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Distinction of bloodstain patterns from fly artifacts

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Abstract

Forensic scientists may encounter blood spatter at a scene which may be pure or a mixture of fly artifacts and human bloodstains. It is important to be able to make an informed identification, or at least advanced documentation of such stains since the mechanics of production of fly artifacts are not determinable to the crime scene reconstructionist from regular police forces. We describe three cases in which experiments and crime scene reconstruction led to additional information. *Case 1:* Above the position of a victim, numerous blood stains of the low–high-velocity type were found. Exclusion of these stains being caused by force (but instead caused by the activity of adult blow flies) by use of the following observations that were confirmed in experiments: (a) sperm-/tadpole-like structure with length > width, (b) random directionality, and (c) mixture of round symmetrical and teardrop shaped stains. *Case 2:* A reddish spatter field was found on a fan chain two rooms away from the place where a dead woman was found. Localization of the spatter on the bottom end of the surface hinted strongly towards fly activity. *Case 3:* Double homicide; submillimeter stains were found on a lamp between the two corpses. Activity of flies was less likely compared to alternative scenario of moving lampshade and violent stabbing.
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1. Introduction

In the last years, forensic entomology [1–7] and blood stain pattern analysis [8–19] became more and more part of forensic investigations and trials [14,21] outside of the United States.

In this context, crime scene experts often note that flies might leave information that could produce confusion within the scene. The mechanics of production of fly artifacts are not determinable to the crime scene reconstructionist from regular police forces, since regurgitation and defecation from a fly are frequently not taken into account.

Only old German texts [8] and modern text books from the United States mention artifacts produced by flies [16–19], e.g.:

> *The activity of flies at the scene where blood has been shed is another possible source of small stains of blood that may be confused with medium- to high-velocity impact spatter . . . An understanding of the mechanics of flies feeding on blood an decomposing bodies is essential for proper interpretation of these bloodstains. The horse fly is characterized as a biter, while the common house fly is specialized as a lapper and sucker. Flies ingest blood and regurgitate it onto a surface to allow enzymes to break down the blood. At a later time, the flies return to the areas of regurgitated blood and consume a portion of the blood. The surfaces upon which these activities have taken place will contain small spots of blood material which are often a millimeter or less in diameter with no definite point of convergence or origin. Some of the stains will exhibit dome shaped craters due to the sucking process and others may show swiping due to defecation. These stains may be observed on many surfaces at the scene especially lamp shades, blinds and ceilings as well as on the victim and clothing. Their locations may be inconsistent with blood spatter associated with injuries sustained by the victim.* [19]

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Although not true spatter, another pattern often confused with spatter is the ''fly speck'' or ''fly spot'' pattern. Flies present within the scene will feed on blood found there. This blood is both tracked about and regurgitated by the flies. In the instance of the tracking pattern, the marks are extremely small but a pattern may be evident on close examination.

> In the case of regurgitation, the specks are remarkably symmetrical . . . Most often, the analyst finds these patterns in warm areas where the flies rest, such as high in window corners or along walls where the sun strikes. Such stains will usually test positive for blood with a presumptive test. Obviously, care should be exercised in evaluating any abnormal patterns which meet these criteria. [10]

However, no integrated approach by natural sciences and criminalists had been used until actual case work (see cases below) and presentation in courts made it necessary to develop a method to safely distinguish between blood spatter caused by force and blood spatter-like patterns produced by flies.

This is especially important since even artifacts caused by flies may very well include the victim's blood. Neither presumptive blood tests like Hemastix (2190)/Heglostix (Bayer 028165A; hemoglobin catalyzes oxidation of 3,3′,5,5′-tetramethylbenzidine (color reagent) by diisopropylbenzole dihydroperoxide from green to blue), Sangur (Merck), or Luminol, nor DNA typing will differentiate between the two types of stains. This leaves recognition of stain patterns and other physical information as the relevant criteria. The following text illustrates stains produced by the activity of flies and suggests methodology for evaluating stains in a decomposed body scene.

Furthermore, from the above quotes it appears that some documentation of the craters was possible. In many countries, it is however unlikely that a blood stain pattern expert will enter he actual scene and therefore, documentation of craters has, to our knowledge and does usually never take place.

2. Blood spatter types

Blood that is subjected to a low-velocity impact (less than 1.5 m s^{-1}; resulting blood spots often around 4–8 mm in diameter) is called low-velocity blood spatter. It is caused by free-falling blood under the influence of gravity, including blood cast off from fist shoe, or weapon.

Blood spatter as reported in the following three cases was usually thought to be caused be either high-velocity impact, or by a mixture of medium to high-velocity impact. Those types of spatter are defined as blood subjected to a medium velocity impact (about Ca 10 m s^{-1}), e.g. blows with a hammer, or axe (medium velocity; spots typically measuring about 4 mm in diameter), or blood sources that are subjected to a high-velocity impact (>Ca 10 m s^{-1}), e.g. a gunshot (blood spots typically <1 mm in diameter) [9].

3. Case I: Double homicide in Nebraska

3.1. General scenario

The remains of two men were discovered at 14:25 h on 14 June 1997 in a third level apartment in a five-plex apartment building in urban Lincoln, Nebraska, USA [23].

Both victims were fully clothed; both had a gunshot wound to the head and gunshot wounds to the torso. One victim was found face down in the kitchen area and the other victim was prone on the living room floor on carpeting. Pools of a reddish substance were observed around the bodies of the victims.

The bodies were in the active decay stage with black putrefaction only just beginning; the skin was intact everywhere except where there were gunshot wounds. At the wound sites, there was dried blood and body fluids and in the areas around the bodies, flies, maggots and pupae as well as some adult flies were present. The temperature registered 30 °C on the wall thermostat.

3.2. Forensic entomology

On 15 June 1997, at 06:45 h, the police collected six adult flies, three third instar fly larvae and several hundred first instar fly larvae in ethanol from the scene. Adult flies had probably gained access to the apartment by an open space beneath the front door. Both adults and larvae were identified as *Phormia regina* (MEIGEN) (Diptera: Calliphoridae) [20], the black blow fly and concluded from the presence of small, first instar larvae and large, third instar larvae that two distinctly separate periods of egg-laying by adult flies had taken place.

3.3. Blood stains

Initial observation of the scene gave the appearance of extensive low, medium and high-velocity blood spatters. Above the position of one of the victims, numerous stains of the low–high-velocity type were found (Fig. 1). Similar areas were found on a kitchen hanging lamp, the interior and exterior of the entry door, the bathroom, the two bedrooms and the walls around the victims. The stains were tested positive for blood with a quick test for hemoglobin (Hemastix/Heglostix).

The first assumption to be made was that there had been slinging of a lot of blood around the kitchen and living room. This would suggest not only gunshot wounds, but considerable movement of the victim and suspect(s). It could suggest a motive of robbery, burglary, assault, or a surprise attack. Examination of the kitchen and living room did neither indicate struggling or fighting to any great amount. In the bedrooms and bathroom there were flies, but no signs of bloodstain patterns. There were no maggots in these rooms. The conclusion we made was that not much activity had

Fig. 1. Blood stain patterns produced by flies in Case 1 above the position of one of the victims (misinterpretation as low–high-velocity type relevant in the trial). Note the wide distribution of stains in contrast to Fig. 2c.

taken place in the bedrooms or the bathroom of an assaultive nature and the bloodshed had taken place in the kitchen and living room.

Reconstructing the angle of impact of many of those stains, however, led nowhere. There was no indication that the bodies had been moved and there were no signs of a struggle in the bedrooms, or bathroom. Smaller, round type spatters were mostly <3 mm in length and >1 mm in diameter. Furthermore, stains of a sperm-like shape (irregular, uneven form with tail much longer than the body) as well as a missing systematic directionality were observed. Since all stains were composed of blood, how did they (a) get into all of the rooms and (b) transfer to the walls?

3.4. Experiments and measurements at the scene of crime

It is known that after feeding, flies regurgitate and defecate. Hence, flies could have caused stains, containing blood of the victims, by regurgitation, defecation and transference. In such cases, it is expected that presumptive blood tests would indicate the presence of blood. To prove that the unusual bloodstain patterns originated from the body of the victims, whereas the mechanism of transfer was provided by adult flies, the ratio Ltl/Lb (length of tail/length of body) was calculated as 3.3 ± 2.4 (Table 1). Such a high value will not be reached under most case conditions, especially since not only the calculated angles of impact but also the directionality of the stains never point into one direction as would be expected from a violent impact on a source of blood. Also, a mixture of round, symmetrical and teardrop-like stains was found to be highly suspicious for fly activity (Fig. 2a,b).

Additional tests under laboratory conditions on vertical paper surfaces with adult *Calliphora vicina* Robineau-Desvoidy (Diptera: Calliphoridae) blow flies matured and maintained at room temperature (20–25 °C) and supplied with a reddish-brown food mixture, led to the following results:

- After 1 day in a breeding cage, of 304 stains, 112 (36.8%) had a round shape whereas 192 (63.2%) had a tear- or sperm-like shape.
- The directionality measured along the longer axis of the tear- and sperm-like stains did show a random distribution of stain orientations with an artificial preference for the top left where a window (light source) was situated. In this experiment, orientation was directed into the following directions: 42.8% upwards left, 19.8% upwards right; 19.3% downwards left; and 18.2% downwards right.
- The ratio Ltl/Lb was 1.5 ± 1.6 ($n = 80$) (i.e., tendency towards ratios >1).

Table 1
Original data from crime scene in Case 1, $n = 32$ (suspected fly stains, tear/sperm-like shape only)

Stain number	Ltot	Lb	Ltl	*W*	Ltl/Lb	*A*
1	5.0	2.5	2.5	1.0	1.0	23
2	7.0	2.0	5.0	0.5	2.5	14
3	4.0	2.0	2.0	1.0	1.0	30
4	6.0	2.0	4.0	1.5	2.0	48
5	10.0	2.0	8.0	1.5	4.0	48
6	8.0	2.0	6.0	2.0	3.0	90[a]
7	9.0	2.0	7.0	2.0	3.5	90[a]
8	7.0	1.0	6.0	1.2	6.0	–
9	11.0	2.0	9.0	2.0	4.5	90[a]
10	9.0	4.0	5.0	3.0	1.3	48
11	6.0	1.0	5.0	1.0	5.0	90[a]
12	8.0	2.0	6.0	1.5	3.0	48
13	11.0	2.0	9.0	1.0	4.5	30
14	15.0	2.0	13.0	1.5	6.5	48
15	4.5	1.5	2.5	1.2	1.7	53
16	21.0	3.0	18.0	2.0	6.0	41
17	9.0	2.0	7.0	0.5	3.5	14
18	12.0	1.0	11.0	1.0	11.0	90
19	6.0	1.0	5.0	1.5	5.0	–
20	10.5	1.5	8.5	0.7	5.6	46
21	20.0	3.0	17.0	2.0	5.6	41
22	5.0	2.0	3.0	1.0	1.5	30
23	5.0	3.0	2.0	0.5	0.7	9
24	15.0	5.0	10.0	1.2	2.0	13
25	12.0	2.0	10.0	1.2	5.0	36
26	4.5	2.5	2.0	0.9	0.8	21
27	3.0	2.3	0.7	0.7	0.3	18
28	6.0	5.4	0.6	1.0	0.1	11
29	5.0	2.0	3.0	2.0	1.5	–
30	6.0	4.0	2.0	1.0	0.5	14

Ltot: total length of stain in mm; Lb: length of body in mm; Ltl: length of tail in mm; *W*: width of body in mm; Ltl/Lb: ratio of length of tail/length of body; *A*: impact angle (*W*/Lb) (°; standard ratio for any bloodstain).

[a] Equal body length and width with a tail.

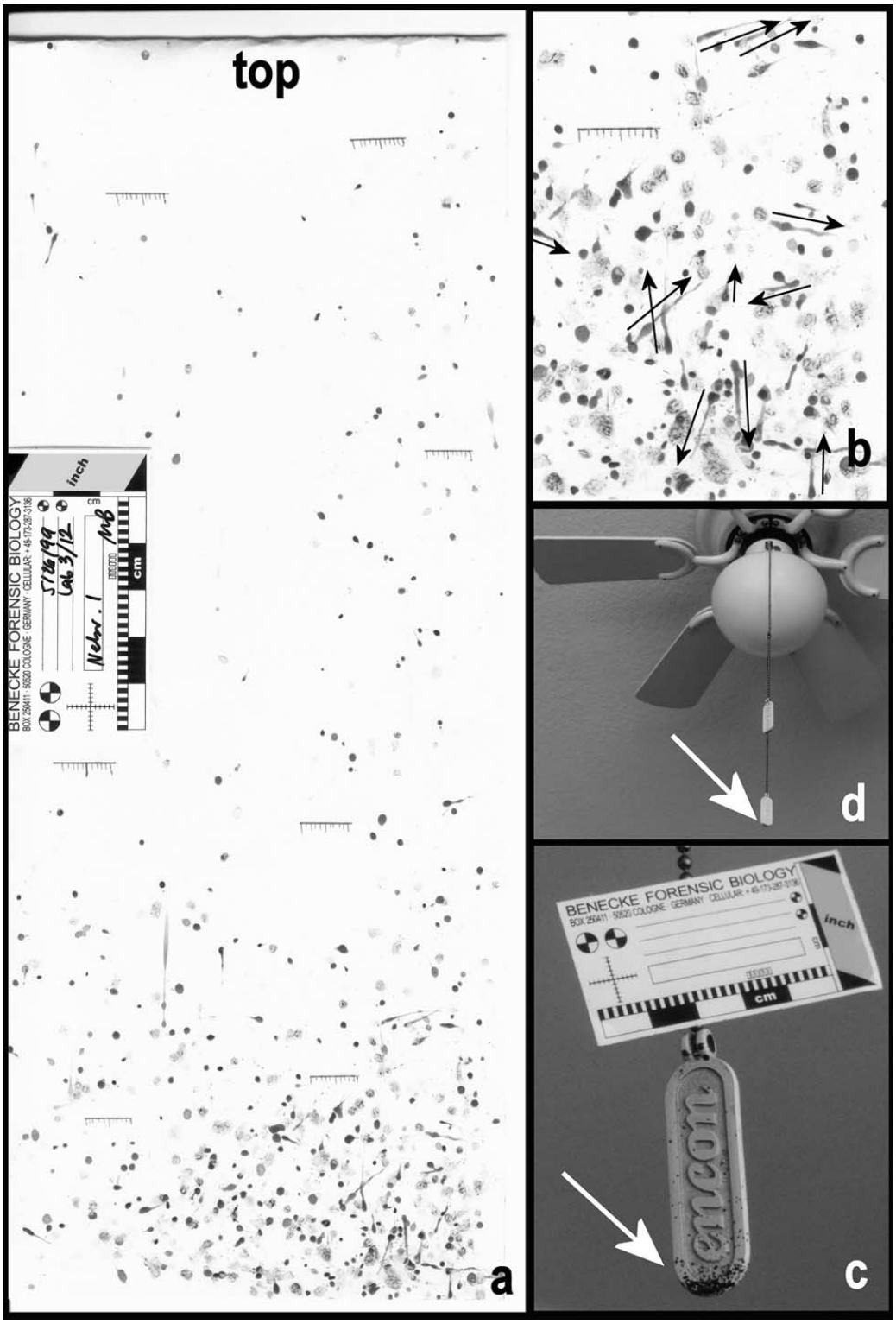

Fig. 2. Patterns of distribution, localization and orientation of stains. Case 1: (a) General orientation of blood spatter-like fly droppings in the laboratory (adult *Calliphora vicina* blow flies) on a vertical surface after 1 day in a breeding cage. Animals preferred bottom border for unknown reasons. (b) Random directionality of stains; as examples only, some arrows indicate directionality. (c and d) Location and concentration of stains in Case 2. Stains are too small to display directionality. In (c), note the similarity in distribution area compared to Fig. 1 even though more flat space was available for the flies to rest on.

However, single stains will not provide results that are statistically sound. Although the ratio does not conclusively identify a stain as a fly artifact, it provides a tool to eliminate suspect stains (see also Section 6).

3.5. Conclusion

With information that stains appearing as human blood spatters were fly artifacts, coupled with other scene evidence, we felt confident that the possibility of an execution or revenge slaying could be put into the mix of suspect behaviors at our crime scene.

4. Case II: Corpse of lonely woman

In Summer 2001, a dead female person was found in her bedroom in an urban apartment in Cologne, Germany. The body had entered dried-out state of decay with severe undernourishment during lifetime and an underlying minimal greenish discoloration of the face and the abdominal area after death. In the anal region of the corpse, few blow fly maggots (oldest larval stage L3) were found. As soon as the windows were opened, adult *Lucilia* sp. entered the room. Therefore and because of numerous dots in the face of the dead person, the police asked if blow flies had been present, or if those dots had to be attributed to a source to be investigated on.

The windows were closed before the police entered which explained the presence of only few flies. We found mostly pupae of phorids (Diptera: Phoridae), which was in accordance with the reconstruction of events. Apart from piles of empty pizza delivery cardboard boxes and cigarette butts, which did not provide food sources for blow flies, the apartment was very clean and expensively furnished. The bathtub was half filled with discolorated water that was most likely used to wash clothing.

Since the entrance door was regularly locked and no signs of a violent fight were present, a reddish spatter field at a fan chain in the kitchen became of interest (Fig. 2c and d). The kitchen was located two rooms away from the sleeping room and there was no visible evidence that linked the kitchen to any violent event. Closer examination led to the conclusion that the stains were fly artifacts. Since the eyes of the corpse were still intact and not used as a food resource by maggots, it was concluded that only very few adult individuals of a smaller fly species had been living in the apartment at some point before, or at the time of death. Those few individuals used the fan chain as a resting place and deposited reddish material with a typical preference for the lower border of the surface. The same effect is present in Fig. 2a under laboratory conditions, yet in a much larger scale, where the flies also preferred the bottom border of the hanging piece of paper.

Because of the nature of the stains, they were neither taken into account for the further police investigation nor the reconstruction of the events at the scene. The case was considered to be self neglect in contrast to killing or neglect by another person [21].

5. Case III: Slaying of mother and child

On 30 January 2001, the dead bodies of a mother and her child were found in the living room of their house on the border of the city of Cologne, Germany. They had been dead for around 6 h. Another child that had been sleeping upstairs was alive and not hurt. Blood stain patterns were used to determine the course of events.

The crime scene reconstruction based on blood spatter became important to check the statements of an accused man who owned a knife that was used for the stabbing. For legal technicalities (rights of inheritance) it also became important if the woman, or her child had been killed first. Thirdly, the defense lawyer wanted proof that his client had stabbed the child with brutal force to make clear that his client had no mental control in the moment he performed the stabbing. Apart from medico-legal considerations, it was thought that the velocity of the blood spatter might help to address these questions.

Amongst numerous other reddish stains in the house (all stains were determined as originating from the victims by DNA typing), few very small stains on a lamp were observed. This lamp was located only ca. 1.80 m over ground and had been hanging directly between the locations where the two bodies were found. The police asked if these stains were caused by the impact of violence, or by flies. As in most cases, the presence of flies was not looked at by the first team which entered the house through a window. After that, all flies may have flown out of the window. Therefore, a combined blood spatter and forensic entomology expert statement was asked for by the police and later again requested by the judge during the trial.

The tiny, round stains on the lamp were distributed over the complete surface (Fig. 3). Genetic fingerprinting led to only one conclusive DNA type out of six stains (DNA of the child was found in one stain, no result in the other stains). It was discussed that the stains might have originated from the offender's knife that got stuck in the vertebra of the child (as documented by the forensic pathologist). When the offender took the knife out of the bone with a jerk, few tiny droplets of blood may have been distributed with a relatively high initial velocity but got slowed down due to the resistance of the air.

On the other hand, since a possible patterning as in fly artifacts could not be ruled out with certainty (Fig. 3 bottom), no absolute statement could be made about the nature of these stains. In the court, we reported that because of the season of the year (winter) and the state of the house (no rotting organic material present), it was less likely that flies had produced the stains but that it was more likely that the blood actually shed off the knife during the stabbing. Droplets then reached the lamp at least at two separate events whilst the lamp was

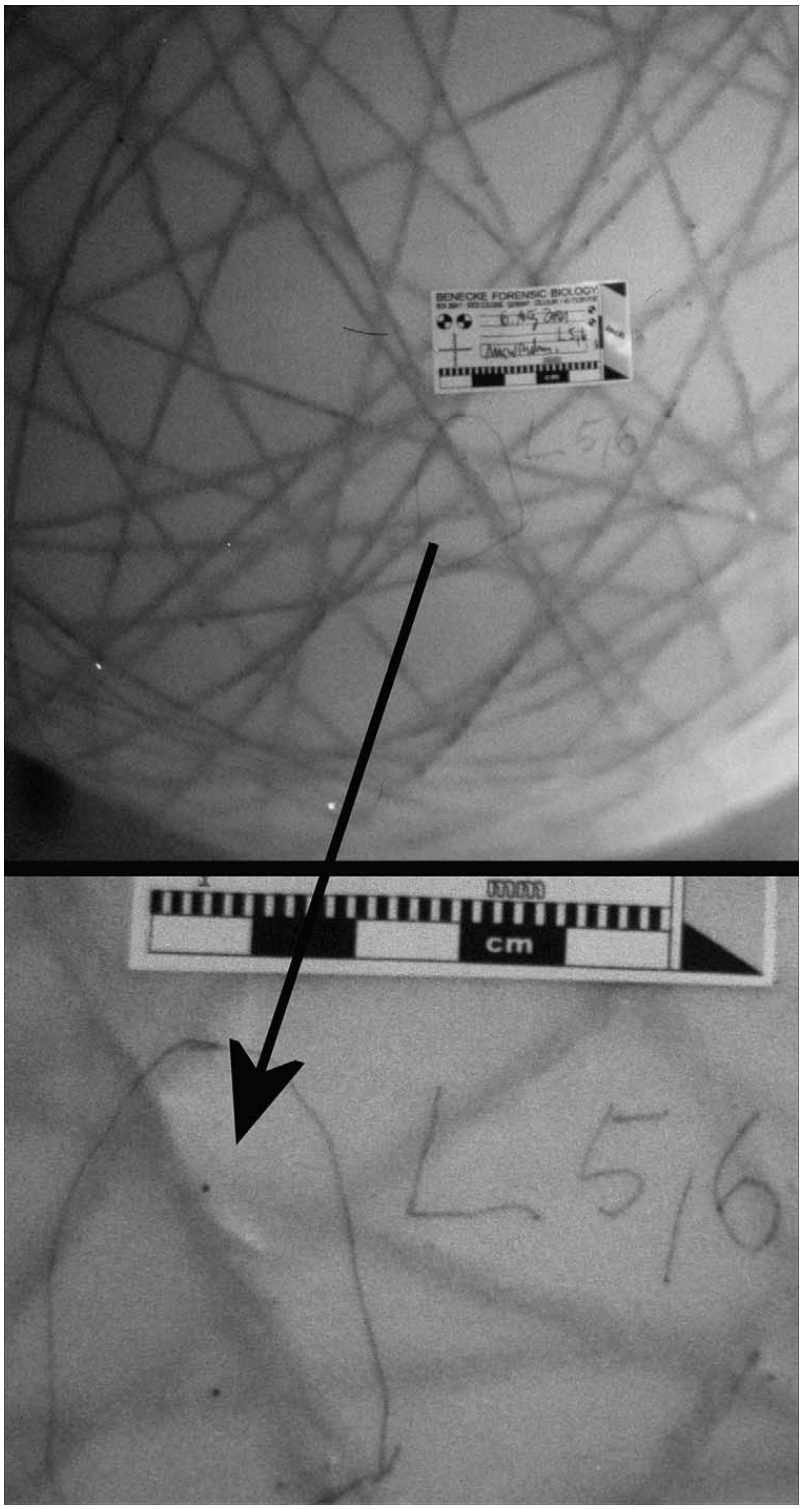

Fig. 3. Blood spatter-like droppings in Case 3. Top: Overview over lamp that was hanging only ca. 1.80 m over ground. Very small stains were found all over the lamp, on all sides, including top and bottom. Bottom: close-up of those stains. Stains were recovered by cutting them out, not by wiping them.

rotating around its axis. Since the lamp was located ca. in the height of an adult central European person's head, rotation was most likely induced by the people moving and maybe fighting, inside of the room during the crime.

6. Practical hints

From our case work experience and from our experiments, the following suggestions and techniques are offered

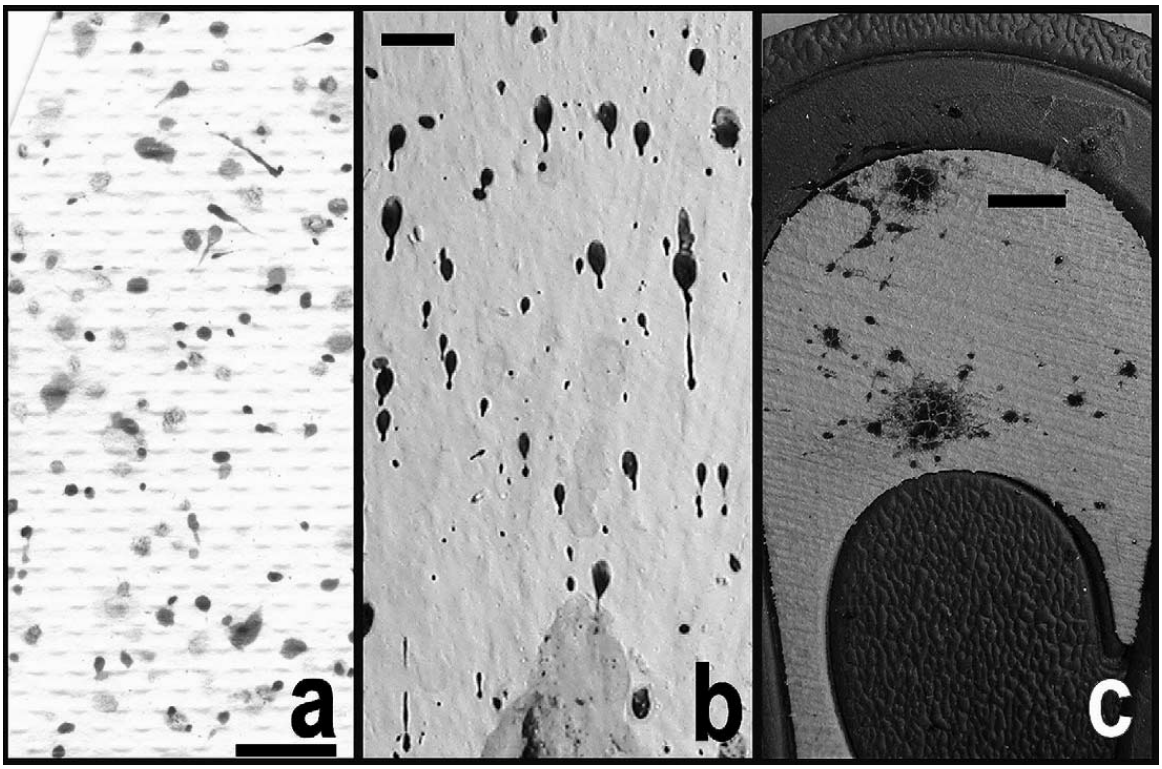

Fig. 4. Differences between blood spatter caused by violence in contrast to artifacts caused by flies. (a) Stains produced by flies on a vertical plane (sheet of kitchen paper): most prominent: random orientation of tails; body and tail frequently undistinguishable; tails do not end in dot. (b) Complex blood spatter pattern caused by blood that exited a punctured blood vessel of a man who was standing next to a vertical plane (wall) covered with wall paper. Larger stains do show orientation, their tails end in a dot, body and tail can be distinguished. (c) Stains on rough surface (kneeling person was shot, blot drops on top of sole of sandal): possible satellite spatter still recognizable. Bars: 1 cm.

for use in differentiating between fly artifacts and human bloodstain patterns (see also Fig. 4).

1. Document fly activity at a scene. Flies will be at a scene if access to the scene is available to them. They will stay at the scene as long as a food source is available to them and/or as long as they are trapped. Therefore, check for dead flies, too. If evidence of flies is present at the scene, assume that fly artifacts will be at the scene. Follow standard protocols of description of insects at crimes scenes [2,3,22]—where, when, how many?
2. Document the range of stains. Fly activity will often concentrate near light sources, on light colored walls, windows and mirrors. They will often be present in rooms away from the body. Compare stains away from the body with stains near the body.
3. Compare stains with known fly artifact patterns.
4. Identify suspected human bloodstain patterns that are of the ‘‘spot’’ or ‘‘tear’’ drop pattern that offer a potential for use in reconstruction and eliminate the following:
   (a) Stains that have a tail/body (Ltl/Lb) ratio greater than 1;
   (b) Stains with a tadpole/sperm type structure;
   (c) Stains with a sperm cell type structure that do not end in a small dot;
   (d) Any stains without a distinguishable tail and body;
   (e) Any stains with a wavy and irregular linear structure; and
   (f) Any stains that do not participate in directionality consistent with other stains that suggest a point of convergence at a point of origin. Larger fly artifacts, within a group, will point in all directions. Cast off human blood will produce stains, within a group, that indicates a common general convergence point.
5. Note the absence of known human bloodstain pattern characteristics. The absence of misting around a concentrated mass would suggest the stains might not be from human cast off blood origin. Within a group, human cast off patterns often leave secondary wave cast off patterns and run off patterns.
6. Cover blood stains, especially on the floor, with paper sheets to prevent them being destroyed by investigators walking on the stains.
7. One or two stains do not make a case. Stains that could be fly artifacts should be eliminated and an evaluation based upon stains that can be explained in terms of origin and relevance to the reconstruction.
8. Use a high-resolution camera with a macro functionality and include a scale in every single picture.

Forensic scientists, crime scene technicians and investigators may encounter blood spatter at a scene which may be pure or a mixture of fly artifacts and human bloodstains. It is important to be able to make an informed identification, or at least advanced documentation of such stains.

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