

Six Forensic Entomology Cases: Description and Commentary*

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ABSTRACT: Insects are known to be useful in estimating the postmortem interval (PMI). Here several cases are reported which show that a wide range of applications in medicolegal questions and hygiene together or apart from estimating the PMI can be answered by use of forensic entomology techniques, including close observation of larval development. Case 1 describes how blowfly larvae fell from a putrefied corpse, hid, and finally emerged from pupae three months after disinfection and renovation. In case 2, the entomological state of the decomposed corpse of a heroin user is described. Case 3 deals with a single adult *Protophormia terranova* found in the skull of a partially mummified woman. Case 4 reports the finding of *Serratia marcescens* bacteria in red *Muscina stabulans* pupae which were found on a 5-day-old corpse. In case 5, blowfly eggs on the corpse of another heroin user are interpreted as an indication of the decedent being laid outside at night after his death in a flat. Case 6 deals with the finding of *Parasarcophaga argyrostoma*, which in Cologne might be an indicator species which tells if a corpse was lying outside at least for some time.

KEYWORDS: forensic science, forensic pathology, forensic entomology, blowflies, *Lucilia spec.*, *Muscina stabulans*, drugs, post-mortem interval (PMI), *Syrphidae*, *Piophilidae*, *Necrobia rufipes*, *Serratia marcescens*

Arthropods have been shown to be useful in estimating the post-mortem interval (PMI) (e.g., 1–9). Because insects are attracted by specific states of decay, particular species colonize a corpse for a limited period of time. This produces a faunal succession on cadavers. Together with the knowledge of growth rates under specific environmental conditions, this faunal evidence provides an estimation of time since death.

However, it is possible to obtain further information from the insects found at the scene of a crime. For example, beside the estimation of PMI

- suspects have been linked to the scene of a crime as a result of them having been bitten by arthropods specific to the vicinity (10,11);
- late colonizing insects allow analysis even of badly decomposed or skeletonized corpses (3,12,13);
- insects which live in restricted areas but are found on a corpse in a different area can prove that the body was moved after death;

¹ Office of Chief M.E., Forensic Biology Dept., New York, NY 10016.

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- blowfly larvae can give information on how long children had been neglected by their parents (2);
- appearance of larvae and flies in clean, empty or occupied rooms can be explained by linking the entomological findings to known death cases from the surroundings of the scene (3,15);
- in former times, crime instruments were reported to be identified (14,59); and
- the question as to whether a corpse was killed and/or brought outside (a) by night or by day and/or (b) while it was raining or not can be examined (1,3,15).

Together with the impressive possibilities of estimation of PMI, the steadily increasing use of forensic entomology in a few European countries [especially in France (e.g., a laboratory of the Gendarmerie Nationale in Rosny sous Bois, and a university laboratory in Lille), Belgium and England, but also in the Czech Republic and in Russia] as well as the successful research and casework in the United States may encourage further European interest in these effective and well-established techniques (15,16,57). This paper focuses on the wide range of applications for entomological analysis in medicolegal questions and not just those concerning estimation of PMI.

Materials and Methods

Insects were killed and stored in 75% ethanol (59). Dipteran larvae were bred in jam jars which were covered with a moist piece of cloth and which were filled with dry bark and leaves and—in the case of feeding larvae—with small pieces of rotten meat (18). All animals were collected before autopsy in the Institut für Rechtsmedizin der Universität zu Köln. Determination of animals followed (19–23) (flies), (19,24–26) (beetles), (1,27) (dipteran larvae/pupae), and (23,28–32) (ecology). Outside temperature and humidity were recorded half-hourly by a weather station nearby which is operated by the Landesumweltamt Essen. Weight and height of corpses are given as measured at autopsy.

Case 1: Maggots Continuously Found in Winter in a Vacant and an Occupied Flat

The corpse of an elderly Caucasian woman was found in her flat on the third floor of an urban building on 6 November 1995. The body was discolored and the skin was found to be partly detached due to putrefaction. Police officers reported that at their arrival many adult flies but “no striking amount” of maggots were observed on the corpse. Two days later the flat was sprayed with Pyrethrum (8 Nov. 1995), disinfected with Lysoformin (9 Nov. 1995) and then completely renovated, including fresh painting of all walls and the removal of all carpets. The flat was then left vacant. At the end of February 1996, an inhabitant of a flat in the



FIG. 1—View into the bathroom of a flat situated one floor beneath a flat in which a corpse had been found three months earlier (case 1).



FIG. 2—In case 1, blowfly larvae were reported to squeeze themselves through a bathroom partition wall made of plaster. Note the adhesive tape which was thought to prevent larvae from entering the room.

building reported that for the past three months maggots were found in hers, and in another occupied flat (Fig. 1). Maggots were reported squeezing themselves through a bathroom partition wall made of plaster (Fig. 2) and collecting under a mat near the balcony. Furthermore, the caretaker collected up to ten dead green flies per week in the vacant flat of the deceased.

An inspection of the flats, which were all in a clean and proper

condition, on 22 Feb. 1996, revealed five puparia and six postfeeding, slightly darkened larvae (starting to pupate) of the blowfly *Calliphora vomitoria* LINNÉ under a mat near the balcony situated under the vacant flat. In the flat of the deceased the following were found: (a) three dead and one febrile weak adult green-metallic *Lucilia caesar* LINNÉ, each of 7 mm in length, in the bedroom and in the bathroom, (b) four puparia of *Calliphora spec.* ROBINEAU-DESVOIDY behind unremovable floor ledges, and (c) four febrile adult *Lucilia caesar* L. sitting in cracks in the concrete of the balcony. Up to June 1996, dead adult flies but no other arthropods were found occasionally in the vacant flat.

The unusual appearance of two blowfly species which should have been killed by pyrethrum may be explained by a rapid decrease of temperature which started six days before disinfection and reached its maximum the day before the corpse was found (Fig. 3). Supposedly, female flies laid their eggs on the corpse in mid-September. While many eggs could develop, temperatures decreased and from the beginning of November many maggots started to search for secure places in which to diapause. This behavior is characteristic of many insects under unfavorable conditions, especially at low temperatures (e.g., 3). For that reason, Pyrethrum did not reach the hidden and nearly lifeless maggots. After renovation, the caretaker maintained the empty flat at around 14°C. This temperature allowed pupation and hatching of some flies; however, mainly due to low temperatures in winter they could not fly away (1,3,34–40). In the laboratory (room temperature 22°C), the individuals which were caught in the flat showed a normal flying behavior.

Two facts support the idea that maggots originated from the corpse, and hid both behind vertical floor ledges and in cracks a few days before disinfection because of a sudden drop in temperature. Firstly, no cadavers or skeletons were found anywhere in the surroundings, including drains. Secondly, maggots, pupae and flies of the predominant carrion feeding species in Cologne were exclusively found in rooms which were located towards the north (where the woman died) but not in rooms at the sunny, warmer south side of both flats. Due to the continuously low temperatures and poisoned surroundings the post-feeding larvae finally developed slowly but constantly (without feeding any more) into small adults over a period of six to eight months (shrunken abdomen; 60% of normal body length—for variation of body length of *Lucilia caesar* see Ref 41, for *Calliphora* see Ref 42). A prolonged development at low temperatures but together with enough food would have led to larger specimens (43).

Case 2: Cheese Skipper Larvae on Heroin Addict

A 38-year-old known heroin user committed suicide at the end of November 1995 by laying her neck on a rail in the path of the wheels of a moving train. The corpse was found under foliage in shrubbery near the tracks which run through the city. The soft parts of the trunk were reduced to a greasy mash. Organs of the abdominal cavity and the chest were completely disintegrated (Fig. 4). A small amount of decayed tissue was found adhering to the pelvis and the extremities. A shock of hair measuring 35 × 20 cm (14 × 8 in.) was found near the skeletonized skull. A first estimate led to a postmortem interval of 2 to 3 months. The body was wearing jeans which were still in good condition.

In the autopsy room, within the decomposed mush, but also on the uncovered bones, masses of yellow piophilid larvae of 8 mm in size could be observed, increasing to 50 cm in height or 10 cm aside for more than five hours at 17°C. On top of the leathery dried

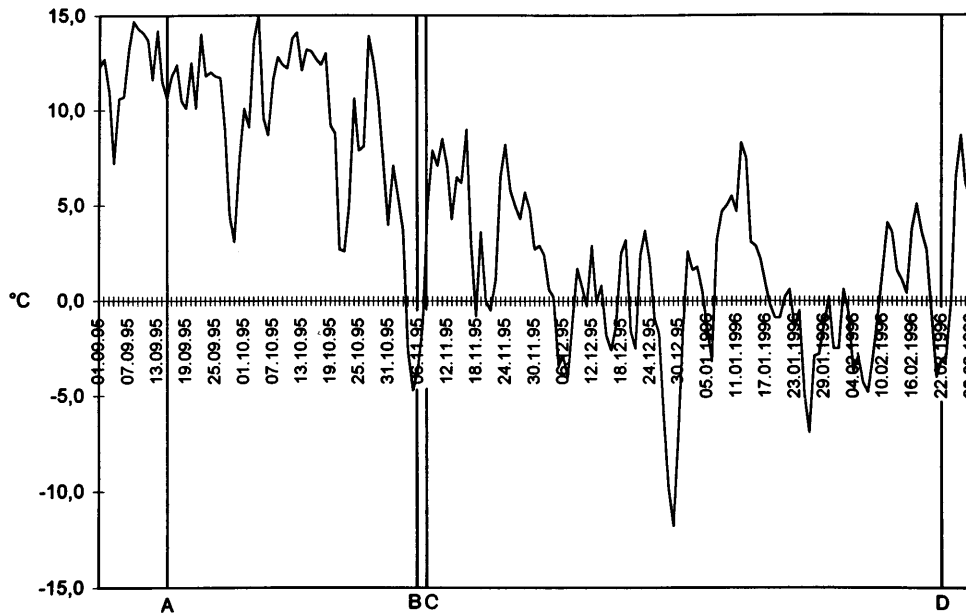


FIG. 3—A rapid decrease of temperature which started six days before disinfection and reached its maximum the day before the corpse (case 1) was found can explain the unusual appearance of two blowfly species which should have been killed by pyrethrum. (A) supposed time of death (concluded from letters in letterbox etc.), (B) corpse found, (C) disinfection (2 days), (D) first entomological inspection.



FIG. 4—Corpse of a 38-year-old known heroin user which was found under foliage in shrubbery near the rails which run through the city. Organs of the abdominal cavity and the chest were completely disintegrated. Within the decomposed mush, but also on the uncovered bones, masses of piophilid larvae could be observed (case 2).

parts of skin, a nearly closed layer of pale yellow eggs was found; similar eggs were found in the shock of hair. Because the breeding room had been poisoned while breeding the eggs, determination had to be made by use of single body parts of one adult fly which was determined as *Piophilid casei* LINNÉ (Fig. 5). *P. casei* is a typical inhabitant of freely exposed cadavers three to six months postmortem, i.e., in the third of eight successional waves (1,44).

Because single *P. casei* females lay around 200 eggs, the observation of masses of eggs covering the body led to the conclusion that a first, and probably a second, generation of cheese skippers had hatched on the corpse. Under good conditions, *Piophilid* eggs develop to adults within 11 to 19 days; together with the information given in (1) and our temperature data (Fig. 6) a postmortem interval of 90 days (start of the third wave) plus 22 to 38 days,

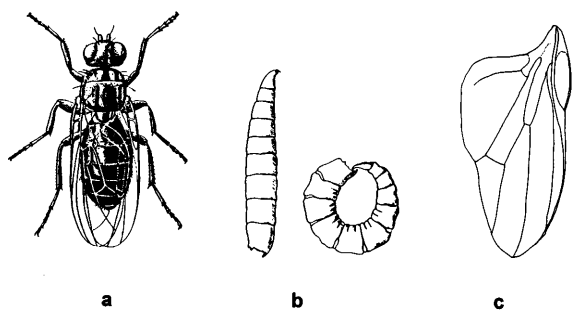


FIG. 5—*Piophilidae casei* L. is a typical inhabitant of freely exposed cadavers three to six months postmortem. In case 2, the wing (C) was the main key for determination. (A) adult *P. casei*. (B) *P. casei* larva, (left) relaxed, (right) ready to skip.

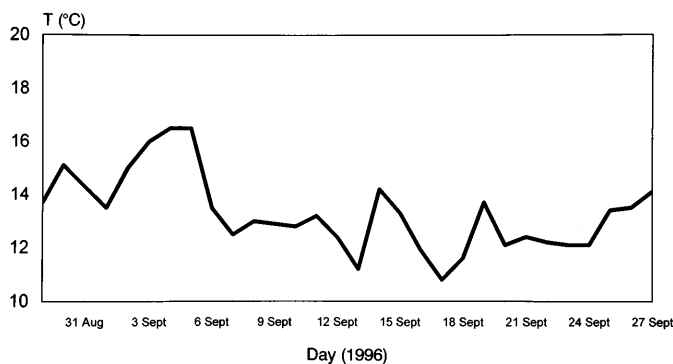


FIG. 6—Temperature profile in case 2.

i.e., 112 to 128 days, was calculated. Later it was found that the woman had been missing for four months. This case indicates that *P. casei* does not shorten its development significantly under the influence of heroin as was observed for some arthropods (45). However, the exact concentration of heroin could not be determined because of the severe decomposition.

Under the shock of hair on the clothing of the corpse, several beetles were found that to our knowledge are not highly specific for a certain state of decay (1,44). We found two adult staphylinidae (one *Oxytelops tetracarinus* which is the most common representative of the genus *Oxyteles* (GRAV.) and is frequently found in excrement and rotten plant materials; one *Philonthus spec.*) which on their own are not suitable for estimating PMI because of their common occurrence on cadavers, e.g., even two years after burial on corpses (1). Furthermore, three adult individuals of the genus *Atheta* THOMSON (which lives on dry carrion but also on fungi and decaying leaves) and both larvae and two adults of the clerid ‘‘red legged ham beetle’’ *Necrobia rufipes* (DE GEER) were found. One of the *Necrobia* larvae immediately burrowed into a piece of gauze, pupated at 17°C, which is 1°C less than its supposed lowest breeding temperature (29) (Fig. 7), and hatched out after 54 days. *Necrobia rufipes* is known to be a late inhabitant of corpses and feeds on dry cadavers (also on mummies and ham) and probably on larvae of other arthropods. The observation of one dead pupa of *Fannia* (housefly) and the absence of any silphid beetles was without diagnostic value but is mentioned for the sake of completeness.

Case 3: Adult Fly in Decomposed Head

On the occasion of his arrest on 8 May 1996, a man told the police that his wife was lying dead in their flat and had been

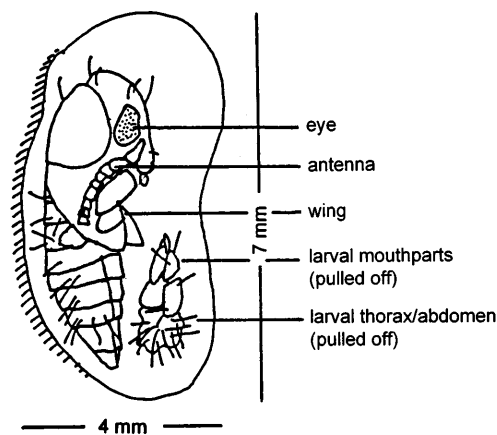


FIG. 7—Developmental stage of this pupated *Necrobia rufipes* individual (sketch) helped to estimate PMI in case 2.

there for 29 days. Asked why he did not report the death, the man answered that he was afraid of losing the flat. Police found the corpse with a large population of flies and larvae together with signs of mummification (Fig. 8). The corpse was covered with two blankets. As the mean outside temperature was calculated to be 10.9°C, most likely the heating was turned on. Together with the known covering of the corpse and the insect-producing heat (47), inside temperatures were assumed to have been constantly higher than 20°C.

During the postmortem examination, masses of maggots were found on the corpse, conspicuously in the vaginal tract and in the hair; further maggots were seen in the bladder. Unfortunately, maggots were washed away by the autopsy team before the forensic entomologist was informed. The head was partially mummified; the skin of the face, the soft tissue of the lower jaw, eyes, ears and tongue were missing; the mouth was widely opened, and the skull was fully intact. After detaching the skull-cap, a single adult *Protophormia terranova* (ROBINEAU-DESVOIDY) was found inside the skull. The brain was missing. Inside the skull, larvae were found. It is known that *Protophormia* develops within 19 to 23 days at 22°C from egg to adult (3,48). In Cologne, *P. terranova* is reported to be the most synanthropic species (= species associated with humans) after *Musca domestica* LINNAEUS and *Lucilia sericata* (MEIGEN) (31).

However, our observation is unusual, firstly because *P. terranova* ordinarily pupates on the surface of the breeding medium unless it is very wet or exposed to bright light (an alternative explanation might be that the fly became trapped accidentally; however, development was completed under unusual breeding conditions). Secondly, *P. terranova* adults are usually found on corpses more than one month after death (8). Thirdly, this is the first observation of *Protophormia* on a corpse from the city of Cologne in our institute.

Case 4: Red Pupae on the Corpse of an Alcoholic

On 14 August 1996, a 46-year-old known alcoholic (80.5 kg) was found dead in his bedroom. He had been dead for five days. Blood alcohol concentration was calculated to be 1.6 parts per thousand. The man had a history of high blood pressure. The corpse was in a state of bloated decay. Clusters of eggs were found in his beard and in his pubic hair. Many fly larvae of 2 to 3 mm in length were seen mainly under skin bladders caused by putrefaction



FIG. 8—A single adult *Protophormia terranovae* was found inside the skull of this woman. She was lying dead in her flat for 29 days (case 3).

gases. Because *Lucilia ceasar* LINNÉ females were observed ovipositing onto the body in the autopsy rooms, entomological analysis focused on two dark red pupae measuring 6 mm which were found adhering to the abdomen of the corpse (Fig. 9).

Pupae were bred at 17°C to 20°C and two adult *Muscina stabulans* FALLÉN flies measuring 9 mm in length emerged 14 days later, on 28 Aug. 1996. *M. stabulans* develops within 28 days at 16°C from egg to adult (49); larvae, as a rough estimate, are supposed to have fed on the man either while he was living or while he was in an unconscious state. (If, on the other hand, this was a case of myiasis and *M. stabulans* involvement (58) because of the body temperature of 37°C and because of the elevation of temperature by maggot masses, a shorter time of development would be expected.) To determine if the man might have fallen severely ill before he died, larvae were crushed and tested for bacteria.

The red color of the pupae and red spots on the slightly moist paper towels on which the pupae were laid appear to have been caused by *Serratia marcescens* (Enterobacteriaceae). This ubiquitous bacterium, previously thought to be nonpathogenic, is now known to cause wound infection and sepsis in people whose immune system is compromised; a reason for this is that *S. marcescens* is often resistant to antimicrobial substances (50). For example, in 1986 and 1987, an average of 93 people died from infection with *S. marcescens* in the U.K. (50). An illness or infection caused by or followed by the occurrence of *S. marcescens* together with unconsciousness could be an explanation for the occurrence of *Muscina stabulans* larvae on the alcoholic before he died.

Case 5: Corpse of Drug User with Postmortem Lividities at Two Different Points

A known drug user (28 years old, 172 cm, 61.9 kg; blood: no alcohol, caffeine 0.85 mg/L, Diazepam 0.12 mg/L, Nordiazepam 0.03 mg/L; urine: morphine 4.8 mg/L, Codeine 0.16 mg/L) was found dead near woods inside Cologne on 21 Aug. 1996 at 7:05 A.M. Toxicological analysis suggested that death occurred within

three hours after ingestion of heroin. The dressed corpse lay freely exposed on a patch of grass; police reported that the corpse had not been seen there at 10 P.M. the evening before. Mean outside temperature was 23.1°C (20 Aug. 96) and 20.3°C (21 Aug. 96) (Fig. 10). On the eyelids, masses of eggs were found (Fig. 11).

Using characteristics of the mouth parts, the anterior spiracles and the posterior end views of third instar larvae which were bred from eggs allowed species determination of the blowfly *Lucilia ampullacea* VILLENEUVE, one of the *Lucilia* species that is seldom found associated with (living) humans in Cologne (31).

This case is interesting for two reasons. Firstly, in the Weimar child murder case, one of Germany's most famous lawsuits, the author was asked if arthropod evidence could tell if two corpses were placed outside near woods by day or by night (56). The idea was to compare the developmental stages of gen. *Lucilia* and gen. *Calliphora* on the corpses. Since most authors report that *Calliphora* does not oviposit at night (51; see also 52), it was suggested that this might be answered by comparing the occurrence of late stages of *Lucilia* with the occurrence of early stages of *Calliphora*. The forensic entomologist might have been able to answer the central question of the trial if eggs, maggots and insects collected at the scene would not have been thrown away after letting them dry in a paper bag. Maybe even high quality close-up photographs (which were not taken) might have been the key to the true course of events. Secondly, the influence of drugs in corpses to the insects feeding on them is still in progress (45); thus, this case makes a small contribution to the subject by showing that *Lucilia ampullacea* was not repelled by a heroin-intoxicated corpse. (From the life history of the person it is sure that heroin was present even if its quantity could not be determined anymore.) Thirdly, the appearance of only very early developmental stages of flies (as documented by photographs) indicates that the person died in a flat and was then brought outside. As a matter of fact, in criminalistic routine it is not unusual that a heroin user is reported to have died unnoticed in the circle of his friends (the person is thought



FIG. 9—Case 4: The dark red color of *Muscina stabulans* pupae found adhering to the abdomen of a corpse could be explained by the presence of the ubiquitous enterobacterium *Serratia marcescens*. It might have contributed to the death of the corpse on which *M. stabulans* larvae fed before pupating. Line: 6 mm.

to be asleep or to be on a drug trip). The friends wish to prevent questions and investigations and so they deposit the corpse anywhere outside. The double system of lividities, the entomological findings, the fact that the body was lying next to a path and the walker's declaration also support this theory.

The finding of some ten living woodlice (isopods) of the species *Porcellio scaber* adhering to the corpse in this case was of no diagnostic value but is mentioned for completeness. (*P. scaber* is one of ten isopod species which are most widely spread over Germany. However, appearance of *P. scaber* on a corpse in a Cologne flat might give a hint at the death happening outside. Until now, the author has never found isopods at corpses in local flats.)

Case 6: Dead Man on a Balcony

The corpse of a 66-year-old man (46.5 kg, 159 cm, back-calculated alcohol level at time of death: 1.07 parts per thousand) was found on the balcony of his flat on the 8th floor of an urban building in Cologne. The corpse was thought to have been there for 25 days, from 31 August 1996 to 25 September 1996. The soft tissue of the face, neck and right ear was destroyed by maggots; the skin was greasy and colored greenish-brown, the abdomen was bloated. Masses of maggots were found on the corpse.

A single fly which was reared to adult was identified as *Parasarcophaga argyrostoma* (ROBINEAU-DESVOIDY), which is also known as *Sarcophaga argyrostoma*. In Cologne, *P. argyrostoma* is found only near muck heaps, on food containers in the Zoological Garden, etc. (31). Until now, in Cologne, it has never been seen on corpses inside flats. Until now, no information on the dependence of the

height of a flat and colonization of corpses was determined systematically. For that reason, *P. argyrostoma* seems to be a highly indicative species which tells if a corpse found in a more or less closed environment was lying outside (here, on a balcony very near to a flat) at least for some time. *P. argyrostoma* might therefore turn out to be of special help in forensic investigations in urban surroundings like the city of Cologne which suffers from a fauna with a clearly restricted number of species to check whether a corpse was (temporarily) lying outside a flat—even on a balcony—or not.

Final Remarks

Arthropods are not only a valuable help for estimation of the postmortem interval but can also help to answer hygienic and social questions. From a strictly forensic point of view the cases given here show that evidence can still be found after months and even after renovation of a flat (case 1); that the development of even one single species can help to give a good estimate of PMI (case 2); that especially in urban flats the environment in which a corpse was found might severely affect the observations and interpretations of the forensic entomologist (case 3); that even if autopsy cannot settle the cause of death, insect evidence might contribute to that question (case 4); that insect evidence can help to understand a double system of postmortem lividities (case 5); and that species seldomly found require special attention, e.g., to determine if a corpse was lying inside or outside in an urban context (case 6).

The species that are usually reported from crime scenes might not be the only forensic indicators. Because insects are the most



FIG. 10—Temperature profile in case 5. Interrupted line: Time when corpse was not seen by a person out for a walk at the site where the corpse was found later. Continuous line: Time when corpse was found.

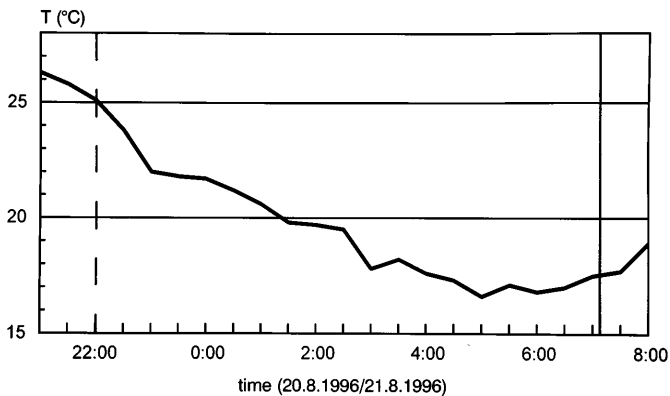


FIG. 11—Masses of fresh *Lucilia ampullacea* eggs on the eyes of a known drug user (28 years old) who was found dead near woods at 7:05 A.M. freely exposed on a patch of grass (case 5).

numerous group of animals on earth [75% of all animals (Oldroyd, after (53))] and because they live even in extreme habitats, including graves (e.g., 44,53), insects whose biology is yet not completely understood might be valuable tools for forensic investigations. This might be a field for further research activities.

To make full use of the potential of arthropod evidence, the

author agrees with Erzinçlioglu (16) that it would be of great help to establish a routine zoological analysis in forensic medicine which might be supported by DNA typing (54,60) and thus allow forensic zoology to take its place among the other subdisciplines of forensic sciences.

Note

The author is aware of the fact that the present-day custom of naming insects might not reflect true phylogenetic relationships (55). However, for lack of anything better, the author for the present uses this system of classification.

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Additional information and reprint requests:

Mark Benecke
Office of Chief M.E.
Forensic Biology Dept.
520 First Avenue
New York, NY 10016

Erratum

The corrections for the paper: Six Forensic Entomology Cases: Description and Commentary. J Forensic Sci 1998;43(4):797–805 was inadvertently left out at page proof stage. Please note the following corrections:

1. p. 797: in the header, Mark Benecke holds a Ph.D. (Hon.).
2. p. 803: Fig. 11 has to be Fig. 10.
3. p. 803: the figure caption for Fig. 11 belongs to Fig. 10. The figure caption for Fig. 10 belongs to the actual Fig. 11. Please refer to the original (new) Fig. 10 below.



Additionally, the following text explains the erroneously printed Fig. 10.

“Wasps” in a Sterile Room

On the 21 August 1996 a number of wasps were reported on the ceiling of a laboratory in which DNA is extracted. On inspection, some ten adult hover flies were found sitting near the openings of a ventilation shaft (see Fig. 10 in (1)). A few days previously, the whole ventilation system in the building had been renewed. Furthermore, laboratory personnel had noticed unpleasant smells every time a decayed corpse was delivered to a nearby autopsy room located on the same floor. This room is connected to the sterile room by the same (horizontal) ventilation shaft. For that reason, laboratory staff supposed that the “wasps” were drone-flies, *Eristalis tenax*, which is the only hover fly species associated with carrion (3–6 month postmortem (2)). They may have found their way through the ventilation system from the autopsy room, possibly aided by negative pressure within the shafts.

The flies were determined as a species of the same family as *Eristalis*, *Episyrphus balteatus* (DE GEER). *Episyrphus balteatus* larvae feed on aphids; adults are frequently found in gardens, often in swarms, and they are the most common hoverfly species in Cologne (3). Due to their ecology, the presence of *Episyrphus* adults cannot

be associated with corpses in the autopsy room. It was suggested that a swarm of *Episyrphus* living in an old graveyard nearby entered the building through an open window at the end of a corridor, reached the sterile room but could not escape because of orienting themselves towards a closed but bright window.

Acknowledgment

The article (1) is dedicated to Prof. Dr. med. M. Staak on the occasion of his 65th birthday.

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