250.
19. Al-Mesbah H, Moffatt C, El-Azazy OME, Majeed QAH. The decomposition of rabbit carcasses and associated necrophagous Diptera in Kuwait. Journal of Forensic Sciences. 2012; 217:27-31.
20. Bharti M, Singh D, Insect faunal succession on decaying rabbit carcasses in Punjab, India. Journal of Forensic Science. 2003; 48:1133-1143.
21. Bourel B, Martin-Bouyer L, Hedouin V, Cailliez JC, Derout D, Gosset D. Necrophilous insect succession on rabbit carrion in sand dune habitats in northern France. Journal of Medical Entomology. 1999; 36:420-425.
22. Smith KGV. A Manual of forensic entomology. Department of Entomology British Museum (Natural History) and Cornell University Press, London, UK, 1986, 5-205.
23. Rozkošný R, Gregor F, Adrian CP. The European Fanniidae (Diptera). Acta Scientiarum Naturalium Academiae Scientiarum Bohemicae Brno, Nova Series 1997; 31:1-80.
24. Gregor F, Rozkošný R, Barták M, Vaňhara J. The Muscidae (Diptera) of Central Europe. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis Biologia 2002; 107:1-280.
25. Richet R, Blackith RM, Pape T. Sarcophaga of France (Diptera: Sarcophagidae). Pensoft Series Faunistica, Sofia, Bulgaria, 2011, 1-327.
26. Szpila K. Key for identification of European and Mediterranean blowflies (Diptera, Calliphoridae) of medical and veterinary importance - adult flies. In: Forensic entomology: An introduction. Gennard D (Ed). Willey-Blackwell, London, UK, 2012, 77-81.
27. Grassberger M, Frank C. Initial study of arthropods succession on pig carrion in a central European urban habit. Journal of Medical Entomology. 2004; 41:511-523.
28. Prado E, *Castro* C, Serrano A, Martins Da Silva P, García MD. Carrion flies of forensic interest: a study of seasonal community composition and succession in Lisbon, Portugal. Medical and Veterinary Entomology 2012; 26:417-431.
29. Hwang C. Spatial and temporal variability of necrophagous Diptera from urban to rural areas. Medical and Veterinary Entomology 2005; 19:379-391.
30. Wyss C, Cherix D, Michaud K, Romain N. Pontes de *Calliphora vicina*, Robineau-Desvoidy et de *Calliphora vomitoria*, (Linné) (Diptères, Calliphoridae) sur un cadavre humain enseveli dans la neige. Revue internationale de criminologie et de police technique et scientifique 2003; 56:112-116.
31. Martínez-Sánchez A, Rojo S, Marcos-García MA. Annual and spatial activity of dung flies and carrion in a Mediterranean holm-oak pasture ecosystem. Medical and Veterinary Entomology 2000; 14:56-63.
32. Arnaldos I, Romera E, García M, Luna A. An initial study on the succession of sarcosaprophagous Diptera (Insecta) on carrion in the southeastern Iberian Peninsula.

International Journal of Legal Medicine 2001; 114:156-162.
33. Arnaldos MI, Romera E, Presa JJ, Luna A, García MD. Studies on seasonal arthropod succession in the southeastern Iberian Peninsula. International Journal of Legal Medicine. 2004; 118:197-205.
34. Baz A, Cifrián B, Díaz-Aranda LM, Martín-Vega D. The distribution of adult blowflies (Diptera: Calliphoridae) along an altitudinal gradient in Central Spain. Annales de la Société Entomologique de France 2007; 43:289-296.
35. Farinha A, Dourado CG, Centeio N, Oliveira AR, Dias D, Rebelo MT. Small bait traps as accurate predictors of dipteran early colonizers in forensic studies. Journal of Insect Science. 2014; 14:77.
36. Erzinçlioglu YZ. Blowflies. The Richmond Publishing Co. Ltd, Slough, 1996, 1-75.
37. Gennard D. Forensic entomology: An introduction, 2nd ed, Willey-Blackwell, London, UK, 2012, 30-78.
38. Serra H, Godoy WAC, Von-Zuben FJ, Von-Zuben CJ, Reis SF. Sex ratio and dynamic behavior in populations of the exotic blowfly Chrysomya albiceps (Diptera, Calliphoridae). Brazilian Journal of Biology 2007; 67:347-353.
39. Martin-Vega D, Baz A. Sex-biased captures of sarcosaprophagous Diptera in carrion-baited traps. Journal of Insect Science 2013; 13(14).
40. Archer M, Elgar M. Effects of decomposition on carcass attendance in a guild of carrion-breeding flies. Medical and Veterinary Entomology 2003; 17:263-271.
41. Allen JC. A modified sine wave method for calculating degree-days. Environmental Entomology 1976; 5:388-396.
42. Akers RC, Nielsen DG. Predicting Agrilus anxius adult emergence by heat unit accumulation. Journal of Economic Entomology 1984; 77:1459-1463.
43. Allsopp PG, Butler DG. Estimating day-degrees from daily maximum-minimum temperatures: a comparison of techniques for a soil-dwelling insect. Agricultural and Forest Meteorology 1987; 41:165-172.
44. Damos P, Savopoulou-Soultani M. Temperature-driven models for insect development and vital thermal requirements. Psyche 2012; 2012:13.
45. George KA, Archer MS, Toop T. Abiotic environmental factors influencing blowfly colonization patterns in the field. Forensic Science International 2013; 229:100-107.
46. Wall R, French NP, Morgan KL. Predicting the abundance of the blowfy Lucilia sericata (Diptera: Calliphoridae). Bulletin Entomological Research 1993; 83:431-436.
47. Mohr RM, Tomberlin JK. Environmental factors affecting early carcass attendance by four species of blow flies (Diptera: Calliphoridae) in Texas. Journal of Medical Entomolology. 2014; 51(3):702-8.