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EVALUATION OF TEXTILE FIBERS AS EVIDENCE*

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Prof. Paul L. Kirk, School of Criminology, University of California, Berkeley, presents another of his research reports. This is the second article on clothing fibers and their value as evidence, the earlier study having been published in this Journal in 1942. Prof. Kirk has published a number of important police science research reports on various forms of physical evidence and is author of the text, *Density and Refractive Index, Their Application to Criminal Investigation.*

Gabriel L. Plaa and David C. Barron were both graduate students in the School of Criminology, University of California, when this paper was prepared. Mr. Plaa is currently serving in the U. S. Army and is assigned to Military Police Duty, Camp Gordon, Georgia. Mr. Barron is still engaged in graduate studies.—EDITOR.

Textile fibers are among the more common of the microscopic items which occur in evidence, particularly in the debris swept from clothing.(1) Fibers may also be found on all types of surface with which individuals concerned in crime may come in contact, e.g. window sills and furniture. Crimes in which bodily contact occurs show a particularly high incidence of transfer of fibers between the clothing of persons involved, so that fibers are potentially most important evidence in many murders, rapes, and assaults.

Textile fibers are so frequent in occurrence and so commonplace that many investigators overlook or disregard them on the ground that they occur everywhere and therefore have no particular significance in the elucidation of criminal acts. This view has been shown to be erroneous by the study of Burd and Kirk(2) who found that the actual incidence of any particular type and color of fiber was so low as to give its presence a considerable value as evidence. Thus, the clothing of a victim and of a suspect, both of which contain fibers of a particular type and color can be stated to show a certain probability of contact. With a single fiber match, this probability is relatively low since fibers of a single distinguishable color and type were found to occur on the average in a little less than 6 percent of the cloths of a series of 193 wool suitings that were studied.

It would then be expected that on the average, one would search in about 18 cloths before finding a particular type and shade of blue wool fiber. If this value is rounded out to 20, the probability of two particular types of blue wool fiber being found in a single cloth would be 1/20 x 1/20 or 1/400. If this incidence is characteristic of clothing in general, and 8 varieties of blue wool found in one set of clothing matched exactly with similar fibers from another source, the probability of all eight being simultaneously present by accident (or without contact) in both would be the minute value of 1/25,600,000,000, which is virtual certainty. In actual cases, as many as 14 specific types of fiber matches

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have been found between clothing or environment of a victim and that of a suspect, and when contact has occurred 5 or more such matching types are customary.

Since the investigation of Burd and Kirk was limited to the incidence of blue wool in men's suiting, there must be several questions remaining about which a certain degree of speculation is necessary. Thus, is the incidence of stray fibers, i.e. fibers from accidental contacts in a wardrobe, or in casual contacts with other clothing, comparable with that of the actual fibers of which the cloth is constructed? Are the items of clothing worn by women comparable with those worn by men? Is the incidence of cotton, rayon, etc. comparable with that of wool? Is the incidence of colored wool other than blue comparable with the incidence of blue wool? Experience will give some tentative answers, e.g. blue is one of the most common colors; women have a greater variety of color in their clothing and more unusual shades than do men; rayon is shed far less than either cotton or wool even when as much of it is worn; and cotton clothing is made in many more shades and colors than wool clothing. Thus, there is little reason to believe that the study of blue wool is not one of the most conservative choices that could be made, except for the first question of accidental, or stray fiber incidence. It has been the practice in this laboratory to assume that the varieties of stray fibers may be more numerous on cloth than the variety of fibers used in the construction of the cloth. Because of this uncertainty, a probability figure of 1/10 has ordinarily been employed instead of the 1/20 given in the above calculation.

The investigation reported here is a continuation study of fiber and fiber match incidence to elucidate specifically the question of stray or accidental contamination of clothing with fibers from miscellaneous sources. It throws considerable light on the matter of relative incidence of non-blue wool fibers, and some on the comparative incidence of wool fibers of miscellaneous origin in women's as well as men's clothing.

Experimental

In order to study the incidence of fibers from unknown miscellaneous sources, it was necessary to collect from a number of sets of clothing such residues as would be separated with the suction filter. (1) Further, it was essential that none of the sets of clothing swept would be those normally in contact with each other, since contact is all that this type of study is expected to demonstrate, and to have contact when studying accidental contamination would destroy the results. The clothing of 22 men and 13 women was swept, taking special care that none of the parties concerned

were associates of any of the others, and any contact between them would be of a purely casual or accidental type. Each would, however, have on his or her clothing those residues normally acquired from wardrobes, furniture, and other persons with whom contact was normal. The name and address of each person whose clothing was swept was recorded so that other persons of the same household might not be included in later collections. Two samples were taken from each person, one from the surface of the clothing, representing the most recent accumulation which is rapidly and continually lost and replenished, and another from the pockets and pants cuffs which represents a longer term accumulation, and in general a larger sample. In this study only the results of the surface sweepings are recorded.

This study was limited to wool fibers, partially because the number of varieties of cotton fibers is so great that time did not permit their study, and partially because both the segregation and matching of cotton fibers are more difficult and time-consuming than that of wool fibers.

The colors of wool fibers studied were (a) white; (b) opaque black; (c) red; (d) blue; and (e) green, which includes between 90 and 100 percent of all the wool fibers found on clothing. One set of sweepings was examined under the stereoscopic binocular microscope, and all varieties of wool fibers of the colors studied were segregated. These were mounted and compared among themselves to ascertain the distinguishable shades. Each of the latter was established as a standard, disregarding duplicates of any given distinguishable shade. The next set of sweepings was then examined, searching for any fibers that matched any of those from the first. All that did not match were set up as separate standards. This was repeated throughout the entire 35 samples. In all, 595 subject comparisons were made for each of the three colors, blue, red, and green, using a Leitz comparison microscope at 100 X and 440 X, with transmitted illumination. Uniformity of illumination was guaranteed by cutting a fiber in half, mounting each half on a separate slide, and adjusting the two fields of the microscope until an accurate match was obtained between the two halves of the same fiber, and between the fields. Before it was decided that two fibers matched, they were switched between the two fields to ascertain that they matched in both positions. The criteria used for a final match were (a) similar size; (b) similar gross characteristics, and finally (c) indistinguishable color variation.

RESULTS

Designation of fiber shades is difficult since the same word descrip-

Table I.

DISTINGUISHABLE SHADES OF COLOR

RED Designation	*Distinguishable Shades*
1. Dark red	5
2. Medium red	8
3. Light red	4
4. Medium pink	7
5. Light pink	2
6. Brownish pink	3
7. Dark red orange	5
8. Medium red orange	4
9. Dark red violet	7
10. Medium red violet	3
11. Light red violet	5
GREEN	
1. Green	5
2. Light blue green	4
3. Blue green	4
4. Light, light blue green	3
5. Yellow green	3
6. Medium green	2
7. Olive green	1

BLUE Designation	*Distinguishable Shades*
1. Dark blue violet	4
2. Royal blue	8
3. Blue	10
4. Dark blue purple	6
5. Navy blue	3
6. Medium blue violet	4
7. Blue green	4
8. Blue gray	5
9. Medium blue purple	3
10. Light blue violet	3
11. Medium blue	2
12. Light green blue	1
13. Blue black	1*
14. Light blue gray	1
15. Light blue purple	3
16. Light blue	2
17. Dark royal blue	1
18. Miscellaneous*	2

*Two fibers were multi-color blue.

tion may fit various shades that are definitely distinguishable. A list of the shades that were distinguished and their word descriptions is given in Table I. In addition, the two colors, white and opaque black which are single colors, were studied, but not included in the table. Table I lists a total of 53 distinguishable shades of red divided between 11 categories, 63 distinguishable shades in 18 categories of blue, and 22 shades in seven categories of green. Clearly the categories chosen were completely arbitrary, and another observer might break down the list into more or less divisions, and might assign to them different word descriptions. However, that observer would not be likely to differ significantly on the distinguishable fiber categories because it is common experience that if one experienced observer can distinguish a difference in two fibers, other normal experienced observers will almost always coincide in this distinction.

It was noted that 34 of the 35 persons examined had one or more red wool fibers on their clothing; 33 out of the 35 had one or more blue wool fibers; and 22 of the 35 had one or more green wool fibers. White wool, indistinguishable in color between fibers was found to occur in the sweepings of 33 of the 35 persons, or in a total percentage of 94.3. Thus, it can be stated that white wool matches are in general of little value in criminal identification, though the character of the wool, or a very unusual quantity of it might well increase its value in a specific instance.

Black cloth is only occasionally dyed in such a manner that the in-

Table II.

RED WOOL FIBERS

Color and Shade Number	*Incidence*		*Matches*	
	Persons	*%*	*Number*	*%**
Dark Red				
1	2	3.8	1	2.9
2, 3, 4, and 5	1	1.9	0	Less than 100/34**
Medium Red				
1 and 2	2	3.8	1	2.9
3, 4, 5, 6, 7, and 8	1	1.9	0	Less than 100/34
Light Red				
1	2	3.8	1	2.9
2, 3, and 4	1	1.9	0	Less than 100/34
Medium Pink				
1	3	5.7	2	5.9
2 and 3	2	3.8	1	2.9
4, 5, 6, and 7	1	1.9	0	Less than 100/34
Light Pink				
1 and 2	1	1.9	0	Less than 100/34
Brownish Pink				
1, 2, and 3	1	1.9	0	Less than 100/34
Dark Red Orange				
1	3	5.7	2	5.9
2, 3, 4, and 5	1	1.9	0	Less than 100/34
Medium Red Orange				
1	3	5.7	2	5.9
2, 3, and 4	1	1.9	0	Less than 100/34
Dark Red Violet				
1	2	3.8	1	2.9
2, 3, 4, 5, 6, and 7	1	1.9	0	Less than 100/34
Medium Red Violet				
1, 2, and 3	1	1.9	0	Less than 100/34
Light Red Violet				
1	3	5.7	2	5.9
2 and 3	2	3.8	1	2.9
4 and 5	1	1.9	0	Less than 100/34
Averages	1.32 persons per shade	2.51	0.221 matches per shade	0.938% persons per match per shade

*In calculating the percent of matches per person per shade, the person contributing the standard cannot correctly be counted in evaluating the number of persons. Thus, all calculations are based on 34 possible persons.

**Although no match was shown in these instances, it cannot be correctly concluded that the probability of a match is zero since the next fiber studied could match. As a means of averaging the probabilities based on this number of persons, "less than 100/34" is always assumed to be zero since no finite number can be assigned to it.

dividual fibers appear black with transmitted light. Ordinarily, such fibers appear a deep purple or a deep green. However, pure or opaque black fibers also occur frequently, and their incidence was studied. It was found that 8 of the 35 sets of sweepings contained such fibers, i.e. 22.8 percent. Thus, the value of the opaque black fiber is considerable since it would serve to eliminate 4 out of 5 persons on the average, but it is still far less useful than the color shades discussed below.

Table II shows the analysis of incidence of red wool fibers and of matches between them. Columns 2 and 3 give the actual incidence of

various shades of red in the 35 samples studied while columns 4 and 5 show the number of matches and the percentages of persons containing each individual match, which is a direct measure of the probability of their occurrence.

Table III gives the same data for blue wool fibers of accidental origin as is shown in Table II for red wool fibers. As was postulated by Burd and Kirk, it will be seen that the incidence of blue wool is actually greater than that of red or green but it is not as great as that of white or opaque black.

Table IV shows the results of study of green wool fibers, and the same analysis as for red and blue. An over-all average of the probability of occurrence of any given match with any given person is not lower than about 1 percent, or one in a hundred. It may be higher than this but cannot in any case be higher than the nearly 6 percent found to be characteristic of men's woolen suitings. On the other hand, it is evident that finer discrimination in shade was exercised in this study than in the earlier work mentioned. (2) The reason for this is that if any difference could be established between two fibers, they were considered to be different. In dealing with fibers that are structural in a cloth, it is possible and logical to consider that all the variations that exist in a given single color of thread should be listed as a single color because of identical origin and considered that way in establishing matches. This is not possible with miscellaneous fibers accumulated on the surface of cloth and leads to the necessarily different interpretation. If this factor could be taken into account in a study of this type, it would undoubtedly have the effect of yielding fewer categories, and increasing the number of matches somewhat, possibly almost to the value found for cloths themselves.

Regardless of the interpretation placed on the data listed here and in the earlier publication, (2) it is clear that matches between loose fibers of unknown origin located on the surface of clothing establish at least as good and possibly a better, probability of contact of the clothing than do the fibers that constitute the cloth itself. It is not reasonable to suppose that they would be much better, but the contention, here disproved, could be raised that they are less suitable as evidence than structural fibers, because it is not known from where they originated. This tendency has been noted at times in presenting fiber evidence in court, and is the chief reason for the present study. In view of this, it would seem justified now to use the approximate probability of 1/20 for each fiber match found, or better to use the more exact probability found for the particular color when this is possible. The conservative value of 1/10 previously employed in various instances chiefly as a

Table III.

BLUE WOOL FIBERS

Color and Shade Number	*Incidence*		*Matches*	
	Persons	*%*	*Number*	*%**
Dark Blue Violet				
1	5	7.9	4	11.8
2	4	6.4	3	8.8
3 and 4	1	1.6	0	Less than 100/34**
Royal Blue				
1	4	6.4	3	8.8
2, 3, and 4	2	3.2	1	2.9
5, 6, 7, and 8	1	1.6	0	Less than 100/34
Blue				
1	3	4.8	2	5.9
2	2	3.2	1	2.9
3, 4, 5, 6, 7, 8, 9, and 10	1	1.6	0	Less than 100/34
Dark Blue Purple				
1 and 2	2	3.2	1	2.9
3, 4, 5, and 6	1	1.6	0	Less than 100/34
Navy Blue				
1	2	3.2	1	2.9
2 and 3	1	1.6	0	Less than 100/34
Medium Blue Violet				
1, 2, 3, and 4	1	1.6	0	Less than 100/34
Blue Green				
1	3	4.8	2	5.9
2, 3, and 4	1	1.6	0	Less than 100/34
Blue Gray				
1, 2, 3, 4, and 5	1	1.6	0	Less than 100/34
Medium Blue Purple				
1	2	3.2	1	2.9
2 and 3	1	1.6	0	Less than 100/34
Light Blue Violet				
1	2	3.2	1	2.9
2 and 3	1	1.6	0	Less than 100/34
Medium Blue				
1 and 2	1	1.6	0	Less than 100/34
Light Green Blue				
1	3	4.8	2	5.9
Blue Black				
1	2	3.2	1	2.9
Light Blue Gray				
1	1	1.6	0	Less than 100/34
Light Blue Purple				
1, 2, and 3	1	1.6	0	Less than 100/34
Light Blue				
1 and 2	1	1.6	0	Less than 100/34
Dark Royal Blue				
1	2	3.2	1	2.9
Miscellaneous***				
1 and 2	1	1.6	0	Less than 100/34
Averages	1.4 persons per shade	2.267	0.429 matches per shade	1.25% persons per match per shade

*See Table II.
**See Table II.
***Multicolored blue fibers.

Table IV.

GREEN WOOL FIBERS

Color and Shade Number	*Incidence* *Persons*	*%*	*Matches* *Number*	*%**
Green				
1	3	13.6	2	5.9
2	2	9.1	1	2.9
3, 4, and 5	1	4.6	0	Less than 100/34**
Light Blue Green				
1	3	13.6	2	5.9
2	2	9.1	1	2.9
3 and 4	1	4.6	0	Less than 100/34
Blue Green				
1	2	9.1	1	2.9
2, 3, and 4	1	4.6	0	Less than 100/34
Light, Light Blue Green				
1, 2, and 3	1	4.6	0	Less than 100/34
Yellow Green				
1, 2, and 3	1	4.6	0	Less than 100/34
Medium Green				
1 and 2	1	4.6	0	Less than 100/34
Olive Green				
1	1	4.6	0	Less than 100/34
Averages	1.32 persons per shade	6.03	0.318 matches per shade	0.932% persons per match per shade

*See Table II.
**See Table II.

compensation for this particular uncertainty, is no longer necessary, and the value of 1/20 may actually be more conservative than necessary when a number of the matches obtained are between fibers of stray or accidental unknown origin.

SUMMARY

A study is here presented of the incidence of white, opaque black, red, blue, and green wool fibers swept from the surface of clothing and of unknown origin. A total of 35 sets of clothing were studied, 22 from men and 13 from women. The matching fibers of all distinguishable categories were studied to ascertain how frequently such fiber matches might be encountered by chance. Such matches were found in only about 1 percent of the clothing examined. Consideration of the data led to the conclusion that the value of between 5 and 6 percent incidence for blue wool structural fibers in known cloths was a conservative value to apply also to stray fibers of unknown origin, but found to match between two sets of clothing.

REFERENCES

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