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Entomofauna of buried bodies in northern France

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Abstract Autopsies of exhumed cadavers can reveal important evidence for clarification of medical insurance and social issues. This study concerns insects sampled on 22 exhumed cadavers in the Lille area. For each corpse, the species and the stages of development were noted, as well as the time elapsed after burial, the location of the cemetery, the stage of decay and possible preservation treatment. A total of eight Diptera and two Coleoptera species were sampled on the corpses. The relationships between entomofauna and conditions of burial are discussed. Three species were regularly found because of their preference for underground environments or closed environments: *Conicera tibialis*, typically associated with buried bodies, *Leptocera caenosa* which is known to be associated with human faeces, water closets, caves and cracked soil pipes, and *Ophyra capensis*, sometimes found on human bodies kept indoors for several months, where blowflies have not had access. *Triphleba hyalinata*, which is associated with human bodies in wooden coffins, was found only twice.

Keywords Insect · Forensic entomology · Burial · Post-mortem interval · Exhumation

Introduction

In France an exhumation can be performed after a first autopsy to get the opinion of a second expert. This exhumation is requested by the legal authorities, but the exhumation is also often carried out as the first autopsy requested

by insurance companies, social insurance or authorities when an occupational disease is suspected. In these cases, the death very often occurs at home and the first idea of the family is not to call the social insurance. So the corpse is often buried, which often later leads to an exhumation. Examples are cases of pneumoconiosis or accidental deaths at the workplace, to determine the manner of death. Exhumation is the only way to obtain findings useful to determine the cause of death and chain of events. These autopsy results revealed important evidence for clarification of medical insurance and social issues.

In the literature, many studies were conducted about the sequence of arthropods that colonize exposed corpses. However, some defined environmental conditions have not been studied, for example the decomposition of carrion in a marine environment [1] or insects colonizing bodies buried in coffins [2]. Experiments with human or pig carrion have shown that several species are able to colonize bodies buried directly in the soil, especially the Phoridae *Conicera tibialis* and *Triphleba hyalinata* [3, 4]. Leptoceridae, Sphaeroceridae, Psychodidae, Muscidae, Calliphoridae, ants and Staphilinidae (*Aleochara* sp.), Leiodidae, Silphidae, Histeridae were found also on pig carcasses [5, 6]. The depth of burial is important because some groups (e.g. Calliphoridae, Muscidae) may be excluded by burial under only some centimetres thickness of soil [2]. A corpse inside a coffin directly in the soil or in a vault is similar to a cadaver in a natural underground cavity. The fly *Leptocera caenosa* is also found in caves on faeces and carrion.

Autopsies of exhumed cadavers performed for several years in the Forensic Institute of Lille are a unique occasion to study these insects. This work is consequently important. If species are typically associated with cadavers in coffins they can be used as indicators of burial or interment in a confined space.

Material and methods

A total of 22 exhumations with insect samples were performed between 1996 and 2002. Cadavers were from 15 different sites in a

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Table 1 Characteristics of the exhumed cadavers in the Lille region, species of insects and stages of development

Case number	Sex	Date of birth	Date of death	Date of inhumation	Site of inhumation	Date of exhumation	Cause of death	Interval (months)	Stage of decomposition	Conservation treatment	Species	Stages
1	M	1918	17/03/1996	18/03/1996	Montigny en Gohelle	15/10/1996	Pneumoconiosis	7.0	Putrefied	Y	<i>Ophyra capensis</i>	L, P, A
2	M	1943	–	22/07/1996	Lens	09/04/1997	Industrial injury	8.7	Putrefied	N	<i>Conicera tibialis</i>	P
											<i>Ophyra capensis</i>	P
											<i>Acaris</i>	
3	M	–	–	24/03/1997	Lens	02/07/1997	Pneumoconiosis	3.3	Putrefied	Y	<i>Conicera tibialis</i>	L, P
4	M	1918	25/05/1997	26/05/1997	Lens	17/09/1997	Pneumoconiosis	3.8	Mummified	–	<i>Calliphora vicina</i>	Empty P, dead A
5	M	–	17/10/1996	18/10/1996	Merville	09/10/1997	Crime	11.9	Mummified	Y	<i>Ophyra capensis</i>	L2, L3, P, empty P, A
6	M	1920	02/04/1997	05/04/1997	Sain en Gohelle	04/11/1997	Pneumoconiosis	7.1	Putrefied	–	<i>Conicera tibialis</i>	P, A
											<i>Ophyra capensis</i>	L, P, A
											<i>Acaris</i>	
7	M	1918	16/08/1997	17/08/1997	Bruay la Buisière	25/11/1997	Pneumoconiosis	3.3	Putrefied	–	<i>Ophyra capensis</i>	L, P, A
8	M	1932	01/07/1997	02/07/1997	Bruay la Buisière	25/11/1997	Pneumoconiosis	4.9	Putrefied	N	<i>Conicera tibialis</i>	P, A
9	M	1929	28/09/1997	29/09/1997	Bruay la Buisière	03/12/1997	Pneumoconiosis	2.2	Mummified	N	<i>Triphleba hyalinata</i>	A
											<i>Leptocera caenosa</i>	P, A
10	M	1924	16/09/1997	17/09/1997	Barlin	25/08/1998	Industrial injury	11.4	Mummified	N	<i>Fannia scalaris</i>	L
											<i>Phoridae sp.</i>	P
											<i>Ophyra capensis</i>	P, A
11	M	1924	31/07/1998	01/08/1998	Wingles	07/01/1999	Pneumoconiosis	5.3	Putrefied	Y	<i>Philonthus sp.</i>	A
											<i>Leptocera caenosa</i>	L, P, A
											<i>Ophyra sp.</i>	P
											<i>Conicera tibialis</i>	P, A
12	M	1921	31/07/1998	01/08/1998	Courcelles	24/02/1999	Pneumoconiosis	6.9	Putrefied	N	<i>Ophyra capensis</i>	L, P, A
											<i>Fannia manicata</i>	L

13	M	–	25/08/1998	26/08/1998	Calonnes ricouart	24/02/1999	Industrial injury	6.1	Putrefied	Y	<i>Megaselia</i> sp.	L, P
											<i>Omalius rivulare</i>	A
											<i>Staphylinidae</i> sp	L
14	M	1980	18/11/1996	19/11/1996	Saint Souplet	21/04/1999	Road accident	29.4	Putrefied	N	<i>Ophyra capensis</i>	L, P, A
15	M	1927	28/03/1999	29/03/1999	Courcelles	07/07/1999	Pneumoconiosis	3.3	Putrefied	N	<i>Phoridae</i> <i>Ophyra</i> <i>capensis</i>	L, P, A P
16	M	1955	26/04/1999	27/04/1999	Villeneuve d'Ascq	22/07/1999	Industrial injury	2.9	Putrefied	N	<i>Conicera tibialis</i>	L, P, A
											<i>Ophyra capensis</i>	L, P, A
17	M	1930	12/06/1999	13/06/1999	Bruay la Buisière	07/10/1999	Pneumoconiosis	3.9	Putrefied	Y	<i>Ophyra capensis</i> <i>Leptocera caenosa</i>	L, P, A A
18	M	1925	27/02/1999	28/02/1999	Carvin	16/12/1999	Pneumoconiosis	9.7	Putrefied	Y	<i>Conicera tibialis</i> <i>Ophyra capensis</i> <i>Leptocera caenosa</i>	P A P
											<i>Acariens</i>	
19	M	1918	17/09/1999	18/09/1999	Calonnes Ricouart	10/03/2000	Pneumoconiosis	5.8	Putrefied	N	<i>Leptocera caenosa</i>	P, A
											<i>Megaselia rufipes</i>	P
											<i>Triphleba hyalinata</i>	A
20	M	1926	09/09/1999	10/09/1999	Divion	22/05/2000	Pneumoconiosis	8.5	Putrefied	Y	<i>Leptocera caenosa</i>	P, A
											<i>Megaselia rufipes</i>	P
21	F	2000	15/06/2000	15/06/2000	Bersée	11/08/2000	Crime	1.9	Putrefied	–	<i>Ophyra capensis</i>	P, A
22	M	1924	01/11/2001	02/11/2001	Oignies	05/06/2002	Pneumoconiosis	7.2	Putrefied	N	<i>Conicera tibialis</i> <i>Ophyra capensis</i> <i>Leptocera caenosa</i>	P, A P, A P, A
											<i>Fannia scalaris</i>	A

N no, Y yes, M male, F female, L larvae, P pupae, A adults.

– Data not available

colliery region close to Lille in northern France. Cadavers were buried according to occidental custom, placed in a wooden coffin and clothed. The head only was not covered. In most cases, coffins were buried directly in the soil at a depth of approximately 60 cm. In some rare cases, the coffin was placed in a vault.

For each corpse, the following data were recorded: age, sex, pathology, date of death, date of burial, date of exhumation, season of inhumation and exhumation, time interval, stage of decomposition, coffin, clothing, post-mortem treatment, species of insects and their stages of development. After sampling larvae and pupae were divided in two parts: one part was kept in alcohol, the other specimens were placed in a thermoregulated chamber in order to obtain adults.

Results

Data about the corpses, dates of death, of burial, of exhumation, insects species and stages of development are summarized in Table 1.

The repartition of sex was 21 males and 1 female (a baby aged 1 month), and the average age at death was 55 years. The exhumations concerned 15 cases of pneumoconiosis, 4 workplace deaths, 2 autopsies for a second expert opinion in a criminal case and 1 traffic accident. Of the bodies 30% received a formalin-based post-mortem treatment to decrease the effects of the putrefaction and degradation.

The season of inhumation and exhumation is important to interpret the development of insects and to establish if there is a link between the season and the stage of development. Of the deaths 3 occurred in winter, 5 in spring, 10 in summer and 4 in autumn, and for the exhumations, 4 were carried out in spring, 6 in summer, 8 in autumn and 4 in winter.

The average number of months after the burial was 7 months, ranging from 2 to 29 months. In most cases the burial time was less than 12 months with a long delay of 29 months in 1 case, 14 exhumations were performed more than 6 months after the burial, 18 bodies were putrefied and 4 were mummified.

A total of 10 species of insects and some unidentified acari were sampled on the bodies (Table 1), 5 were found more than once: *Ophyra* (=Hydrotea) *capensis* (15 times), *Conicera tibialis* (8 times), *Leptocera caenosa* (7 times), *Megaselia rufipes* (3 times) and *Triphleba hyalinata* (twice). *O. capensis*, *C. tibialis* and *L. caenosa* were found in high quantities, in all stages of development, indicating that several generations had occurred inside the coffins.

This work is not a complete observation of the insect succession on the corpses. However, Fig. 1 shows that each species was observed on the corpses after a certain post-burial interval, or before a certain post-inhumation interval, or whatever the interval was: *O. capensis* was present on corpses inhumed 2–30 months previously, *L. caenosa* and *C. tibialis* were observed from a period of about 2 months to a period of about 1 year, *T. hyalinata* was observed only on corpses inhumed for less than 6 months. *M. rufipes* was present only on corpses after 6 months, *Fannia* sp. was observed after 6 months to 1 year, and some Staphilinidae were present between 6 months and 1 year. *Calliphora vicina* was observed only once on a corpse exhumed after 3 months.

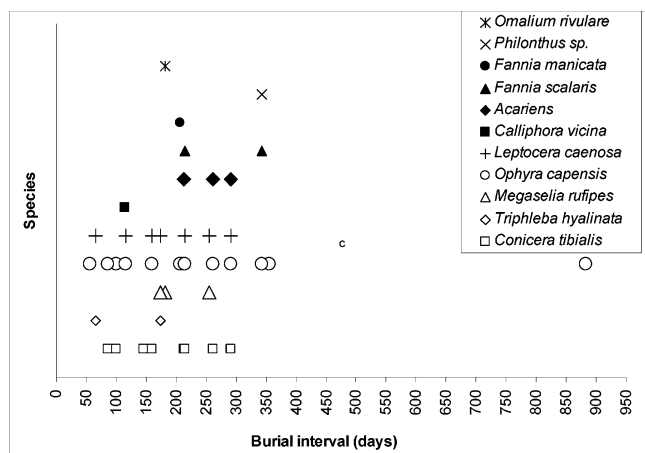


Fig. 1 Insect species found on the buried bodies according to the burial interval

Discussion

Three species of Phoridae (scuttle flies) have been observed in this study. This family is one of the largest family of Diptera and includes 3,000 species throughout the world. Several species of Phoridae have been found on human or animal carrion: *Anevrina* sp. [2], *Conicera tibialis* [3, 4, 7], *Diplonevra* sp. [2], *Dohrniphora incisurata* [5], *Dohrniphora* sp. [6], *Metopina subarctuata* [5], *Triphleba hyalinata* [3], *Megaselia scalaris* [8, 9], *Megaselia rufipes* [3] and *Megaselia abdita* [8].

Among these species, only four have been observed on human cadavers in Europe: *Conicera tibialis*, *Megaselia rufipes*, *M. scalaris* and *Triphleba hyalinata* [3].

Conicera tibialis, called the “coffin fly”, is regularly observed on buried bodies, sometimes in very high numbers. Adults can penetrate the ground down to a depth of 2 m to lay eggs directly on the cadaver, and then several generations can succeed underground, in restricted cavities, which explains the great quantity of pupariae [7]. Adults are active from April to November. They have been found after post-mortem intervals of 5 years [3], on a corpse hidden for 4 years [9], and on pig carrion buried for 105 days [4]. We always found it in very large numbers at all stages of development, after a post-mortem interval of 2 months, up to a period of a least 1 year.

Megaselia rufipes presents a variable biology and has rarely been found on human cadavers. One publication concerns the recovery of pupae after a post-mortem interval of 40 days [3]. It was seen 3 times in this study after a period of 6 months. This indicates that this species is perhaps more abundant in an underground environment or on corpses with difficult access.

Megaselia scalaris is a tropical and subtropical species, regularly observed in Mediterranean regions, and for only a short time in west Europe inside houses. Dewaele et al. [9] found this fly on a human cadaver in Belgium, where they were responsible for a vaginal myiasis before

death. This species can cause cutaneous, ophthalmic, nasosinus, intestinal, urogenital and vaginal myiasis [3], also in reptiles [10]. This species has not been found during the present study.

Triphleba hyalinata is associated with human bodies in wooden coffins. It presents a particular biology because only one annual generation occurs with an adult emergence from October to March. It has been already found on a putrefied body outdoors in December after a post-mortem interval of 26 days [3]. It seems to be rare in the study area because it was observed only twice.

Leptocera sp. (Diptera, Sphaeroceridae) is known to occur on buried pig cadavers, after some days [5] up to 3 months [6]. Nevertheless *Leptocera caenosa* is especially known to live in association with human faeces. It is found in water closets and inside houses where it is a factor of nuisance and sanitary risk [11]. It also develops in sewers and cracked soil pipes [12], and in caves on feces and carrion [13], it is consequently logical to find it with a relatively high frequency inside coffins. It was one of the most abundant species after *Ophyra capensis* and *Conicera tibialis*.

Ophyra capensis was the most abundant fly found on exhumed cadavers in this study. *Ophyra capensis* usually breeds on feces, carrion, birds and mammal nests, and poultry farms [11]. This species has been found on human cadavers kept indoors for several years, where blowflies have not had access. *Ophyra* sp. has been found on buried bodies [6], therefore this species seems to be highly linked with buried bodies in coffins.

Some species were found only one or two times and always in small quantity. Fanniidae (*Fannia scalaris*, *Fannia manicata*) develops in various organic materials, rarely on buried bodies and have been mentioned just one time on buried bodies [6]. *Calliphora vicina* generally does not lay eggs directly on buried bodies because of access difficulties. This fly has been observed laying eggs on the soil surface above a body buried 30 cm deep [6, 14]. Probably this fly laid the eggs before the body was buried, because we found only a few empty pupariae.

Some Staphilinidae were also found on the corpses. *Omalius rivulare* and *Philonthus* sp. (Coleoptera, Staphilinidae) are predaceous Coleoptera usually found on the soil surface. They seem to be regularly found on buried bodies because they feed on Diptera larvae [5, 6, 7].

The list of insects found on buried bodies also includes Psychodidae (Diptera), parasitic Hymenoptera, *Aleochara* sp. (Staphilinidae) [5], Silphidae, Leiodidae and Histeridae (Coleoptera) [6].

To resume, three species were regularly observed in coffins because of their ecological preferences: *C. tibialis* associated with bodies in coffins, *L. caenosa* associated with organic materials in underground environments, and *T. hyalinata* associated with buried bodies. One abundant species not really associated with buried bodies was *O. capensis* which can colonize confined bodies. Females certainly lay eggs on the surface of the coffins. The presence of one of this species is consequently an indication of internment in a confined space. The other species *Fannia*, *C. vicina*,

were rarely found because of access difficulties, and are not associated with buried bodies. Finally, the Staphilinidae were attracted by buried bodies as well as other sort of organic materials because they feed on other insects.

The effect of the season of inhumation is important for all species. They were often observed on corpses buried in spring and summer, which are two seasons favorable for insect activity. Nevertheless, *L. caenosa*, *O. capensis* and *C. tibialis* were also observed on corpses buried in fall and winter (Fig. 2).

The effect of the season of exhumation is also important to explain the presence of *L. caenosa*, *O. capensis* and *C. tibialis* (Fig. 3). They were often observed in fall; this is logical because this time is just after the season when flies are the most active. A particular observation was *T. hyalinata*, found only in fall and winter in the adult stage. This confirms that this species presents only one annual generation with adult emergence in winter.

Concerning the effect of the stage of decomposition, only *O. capensis* was found on both putrefied and mummified bodies but other species were present especially on putrefied bodies. Amazingly, no effect of preservation treatment was observed, because the same species were seen during the same periods on both categories of corpses.

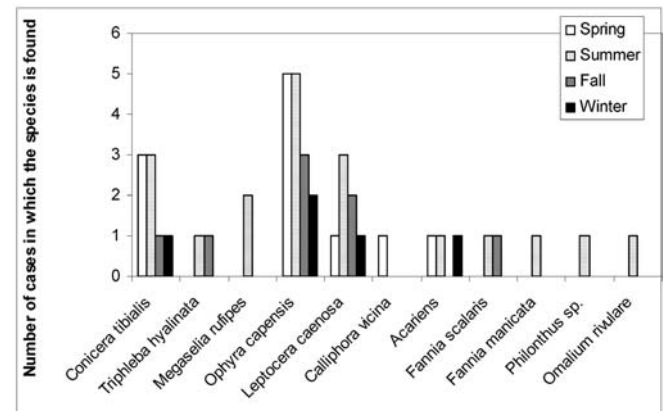


Fig. 2 Insect species according to the season of inhumation

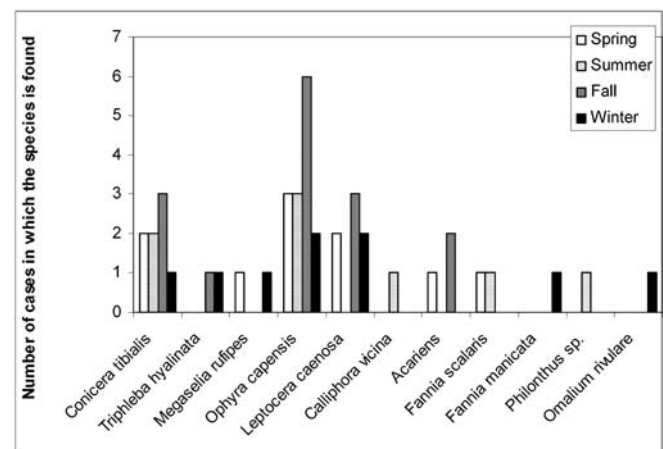


Fig. 3 Insect species according to the season of exhumation

For the location of the cemeteries, it is interesting to note that *T. hyalinata* and *M. rufipes* were found only in the west of the area in three localities but due to the small number of cases with these two species it is difficult to explain this particularity.

Conclusion

Very few studies have dealt with insects developing inside coffins. Some of the sampled species prefer underground or confined spaces to reproduce. Consequently, when *O. capensis*, *C. tibialis*, *L. caenosa*, *M. rufipes* or *T. hyalinata* are found on an exposed corpse, the entomologist has to consider a potential confinement of the body before the recovery.

Nevertheless, estimating the duration of confinement and the period between exhumation and the discovery of the corpse seems to be very difficult when considering these species only.

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