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Postmortem Insect Activity May Mimic Perimortem Sexual Assault Clothing Patterns

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ABSTRACT: Determination of perimortem sexual assault can be confounded in homicide cases in which only badly decomposed or skeletal remains are recovered. One indicator of assault is a characteristic pattern of clothing disarray, including tearing, removal, or displacement of clothing. Preliminary findings from two studies of clothed pig carrion of approximate human size (59 to 162 kg) reveal that postmortem insect activity, particularly maggot masses, and natural decompositional changes such as bloating can produce changes to clothing which mirror those seen in cases of sexual assault.

KEYWORDS: forensic science, postmortem change, forensic anthropology, entomology, sexual assault

The investigation and prosecution of few crimes rely as heavily on physical evidence as does the crime of sexual assault (1). Cases of sexual homicide are often difficult to solve because of a lack of this physical evidence (2), a problem which increases with delayed recovery of the body. Advanced decomposition of the victim complicates crime scene interpretation and can lead to inaccurate conclusions (3).

In sexual assault cases involving advanced decomposition, the physiological indicators of the assault such as the presence of semen and bruising (4) have disappeared and the identification of the sexual nature of the attack is dependent on crime scene interpretation. A primary indicator of sexual homicide is the state of the victim's attire or lack of attire (2,5). Ripped or soiled clothing and torn-off buttons are characteristic signs of a struggle (1). Patterns of disturbed clothing on the victim, allowing exposure of the breasts and genitals, suggest the sexual nature of the crime (2). These clothing patterns, termed ''sexual disarray'' (2), may be the only physical evidence of the assault remaining in cases involving decomposed or skeletal remains.

Interpretation of such evidence can be complicated by natural postmortem taphonomic processes, such as the alteration of the scene and evidence by carnivore scavenging (6). Insect activity has also been shown to modify the crime scene during the postmortem interval (7). Maggot masses are capable of transporting sizable objects such as dentures and bones considerable distances as well as producing postmortem artifacts that mimic perimortem trauma to soft tissues (7).

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Preliminary results from two separate field experiments using clothed pig carrion (*Sus scrofa*) as a model for human decomposition suggest that postmortem insect activity frequently reproduces the sexual disarray clothing patterns seen in cases of sexual assault and sexual homicide.

Materials

Fourteen pigs, ranging in size from 19 to 162 kg, were allowed to decompose at a research facility located 50 km west of Edmonton, Alberta (site 1). An additional six pigs, all 80 kg each, were decayed at a biological research station located within Edmonton city limits (site 2). Depositional environments included full sun, partial shade or full shade exposure as well as surface, open pit and partial burial depositions throughout the boreal forest and pasture research facilities (Table 1). Prior to deposition, all carcasses were dressed in adult-size clothing, complete with undergarments, socks or hose and shoes (Fig. 1*a*). Carcasses were monitored daily, including the recording of ambient, body and maggot masses temperatures. Observations were made with minimal handling of the carcasses and care was taken not to disturb the clothing. A photographic record was maintained throughout the experiment, which ran a total of 40 days (June and July 1997) at site 1 and 90 days (August to October 1997) at site 2.

The site 1 carcasses were initially protected from carnivore and rodent scavenging by wire mesh and cages. Control pigs, set out with no protection, showed no signs of scavenging during the first phase of the experiment and the protective cages were removed from all specimens early in the study.

Decompositional stage scoring followed a five-stage protocol, adapted from Anderson and VanLaerhoven (8):

Fresh—From the time of death until the first signs of bloating are seen. A decrease in body temperature, no odor and the arrival of blowflies and the subsequent depositing of eggs characterize this stage.

Bloat—Distention of the abdomen caused by gas accumulation in the carcass marks the onset of the stage. Other signs include discoloration and marbling, strong odor, an extruded anus and a decrease in body mass.

Active decay—Begins with the collapse of the thorax as a result of feeding by sizable maggot masses. The carcass is greasy and has a strong odor.

Advanced decay—Follows the disappearance of the maggot masses and features a marked decrease in overall body mass. Primarily mummified skin and putty-like flesh remain.

Dry remains—Only bone, cartilage and mummified skin remain. No odor is detectable and maggots are completely absent.

TABLE 1—*Summary of carrion environment, clothing and postmortem clothing changes.*

ID#	Initial Weight, kg	Depositional Environment	Clothing	Buttons/Seams Torn	Upper Clothing Displaced	Lower Clothing Displaced	Under-garments Displaced	Socks/Stockings Removed
SITE 1								
SFS-2	19	full sun/open pit	sweater/shorts					N/A
SFS-5	21	full sun/surface	shirt/underwear/socks				X	
SS-5	21	partial shade/surface	t-shirt/underwear/socks					
PRED1	26	shade/partial burial	dress/jacket/bra/slip/hose		X			
PRED2	26	shade/surface	dress/underwear/bra/hose					
SS-1	36	shade/surface	pants/shirt/socks/underwear		X			
SS-6	59	shade/surface	dress/underwear/hose	X		X		
SS-3	80	shade/surface	shirt/skirt/hose/underwear	X	X	X	X	X
SS-4	80	partial shade/surface	t-shirt/underwear/socks		X		X	
SFS-3	80	full sun/surface	skirt/shirt/underwear/hose	X	X	X	X	X
SFS-4	80	full sun/surface	shirt/jacket/pants/boxers/socks		X	X	X	X
SFS-6	80	full sun/surface	shirt/underwear/socks		X		X	
SFS-1	156	full sun/open pit	shirt/pants	X	X	X	N/A	N/A
SS-2	162	shade/surface	dress/bra/boxers/hose	X	X	X	X	X
SITE-2								
GFS-1	80	full sun/surface	t-shirt/skirt/jacket/socks	X	X	X	N/A	X
GFS-2	80	full sun/surface	shirt/pants/scarf	X	X	X	N/A	N/A
GFS-3	80	full sun/surface	sweater/jacket/pants	X	X	X	N/A	N/A
GSH-1	80	shade/surface	jeans/t-shirt/jacket/socks	X	X	X	N/A	X
GSH-2	80	shade/surface	t-shirt/jacket/skirt/hose	X	X	X	N/A	X
GSH-3	80	shade/surface	dress/tights	X	X	X	N/A	X

FIG. 1—(*a*) An 80 kg pig (SFS-6), hours after death, clothed and placed in full sun.

FIG. 1—(*b*) The same carcass (SFS-6), photographed 17 days postmortem. All clothing changes are the result of maggot activity only.

Observations

Insect activity generated substantial clothing changes, primarily during the bloated and active decay stages of decomposition. Maggot masses were observed shifting the position of clothes several centimeters over a period of minutes. Arrangement of the clothing on the carcasses changed daily from the onset of the first maggot masses (3 to 15 days postmortem) through to the advanced decay stage (11 + days postmortem), at which time maggots were no longer observed on the carcasses.

One important observation was the ability of the maggot mass to move clothing located on the underside of the body, despite the weight of the body overlying it and direct contact with the ground. The result, seen in the advanced decay and dry remains stages, was typically the bunching of clothes around the neck (Fig. 2) and distal hindlimbs (Fig. 3) in which the level of clothing is identical on both the upper and lower surfaces of the body. Of the carcasses dressed in skirts, the underwear and hose were removed down to the distal hindlimbs while the skirt was pushed up toward the thorax. Carcasses dressed in underwear and pants had both stripped down to a level equivalent to the ankles in humans (Fig. 1*b*).

Maggots in mass also completely removed articles of clothing, particularly snug-fitting articles such as socks, hose, shoes and underwear, and in one instance removed a sock from a hindlimb and transported it 35 cm from the body.

Carcass size was an important variable in the frequency and type of clothing changes observed. Carcasses 26 kg or smaller experienced only two instances of postmortem change (Table 1); all carcasses in this weight range reached the dry remains stage within the course of the experiment. All carcasses approximating human size (59 to 162 kg) experienced extensive clothing disarray; all but one of these carcasses had reached the advanced decay stage.

No significant differences in the degree of clothing displacement were observed between sun and shade exposed carcasses, although

FIG. 2—*156 kg specimen (SFS-1), surface deposited in full sun, seen 25 days postmortem. Note the uniform displacement of shirt towards the head on upper and lower surfaces of the carcass.*

FIG. 4—*A close-up view of the thorax and cranium of SFS-6, photographed 13 days postmortem. Following the removal of the protective carnivore screening (*upper right hand corner*), the maggot mass visible along the edge of the clothing shifted the shirt cranially and dorsally within a day.*

FIG. 3—*A close-up view of the distal hindlimbs of SFS-6, taken 13 days postmortem. Maggot masses (*upper left-hand corner*) were observed displacing the underwear distally along the hindlimbs.*

variations in the onset and timing of changes were noted. As direct sunlight stimulates maggot activity (9), masses developed 1 to 8 days earlier in the sun-exposed carcasses. Clothing changes were therefore seen earlier in the sun-exposed pigs at both sites.

Natural decay processes produced additional clothing changes. The bloating of the thorax caused the bursting of seams and the tearing-off of buttons in snug fitting shirts made of tightly woven, nonstretch fabrics. Discoloration of clothing began during the second week postmortem and was primarily the result of the seepage of fluid from the carcasses, in addition to slight rain and soil staining.

Discussion

The use of domestic pigs as models for humans in decomposition experiments is well established (8–14). They are considered by some to be the best available model for humans because of their equivalent thoracic cavity size (10), relatively hairless skin, and omnivorous diet with similar gut fauna (8). Carcass sizes of 22 to 23 kg have been recommended (15) and used (8,13,14) because this size approximates an adult male human torso.

The clothing-related findings of this study may not have been observed in previous pig carrion studies because the majority utilized unclothed specimens (8,9,12), small carcasses sizes (under 27 kg) (13,14), or carnivore protection which may have restricted clothing movement. A previous entomological/decomposition experiment involving humans utilized undressed cadavers (16).

The variations in frequency seen relating to carcass size may be explained, in part, by the better fit of the clothes to the larger-sized pigs. Only adult-size clothing was used and the clothes were often loose and ill-fitting on the smaller size carcasses (under 26 kg), allowing ample room for the maggot masses to maneuver beneath. However, loose fit alone does not fully explain the discrepancy between the small- and large-sized carcasses. Unbuttoned, baggy shirts on large carcasses were displaced by maggots (Fig. 1*b* and Fig. 4), while snug fitting undergarments and socks on smaller carcasses did not change position throughout the course of the experiment. Larger carcasses attract greater numbers of arthropods and support larger maggot masses than do smaller carcasses (12). This increased activity and mass size may explain the greater degree of clothing displacement observed on the larger carcasses.

Differential interpretation of the postmortem clothing patterns produced by insects from that of carnivores or the perimortem activity of humans requires careful observation of the victim's remains and clothing as well as that of the immediate surrounding area.

Discerning Insect vs. Carnivore Clothing Artifacts

Carnivores are capable of dramatically altering human remains, the crime scene and associated evidence, including clothing during the postmortem interval (6). Scavenging of soft tissues and the disarticulation and scattering of remains by carnivores may result in clothing patterns which superficially resemble those created by insect activity. Carnivores initially attack exposed parts of the body (17), and heavy clothing deters carnivore scavenging (6). Indicators of carnivore interference include the presence of characteristic

canine tooth puncture marks on bone, soft tissue or clothing (6), extensive disarticulation or scattering of remains (18), as well as the presence of tracks or scat deposits in the immediate area.

Despite considerable evidence of carnivores (coyote, fox and domestic dog) at both research facilities, only three minor instances of scavenging were observed at site 1. All three involved modifications to articles of clothing, yet were easily discernible from those produced by insect activity. One instance involved the disarticulation and complete removal of both hindlimbs with socks from one specimen in the active decay stage. One limb was carried one meter then discarded, while the other was taken four meters from the body and the foot was removed from the sock and partially consumed. The distance the remains were transported and the toothmarks evident on the partially consumed remains indicated the action of carnivores. A second instance involved the displacement and partial consumption of a scarf wrapped around the neck of a large carcass in a state of advanced decomposition. Puncture marks produced by canine teeth were clearly visible along the frayed border of the scarf and minor soft tissue damage with similar toothmarks was also observed at the same time. A final example of canid activity resulted in the moderate chewing and fraying of a shirt tail. Again, clear puncture marks were evident in the fabric.

A further important characteristic of canid activity, evident in the second and third examples cited, was the clothing pattern produced by the tugging of the canid on the clothing. The unidirectional force and the weight of the body on the underlying clothes resulted in the restricted movement of the clothing under the carcass and greater clothing displacement on the exposed areas of the body. This was in sharp contrast to the uniform movement of clothing above and below the carcass caused by maggot masses.

Discerning Insect vs. Human Induced Clothing Artifacts

In some instances, the source of clothing modifications that result from human interactions is easily discernible; assailants frequently remove the victim's clothing by cutting it off (19) or may even leave it folded neatly (2). Clothing changes may also be the result of the action of the victim themselves in cases of suicide (20) or accidental autoerotic asphyxiation (21), scenes which often resemble homicides.

Interpretation becomes more difficult in cases of clothing disarray, particularly in cases with an extended postmortem interval following the departure of the maggots from the carcass (7). The presence of pupal casings, deposited in the immediate vicinity or on the victim and their clothing, indicates prolonged postmortem insect colonization of the corpse (22) and raises the possibility of insect generated clothing artifacts. Total exclusion of insects throughout the decomposition process is unlikely (22); however, variables such as cold temperatures or postmortem disturbance of the body by humans or animals retard or arrest insect activity (7,22) to a level insufficient to produce clothing changes. Thorough examination of the victim, clothing and vicinity for indications of the presence, duration and magnitude of insect activity may be the only method of differentiating the causative agent of clothing changes.

Conclusions

Clothing disturbance patterns produced by postmortem insect activity mirror those derived from a perimortem sexual assault. Similarities between human-induced changes and artifacts created by insects and carnivores increase with extended postmortem interval and complicate crime scene interpretation. Differentiating changes caused by the various agents requires careful examination of the entire scene, including the victim's remains, clothing and depositional environment. Failure to recognize the potential for this phenomenon may result in inaccurate conclusions and the misinterpretation of perimortem events (7).

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