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The persistence of fibres on skin in an outdoor deposition crime scene scenario

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ABSTRACT

Textile fibres were transferred to a pig skin carcass and their persistence determined at daily intervals for up to a 12 day period during which time the carcass was left outdoors exposed to the prevailing weather conditions and animal activity. In the absence of strong winds and precipitation, the loss of fibres was found to be exponential. Stronger winds and heavier precipitation caused an increase in the rate of loss of fibres. The results of this study showed that the majority of fibres transferred to a body deposited outdoors, can be expected to be lost after the first 2 days, however, none of the experiments performed resulted in a complete loss of fibres, even after 12 days exposure. These persistence characteristics differed from those observed in a similar study using small sections of skin, rather than carcasses.

The implications of the results of the present study in relation to the examination of fibre evidence in cases of homicide are discussed.

1. Introduction

Very little data has been published regarding the persistence of fibres transferred to skin left exposed to an open-air environment in a homicide scene scenario. In such cases, fibre recovery from the body of the victim can provide very crucial evidence in both the investigative and corroborated phases of the ensuing police investigation. Where the victim of a homicide has been deposited at an outdoor location, this provides challenges in terms of fibre recovery — particularly in situations where the skin is wet or contaminated with soil or vegetation. In addition, if the body has been exposed to the elements for a considerable period of time, this raises questions as to whether any fibre evidence is likely to persist.

A case study by Spencer [1] reported that the clothing of a supine body exposed for 29 days to wind and precipitation retained significant fibre evidence. A study by Krauss and Hildebrand [2] using small sections of pig skin as a human simulant, investigated the factors affecting the persistence of fibres on skin under open-air conditions over a 14 day period. They concluded that wind velocity had minimal effect on fibre persistence but that a combination of wind and rainfall caused significant fibre loss. They also concluded that the chances of recovering fibres over such a time frame, in these conditions, were high. A study by Davidson and Riley [3] concluded that recovery of fibre evidence from wet skin was still possible using surface debris tapings.

The conclusions from these studies regarding the potential for the recovery of significant fibre evidence from the naked bodies of homicide victims exposed to the elements over a period of time, were confirmed by Palmer [4] who reported on fibre evidence recovered from 3 victims of a serial killing, deposited naked outdoors.

2. Aims

The aims of this study were;

- To investigate the effect of weather conditions on the retention of fibres on skin using a refined human simulant (pig carcass, rather than small skin sections) and a more realistic contact/transfer scenario (rather than 'seeding') as used in a previous study.
- To determine whether any inference/estimation concerning initial levels of fibre transfer can be made, after loss due to climatic exposure.

3. Experimental

3.1. Donor garments

A cream coloured 'River Island' size 14 sweater labelled as comprising of 70% wool fibre; 17% angora fibre and 13% nylon fibre was dyed with Rhodamine B (Basic Violet 10) dye. This produced a pink dyed jumper the constituent fibres of which fluoresce when exposed to ultraviolet light. The sweater was chosen as it was an extremely good shedder of its constituent fibres and deposited many fibres of differing sizes when coming into contact with a recipient surface. The constituent wool fibres were preferentially shed rather

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than the lesser components and therefore persistence with respect to generic fibre type could be ascertained.

A pair of yellow UV fluorescent acrylic leg-warmers was purchased on the internet. On receipt the leg warmers were found not to shed their constituent fibres particularly well and were therefore cut along their length to allow fibres to be readily shed at the cut.

3.2. Recipient surface

A 52 kg pig was humanely slaughtered at a local abattoir and sawn in half longitudinally, effectively producing two simulants. The outer surface of each half was washed with warm soapy water and the moisture removed from the recipient surfaces using paper towel.

In order to aid fibre counting, a grid of 10 cm × 10 cm squares was drawn directly onto the skin of both halves of the carcass using an ink fluorescing blue under an ultraviolet (UV) light source. The thirty 10 cm × 10 cm grid squares on each carcass half were each assigned a unique mark A; B or C1 to 10.

3.3. Fibre transfer

UV fluorescent pink wool fibres from the jumper were transferred to one of the carcasses and UV fluorescent yellow acrylic fibres from the leg warmers were transferred to the other. In order to simulate a realistic, prolonged and forceful contact between the donor item and the recipient carcass, the donor items were worn over a protective suit worn by the 'assailant' whilst carrying the respective carcass over his shoulder.

The carcasses were carried in this manner for a period of approximately 2 min.

Each carcass was then placed on the ground (skin side up) within a large open grass area on the laboratory grounds, each in an East–West orientation approximately 2 m apart. These remained static in the sight of a CCTV camera for a period of 12 days during which time the fibre persistence, climatic conditions and animal activity were monitored.

3.4. Fibre counting

A portable blackout tent was constructed using a 1 mm thick, black damp-proof membrane fitted over a wooden frame, which was sufficiently light proof to allow fluorescence of the transferred fibres to be visualised for counting. The use of the tent negated the need to unnecessarily move the carcass halves during the experiment.

Counting was carried out by carefully placing the tent over the carcass and using a portable UV light source, the number of fibres at each grid location on the carcass was recorded for the time zero.

The number of fibres at each grid location was then recorded for the time zero position (day 1) and the following 11 days.

The number of fibres remaining on each grid square at each daily count was recorded onto a Microsoft Excel spreadsheet.

3.5. Weather monitoring

A Lacrosse Technology WS2350 weather station was used to record and document the prevailing weather conditions during the period of the study. The base station measured and recorded weather data from the thermo-hygro, wind and rain sensors, these sensors having been placed within 3 m of the carcasses.

3.6. Animal activity

One of the laboratory perimeter security cameras was trained on the carcasses for the duration of the experiment and recordings from this camera were examined to assess the extent of animal activity.

4. Results

The number of fibres recorded immediately post contact (T^0) was 619 for wool and 374 for acrylic. By day 10, the number of fibres remaining was 5 for wool and 3 for acrylic (each representing a 99.2% loss) which in each case, persisted until day 12.

On day one of the experiment, the reduction in the numbers of wool fibres and acrylic fibres was from 47% to 67% respectively. By day two the loss was 67% of the wool fibres and 74% of acrylic fibres. By day five, the loss had increased to 93% for wool fibres and 96% for acrylic fibres. In each case, after day 5 there followed a more gradual loss until day 10, when no further loss was observed (see Fig. 1.).

The high initial loss of fibres on day one of the experiment occurred in the absence of any precipitation and an average wind speed of 0.7 ms^{-1} with a maximum of 8.1 ms^{-1} (see Figs. 2 and 3) This loss is likely to be of the more loosely adhering fibres and is at variance with the results of Krauss and Hildebrand [2].

A smaller reduction in the number of fibres was observed for days two and three. No precipitation was observed on either of these days and average wind speeds varied between 0.2 and 0.4 ms^{-1} with a maximum wind speed of 4.4 ms^{-1}. Day four saw 10.3 mm of rain fall (3.6 mm in 1 h), associated with average wind speeds similar to previous days, which resulted in a large decrease in the number of fibres (more marked for acrylic fibres) suggesting that rain may contribute to fibre loss to a greater extent than wind.

Higher average wind speeds on days five and six with no rainfall associated did not result in significant fibre loss. A gradual loss of fibres was observed for the remainder of the experiment where low average and maximum wind speeds were noted.

It was of note that the longer wool fibres appeared to persist for a greater amount of time on the more hirsute areas of the carcass half. This was less obvious for the shorter acrylic fibres. This observation is in keeping with that of Palmer and Banks [5] who found that wool tended to have a greater persistence in head hair than other fibre types and proposed that this was due to scale to scale interactions.

4.1. Animal intervention

The CCTV footage for the 12 day period was viewed and the date–time and duration of animal activity recorded. Graphs of total animal intervention were produced for comparison with fibre loss from each pig carcass. Since the laboratory grounds where the experiment was performed is surrounded by a security fence, the opportunity for the carcasses to be visited by carnivorous mammals was extremely limited and consequently such activity was confined to gulls and crows.

The majority of the time, the crows and gulls were seen to peck at the exposed flesh or maggots around the periphery of both seeded pig

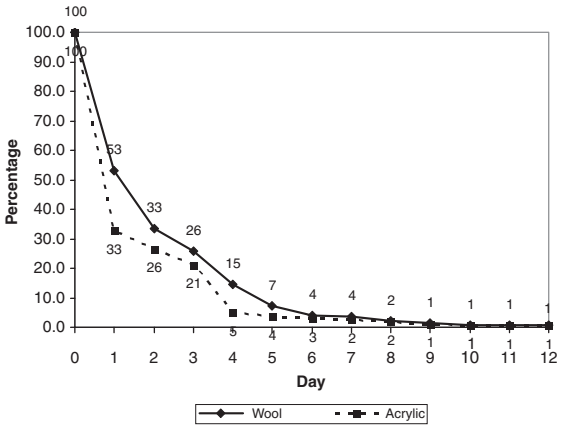

Fig. 1. Percentage loss of fibres.

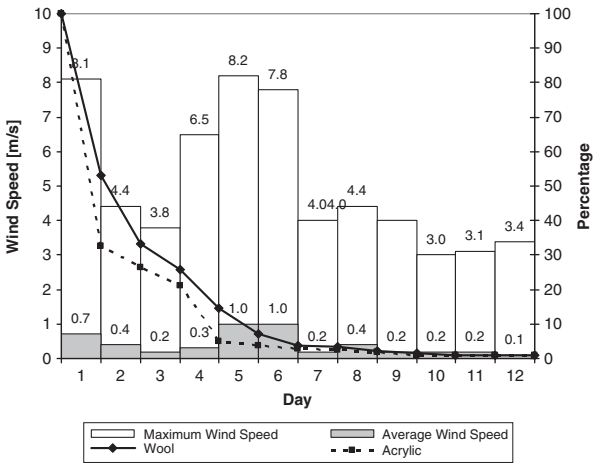

Fig. 2. Effect of wind.

sides rather than at the recipient skin itself. The authors believe that this would not contribute to any great extent to the loss of fibres except possibly at the very margins of the grid squares. However, on a number of occasions gulls, and less often crows, were observed to walk over, or stand on, or flap their wings over the skin of the pig sides, particularly whilst chasing away other birds. Whilst no correlation was found between this activity and any significant loss of fibres; nevertheless, the presence of a secure perimeter fence around the deposition area would have severely reduced the potential for scavenger activity. The potential for fibre loss attributable to animal activity, is therefore likely to be underestimated in this study.

5. Discussion

The initial high loss of both fibre types is consistent with the results of a number of previous fibre persistence studies on a variety of surfaces, e.g.; garments [6,7], head hair [8]; shoes [9], hands and gloves [10] and on the skin of living subjects [11].

Whilst these previous persistence studies demonstrated an exponential loss of fibres from moving recipient surfaces, a similar exponential loss was observed in this study using the static pig skin recipient, however, the rate of loss was much lower. An exponential fibre loss, demonstrating a greater degree of fibre persistence over time, punctuated by larger losses dictated by the weather conditions, appears to be achieved by the static pig skin.

The retained fibres were found to be evenly dispersed on each carcass on each day of counting, implying minimal redistribution.

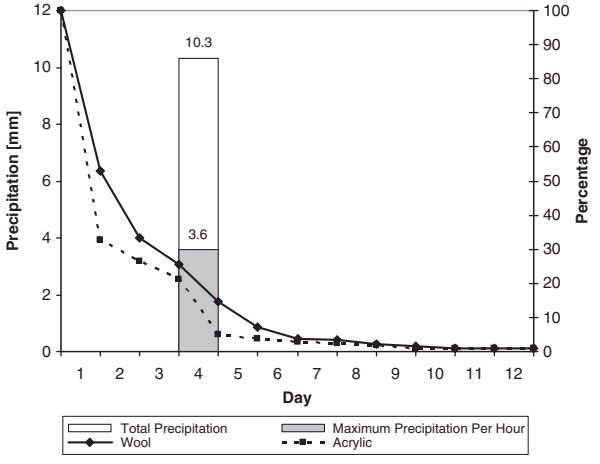

Fig. 3. Effect of precipitation.

Whilst only two fibre types were considered in this study, the very similar results obtained in terms of rate and nature of fibre loss, are in keeping with other persistence studies [6–8]. This suggests that while other fibre types may differ in terms of numbers persisting in such a scenario, they are likely to demonstrate the same characteristics in terms of the persistence dynamics. The authors therefore believe, that in general, it is safe to assume that a large proportion of fibres transferred to a naked body deposited outdoors can be expected to be lost in the first 2 days. This data therefore potentially provides a means of assessing the nature of the contact between items relating to the assailant and the victim.

The results of this study are not in accordance with the rate of fibre loss reported by Krauss and Hildebrand [2] who noted only a small reduction of 10–28% of the fibres (depending on generic fibre type) over the first 10 days where no rain was measured and winds were of average speed (from 3.1 to 6.7 ms^{-1}). This loss appeared to be linear rather than exponential in nature. Little fibre loss was observed on the eleventh day where precipitation amounted to 2 mm, however, on the twelfth day alone where precipitation was 9 mm, a 58–70% loss of fibres was observed.

The discrepancy is most likely due to the different experimental designs; the present study used more realistic human simulant surface (involving a larger and more 3 dimensional surface area) with a more realistic contact situation, rather than small recipient 2 dimensional surfaces which were then seeded with fibres.

6. Conclusion

Whilst only two fibre types were considered in this study, the authors believe that the congruence of results observed, shows that in general, a large proportion of fibres transferred to a naked body deposited outdoors can be expected to be lost in the first 2 days. This indicates that any significant fibre collectives recovered from such a body after this time, are very likely to represent only a proportion of those originally transferred.

Where an estimate of a time of outdoor deposition of a body can be made (e.g. via pathological and entomological data) and significant numbers of fibres representing a collective are recovered days after this estimate, the authors' believe it is safe to assume these represent a primary contact around the time of the deposition.

Whilst the authors believe that the previous study [2] underestimates the rate of fibre loss, this study also confirms the finding that useful fibre evidence can be recovered from the victims of homicide who have been deposited outdoors over a significant period of time.

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