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CLOTHING FIBERS AS EVIDENCE

A Study of the Frequency of Occurrence of Blue Wool Fibers

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It is common knowledge that loose fibers of all varieties adhere easily to clothing, and that when two sets of clothing come in contact, some fibers from each will be transferred to the other. This transfer will be greatest for the shorter and less conspicuous fibers, and its amount will depend largely on the adherent qualities of the cloth involved. In most crimes of violence, the clothing of the perpetrator contacts, sometimes forcibly, that of the victim, often for relatively long periods, as in certain assaults, sex offences, etc. Moreover, in crimes that do not involve violence, fibers are often available as significant evidence. Thus clothing fibers may often be removed from hit-run cars, window-sills, furniture, and the like.

The significance of cloth fragments has been frequently studied, and matching of torn edges, thread counts, and similar procedures have been the means of solving numerous crimes. The occurrence of such propitious evidence as a piece of cloth is of negligible frequency as compared with that of detached fibers. Yet, the latter has received little attention in the literature of criminology and little, if any, quantitative study. In this paper is reported a study of the frequency of occurrence in men's suiting of the various types of blue wool fibers. These were chosen because blue is the most common color found in men's suit cloth, and wool makes up the bulk of most of the cloths used. When it is possible to give the average frequency of occurrence of each particular kind or color of fiber in an individual's clothing, it will be practical to calculate the probability that two sets of clothing have been in contact based on the number of such fiber species which have been transferred or found in common between the two sets of clothing in question.

In one case investigated in this laboratory, the clothing of a victim, that of two suspects, and residues from the scene of the crime were studied for the common occurrence of identical fibers. In all, sixteen distinguishable varieties were found to check. This evidence, supported by various other evidence of physical nature, was sufficient to obtain a conviction. In another case, involving the rape of a young child, eleven varieties of fibers were found on clothing of both suspect and victim. These included three types from the child's pajamas, and eight from the clothing of the suspect. This evidence was also instrumental in obtaining conviction. Numerous other cases have been studied in which clothing fibers have figured as highly important, and sometimes almost the only available, evidence. In all such cases it is vital to establish not only the identity of fibers from different known sources,

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but also to evaluate the significance of these identities.

General Considerations

The microscopic identification of the kind of a fiber (cotton, wool, silk, etc.) is usually simple and has been very adequately treated in the literature of criminology and that of the textile industries (1) (2) (3) (4). Subdivision of a specific kind of fiber into groups which depend on differences of morphology has been found rather useless because many variations in fibers exist within a single thread, although in special cases, such factors may be found useful. Subdivision according to color is apparently much more valuable because modern dyeing technique ordinarily colors all similar fibers quite uniformly. In the case of wool, the exceptions are sufficiently rare as to constitute evidence of identity in themselves, and, to a lesser extent, this may be considered to be true also of other fibers. The outstanding general exception is print dyed cloth which is most commonly woven from cotton.

In classifying fibers according to color, the number of groups found will depend largely on subjective factors, these varying between individuals. This matter may be dealt with only in some reasonable, empirical way. Experience shows that two or more investigators comparing the same fibers will, in general, agree quite closely as to their identity.

If the frequency of occurrence of particular fiber types and shades of colors is once established, and if one then finds matches for every fiber type found in a piece of clothing, it means that this or another identical cloth was involved. This is the most important limitation of the value of fiber evidence, viz., that numbers of suits may be cut from the same kind of cloth. Usually this limitation is not so important as it appears, for, in most cases, two sets of clothing are involved and cross checks will be found both ways, i.e., victim's fibers on suspect and suspect's fibers on victim. Moreover, many cases involve mixed rather than uniform clothing, a factor which increases the probability of identification. Still another important favorable factor lies in the frequent transfer of stray fibers carried on, but not an integral part of, any of the clothing directly involved. In fact, it is these loose fibers which transfer most easily of all because they are carried loosely on the surface without being attached. Such fibers will be quite characteristic of the environment of the clothing, and may be even more significant than fibers normal to the clothing because of the great variety of fibers possible.

Since a single cloth may contain a diversity of fibers as great or greater than an entire set of clothing, it follows that the set of clothing may be treated as though it were one cloth. Probability factors calculated on the basis of single cloths will be as valid in the one case as in the other. This will also be true in case a cloth is composed of only one or a few colors of fibers so long as the cloths used for calculation of the factors are representative. Actually, the chance of successfully identifying a set of clothing will often be greater than that for a single cloth because of the wider diversity of fibers which will normally be found.

Experiment

In all, 193 cloths were studied for the occurrence of all shades and hues of blue wool fibers. The cloth samples were tailor samples of woolen and wool-rayon fabrics for men's suits. In each case, all shades and hues of blue wool were separated and standards were established arbitrarily. Only predominantly blue fibers were taken, excluding those which were more purple or green than blue. Standards were chosen to differ so definitely that no possibility of confusion could exist. In so doing, some possible intermediate shades may have been omitted. The standards, then, represent a minimum rather than a maximum number of possibilities, and all results based on them yield the corresponding minimum probability. Another observer might choose to set up more standards and increase the apparent probability accordingly, but it is felt better to risk an error on the conservative side than the contrary. Moreover, some variation in dyeing is inevitable, and it is necessary to have a spread between standards that will bracket any such normal variation.

In all, 26 standards were established ranging from white-blue to black-blue. Each was definitely distinguishable from all of the others, but included all clearly observable variations of hue and intensity of blue that were found. Every cloth was thoroughly examined and the existence of all blue wool was recorded according to the standards which were matched. A Leitz comparison microscope with 16 mm. objectives was used with transmitted light to establish matches. In all cases, the illumination was carefully balanced by use of known identical fibers under each tube, after which the unknowns were compared.

Though the choice of standards was somewhat arbitrary, it may be of interest to list the colors of those chosen. They were arranged in order of increasing intensity in most cases. There were included, in order, 4 shades of very light blue; 6 light blues including shades of greenish and violet blue; 8 medium blues including green and violet shades of blue; 5 dark blues including green and violet shades; 1 very dark blue, and 2 very dark blue black.

Results

Of the 193 cloths studied, 81 were found to contain no blue fibers, while 112 had one or more shades or hues of blue. The distribution of blue wool throughout the cloths is shown in Table I.

TABLE I

Distribution of Blue Wools in Cloth Samples

Number of blue shades	Number of cloth samples
1	37
2	24
3	16
4	22
5	11
6	0
7	1
8	0
9	1

It is seen that many cloths contain multiple types of blue wool, but rarely more than 5 such types. The explanation for the high incidence of cloths with 4 different blues is not apparent. Many fabrics which appear black are, in reality, made up of fibers which appear dark blue, purple, gray, green, and, infrequently, black when viewed with transmitted light. Many of the dark threads contain varying color as well as hue and intensity and this becomes very valuable for identification.

Table II shows the frequency of matches with each of the standards. It is observed that nearly all of the standards were matched by a small percentage of the cloths, e.g., 2—7%. In only 4 instances out of 26 was the percentage greater than this, though in two instances (standards 20 and 24) it was greater than 16%. Standard 20 was a dark violet blue, and 24 was a very dark blue.

TABLE II
Frequency of Matches with Each Standard

Standard	No. of Matches	% of Cloth Containing Matches
1	9	4.66+
2	13	6.74—
3	12	6.22—
4	13	6.74—
5	5	2.59+
6	11	5.70—
7	7	3.63—
8	12	6.22—
9	12	6.22—
10	3	1.61—
11	16	8.29+
12	4	2.07+
19	12	6.22—
20	33	17.10—
21	10	5.18+
22	8	4.15—
23	8	4.15—
24	31	16.06+
25	14	7.25+
26	5	2.59+
Total	295	
Average	11.35	Aver. 5.88

It is to be expected that some shades and hues of a color will be more frequently encountered than others due to availability of dyes, popularity of colors, and other factors. Perhaps the unexpected feature of the data of Table II is the relative uniformity of occurrence of the different variations of blue, a uniformity which is sufficient to assume that the average occurrence of 5.88% will be a reasonable approximation to the occurrence of nearly all of the possible shades or hues of blue wool fiber.

No conclusive evidence is available to show that the probability of occurrence of a particular shade of blue wool is the same as that of the occurrence of shades of other colors or of other fiber types. General observation certainly indicates that the chance of finding some particular shade of blue rayon, green wool, etc., is less than that for a shade of blue wool because of the more frequent occurrence of blue than other colors and of wool than other fibers. Without conclusive evidence it seems entirely conservative to say that no more than 1 cloth in 20 should contain, on the average, any particular hue, shade, and color of a particular fiber type so long as only men's suiting is concerned. This figure is obviously improbable for such common types of fiber as white cotton, which is of such wide and general occurrence that it rarely or ever should receive any consideration in matters of this kind. There seems no reason to draw a different conclusion for women's clothing than for men's if reasonable discretion is used in interpreting the results. A greater probability of repetition is to be expected in the wardrobe of most women because of the greater number of garments. This factor should be more than offset by the greater variety of fiber types and colors represented. Adherence to seasonal color styles may alter the situation in special cases. Further work to check these points should be performed.

It is of interest to calculate the probability factor characteristic of fiber matches. If we accept the figure of 1 in 20 for the occurrence of any particular type of fiber in clothing, then a single fiber match would, on the average, limit the number of possible sources to that number. Five such matches would limit the possibilities to $(1/20)^5$ or one in 3,200,000. Ten matches would be limited to 1 in 10^{13} which in practical work is sufficient to be considered absolute certainty. In fact, 6 matches might be considered as establishing virtual certainty, with a probability factor of 1 in 640,000,000. If, for the sake of conservatism, the absolutely safe value of 1 in 10 be taken as the factor for a single fiber, it is still apparent that nine matches give a probability factor of 1 in 1 billion, a factor approaching certainty. Such figures must be interpreted with care, largely because they refer only to the probability of a kind of cloth being involved and take no account of the fact that numerous individuals may wear identical clothes. As pointed out before, this difficulty may, in most cases, be favorably resolved by considering mutual cross matching of the sets of clothing, matching of stray fibers, and the usual occurrence of multiple types rather than a single type of cloth in the clothing involved. If such factors are not present, it then becomes possible only to establish the probability of a type of cloth being involved rather than a particular person wearing that cloth. Statistics on the frequency of use of particular types of cloth should be collected in order that accurate probability factors might be calculated for the individual rather than for the cloth.

A further point that may aid the investigator is the consideration of the proportion of each fiber type in the cloth which tends to be duplicated in the fiber matches. This would in no way affect the probability factors given above, since they are calculated purely on the basis of their occurrence in cloths. It would affect the probability of finding a particular match in a specific case.

Summary

In order to determine the frequency of occurrence of the distinguishable hues and shades of blue wool in men's suit cloths, a study was made of all blue fibers in 193 samples of woolen cloth.

Single fiber varieties were found to occur, on the average, in 5.88% of the cloths examined.

An analysis of the value and use of such frequency data in the investigation of crime is presented.

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