Nicholas Petraco, [1] *M.S.*

The Occurrence of Trace Evidence in One Examiner's Casework

ABSTRACT: This study reviews the occurrence of trace evidence in routine casework from 1977 through 1983. Four primary categories of trace evidence are described. Each item of trace evidence was placed into one of the four primary categories. The occurrence of each category was evaluated for six different crime classifications over a period of seven years. The diversity of the trace evidence encountered. and the locations from which it was obtained, was also examined and evaluated.

KEYWORDS: criminalistics. trace evidence, physical evidence

The importance of trace evidential material in solving crimes has been known for the past hundred years. Sir Arthur Conon Doyle, through his fictional character, Sherlock Holmes, solved many a mystery by reconstructing the events of the crime from traces left at the scene. Through his writing, Doyle is believed to have inspired many real-life scientific detectives to look for these valuable clues while investigating crimes. Perhaps Edmond Locard of France, the most noted of these early criminalists, was so inspired. Locard's accomplishments and reputation are well documented and will not be discussed here at length. However, his successful implementation of scientific methodology in criminal investigations, and his belief that every criminal could be linked to the crime he committed by dust particles removed from the scene, are probably responsible for the use of trace evidence today [1–3]. His work has served as a model for many contemporary forensic microanalysts, this author included. A recent series of articles elegantly demonstrates the historic role of trace evidence in solving seemingly unsolvable crimes [4–7].

In spite of the fact that the value of trace evidence has been well established, it is often overlooked by field investigators, crime scene technicians, medical examiners, and forensic science laboratory personnel. Although some forensic science laboratories maintain well-equipped and well-staffed trace evidence sections, many other forensic science laboratories still do not maintain a trace evidence section. Consequently, trace evidential materials often are not collected in even the most serious cases.

This study was undertaken to document statistically the occurrence of trace evidence in criminal investigations to further encourage its use on a routine basis. Data was collected on the various types of microscopic traces encountered during the author's trace evidence casework for a period of seven years. Each case was assigned to the author, at random, without prior screening. as they were processed into the laboratory. They represent the total number of trace cases assigned to, and completed by, the author for the study period.

Method

Collection Procedure

Trace evidence was collected from the various items of physical evidence removed during the investigation at the crime scene, subsequent investigation, and forensic autopsy. The trace evidence collected by the investigator(s), crime scene technicians, or medical examiners was also examined. Each item of physical evidence was observed visually and with a stereomicroscope. After documentation, all visible traces were removed, sorted, and placed in evidence containers. When appropriate, the items of physical evidence were processed with the so-called "sticky tape method." All relevant traces were removed from the tape and stored in various evidence containers.

When necessary, the remaining trace material was collected by vacuuming. The vacuum was equipped with a vacuum sweeper filter attachment described by Kirk [8]. It has been the author's experience that vacuuming has some disadvantages. The primary disadvantage is that vacuuming tends to mix the most recently deposited trace evidence (usually the most useful) with the trace materials that were long ago deposited. However, at times vacuum sweepings yield vital information, especially in cases where the description of a suspect's occupation or environment is required, when pollen or dust studies are requested, or when attempts to clean the scene, clothing, and so forth, of all traces have been made by the perpetrator(s). Inadvertently, trace evidence is almost always left behind, and it can usually be retrieved by vacuuming.

After collection, each item of trace evidence was sorted out, identified, and categorized. This information was then utilized in each case and then evaluated as follows. If the trace evidence was useful in associating people, places, or things involved in the crime, or if the trace evidence was exculpatory in nature, in that it showed that people, places, or things were not involved in the crime, it was deemed relevant and tabulated as such. If, on the other hand, no trace evidence was encountered in a case, or if the trace evidence present had no bearing on a case's outcome, the case was counted as a negative trace case. The data from each case was collected on a daily basis, and tabulated on an annual basis for a seven-year period.

Categorization of Trace Evidence

While trace evidence can encompass innumerable forms of materials, it has been the author's experience that two distinct categories of trace materials are most often encountered:

(1) fibrous substances and
(2) particulate matter.

Of these two groups, fibrous substances can be subdivided into three primary categories:

(1) human hair;
(2) animal hair; and
(3) fibers (synthetic, vegetable, and mineral).

In all, four categories of trace evidence and six classes of crimes were considered in this study (Table 1). The first five crime classifications were used because they were the ones most often investigated by the author. However, the classification "other" was included so that all available data on trace evidential material would be incorporated in this study.

Table 2 shows the total number of times each category of trace evidence was encountered for the various crime classifications. The data in this table were then used to show the occurrence of trace evidential material in routine casework by studying its occurrence.

Results and Discussion

In all, 506 cases were studied for the occurrence of trace evidential material. Of the 506 cases studied, 104 cases were found to contain no useful items of trace evidence, while 402 cases had 1

TABLE 1—*Crime classifications and trace evidence categories.*

Crime Classification	Trace Evidence Category
1. Homicide	1. human hair
2. Robbery	2. animal hair
3. Rape/sex crime	3. fibers (synthetic, vegetable and mineral)
4. Assault	
5. Burglary	4. particulate matter
6. Other (all other crimes)	

TABLE 2—*The occurrence of each category of trace evidence for the various crime classifications over a seven-year period.*

Crime	Trace Categories			
	Human Hair	Animal Hair	Fibers	Particulate Matter
Homicide	180	53	74	55
Robbery	57	9	12	4
Rape/sex	47	9	3	2
Assault	10	3	3	2
Burglary	2	4	4	11
Other	3	2	4	5
Totals	299	80	100	79

or more categories of relevant trace material. The percentage of cases with trace material is shown in Table 3.

It is seen in Table 3 that at least one type of trace evidence was found 80% of the time, and that 26% of the cases which manifested trace evidence had more than one type. Perhaps the most significant feature of the data in Table 3 is the regularity with which trace evidence occurs.

Figure 1 shows the percent occurrence of trace evidence for all the cases examined in this study. From Fig. 1, one can see that the occurrence of relevant trace evidence in all the crime classifications studied is significant, and depends little on the crime classification itself. However, one can see in Fig. 1 a trend that seems to indicate that certain types of evidence tend to occur more often in one crime class than in another. For example, human hair and fiber evidence seem to be encountered with greater frequency in violent crimes such as homicide, robbery, and so forth, while particulate matter tends to occur more often in burglaries. One disturbing finding in Fig. 1 is the low percent occurrence of fibers and particulate matter for the category of rape and sex crimes. One possible explanation for this unexpected finding might be the prevalent use of commercially available rape kits for collecting evidence in these cases. The prepared kits usually concentrate on the collection of physiological fluids and hair specimens, while giving little attention to the collection of fibers and particulate matter.

Figures 2 through 4 illustrate the occurrence of the various categories of trace evidence in all of the cases that exhibited relevant trace materials. Figure 2 depicts the occurrence of the various categories of trace evidence for each year of the study. Figure 3 demonstrates that the fibrous forms of trace evidence are most often encountered, while particulate matter, although significant, occurs less frequently. In Fig. 4, human hair is shown to occur most often, just under 75% of the time, while the next highest occurring category is fibers, appearing in approximately 25% of the trace cases. The remaining two categories, animal hair and particulate matter, both occur in just under 20% of the cases that exhibited relevant trace evidential material. Here again, the significance in the data lies in the regularity with which the various forms

TABLE 3—*The percentage of cases with trace evidence.*

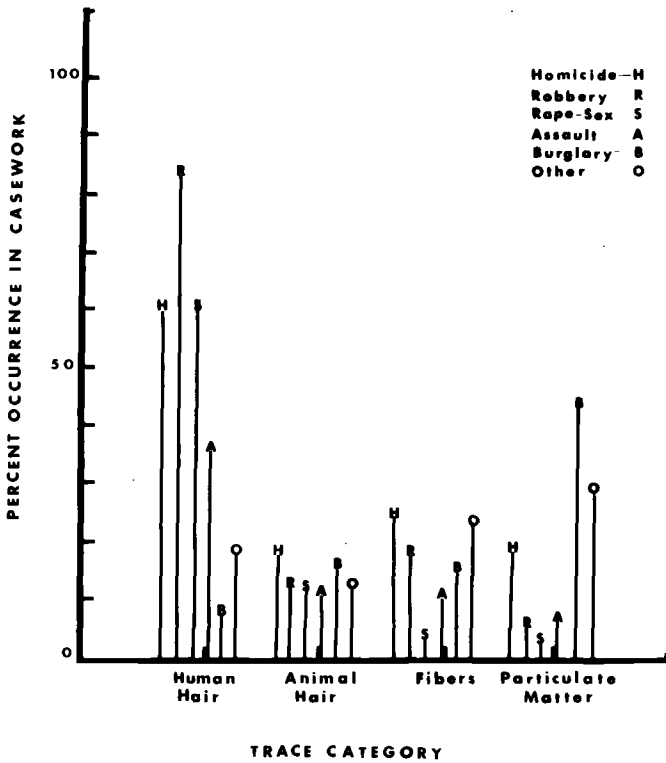| Year	Total No. of Cases	No. and Percent of Cases with Trace		Cases with More than One Type of Trace	
		No.	Percent	No.	Percent
1977	58	48	83	10	21
1978	90	66	73	20	30
1979	83	64	77	13	20
1980	74	62	84	13	21
1981	82	66	81	16	24
1982	62	51	82	20	39
1983	57	45	79	13	29
Total	506	402	80	105	26

FIG. 1—*The percent occurrence of the four categories of trace evidence for all the cases examined in this study plotted according to their crime classifications.*

of trace evidence occur, rather than the fact that one form occurs more or less frequently than another.

General observation of all the data in this study certainly indicates that the chance of finding relevant trace evidence in any given case (if looked for) is quite high (80%). The data even take on greater significance if one considers that the evidence recognition, collection, packaging, transportation, and storage procedures are less than ideal in most cases, a sad reality which
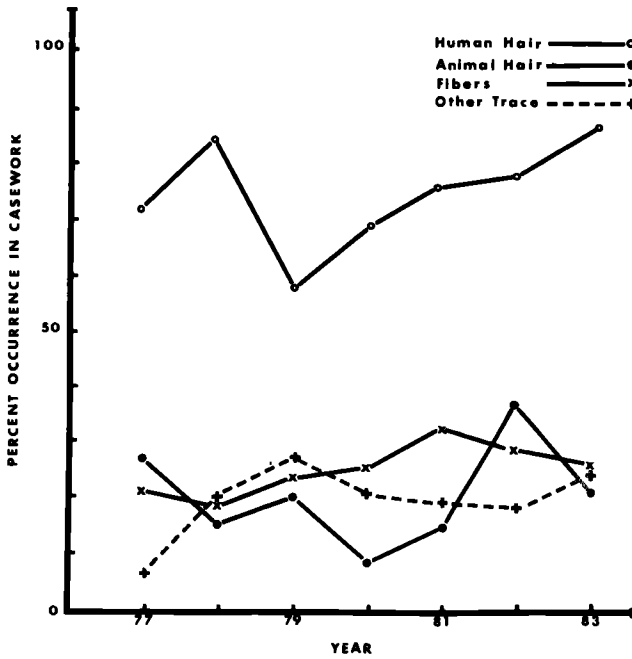
FIG. 2—*The occurrence of each category of trace evidence in cases which manifested relevant trace materials.*
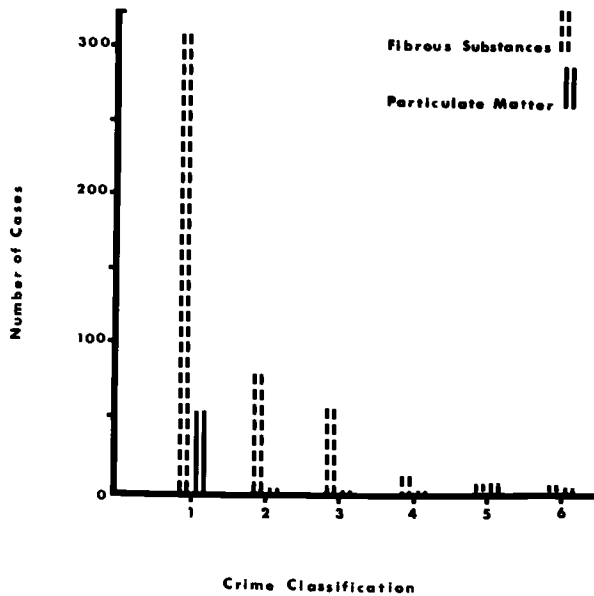

FIG. 3—*The number of cases with fibrous forms of trace evidence are compared to the number of cases with particulate matter for each crime classification: 1-homicide, 2-robbery, 3-rape/sex, 4-assault, 5-burglary, and 6-other.*
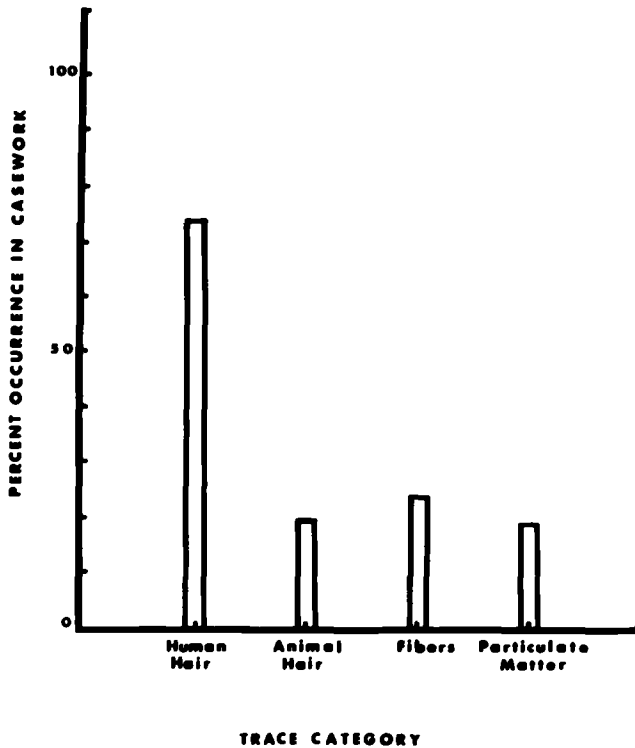
FIG. 4—*The percent occurrence of each category of trace evidence is shown for cases that exhibited relevant materials. All crime classifications are included in each of the four categories.*

has been previously documented [9]. On the basis of this data, one might speculate that if evidence recognition and handling procedures were optimized, it would be a rare case indeed when at least one or more categories of trace evidence were not found.

Another interesting and significant observation to be made from the data is the relatively high occurrence of animal hair in casework. In the past, animal hair has been reported as being encountered infrequently in most forensic science laboratories [10]. Yet the data in Table 4 indicates that perhaps animal hair should be encountered more often. In fact, out of 402 cases with relevant trace evidence, 80 cases had some type of questioned animal hair (Table 2). In these 80 cases, 108 different specimens of animal hair were exhibited, comprising 11 genera.

Another significant observation (especially for the nontrace analyst) was made when the diversity of the trace evidence was evaluated, along with the locations from which it was obtained. For this purpose 1982's casework was chosen and carefully scrutinized. Table 5 contains a list of the various items of trace evidence that were found during 1982, while Table 6 contains the locations (people, places, and things) from which the trace materials were removed.

From Table 5 one can clearly see that nearly any material or substances could at one time be encountered as trace evidence. Table 6 shows that trace evidence is ubiquitous. These are two facts that come as no surprise to any forensic microanalyst. Table 7 illustrates (in condensed form) the occurrence of the various types of trace evidence described in Table 5 cross-referenced to the locations they were recovered as depicted in Table 6.

It is seen in Table 7 that the places involved in these cases produced the highest percentage of trace evidential material, approximately 57%. However, the people and things involved in these cases were also responsible for a significant percentage of the trace evidence found. The

TABLE 4—*The occurrence of animal hair in casework.*

Common Name	No. of Specimens
Cat	21
Coyote	1
Deer	2
Dog	39
Fox	2
Goat	2
Mink	8
Rabbit	9
Rodent	1
Sable	1
Squirrel	1
Sheep (wool)	21
Total	108

TABLE 5—*The items of trace evidence encountered in 1982.*

Fibrous Substances	Particulate Matter
Human hair	animal
Caucasian head, pubic and facial	feathers
Mongoloid head and pubic	various tissues
Negroid head and pubic	vegetable
mixed racial head	leaf fragments
Animal hair	tree bark and twigs
cat	sawdust
coyote	seeds
deer	pollens
mink	mineral
rabbit	glass fragments
rodent	metal shavings
wool	minerals
Fibers	paint chips
acetate	paint smears
acrylic	plaster chips
cotton	soil specimens
glass wool	miscellaneous
nylon	cellophane wrappers
olefin	plastic fragments
polyester	plastic wrapper
rayon	smokeless powder
sisal	urethane foam

most important feature of the data in Table 7 is that it shows how essential it is to consider all aspects of a case when searching for trace evidence, rather than singling out one or two areas as is often done.

Conclusion

The data generated by this study shows that trace evidence should play a more vital role in criminal investigations, a statement forensic microscopists have been making since the development of their discipline. By the use of such information, the event can often be reconstructed; occupations of the principals in the case can often be accurately surmised; locations can be

TABLE 6—*People, places and things from which trace evidence was recovered in 1982.*

People	Places	Things
Victim's	victim's	victim's vehicle
clothing	home	suspect's vehicle
fingernails	business	miscellaneous
hands	suspect's	automobiles
mouth	home	bags
pubic region	business	baseball bats
rectum	crime scenes	bed sheets
Suspect's	alleys	bullet proof vests
clothing	buildings	caps
	fields	carpets
	parks	cigarette packages
	roadways	floor tiles
	sidewalks	furniture items
	streets	guns
		hammers
		hats
		pipes
		ski masks
		spent bullets
		tools
		vans

TABLE 7—*The occurrence of the various types of trace evidence for 1982, cross-referenced to the locations at which they were recovered.*

Recovered From	Human Hair		Animal Hair		Fibers		Particulate Matter	
	No.	%	No.	%	No.	%	No.	%
People		28		20		21		33
Victim's								
body	19		6		7		4	
clothing	4		2		1		2	
Suspect's								
clothing	7		. . .		1		. . .	
Places		56		59		56		56
Victim's								
home	16		8		7		1	
business	8		2		4		1	
Suspect's								
home	. . .		. . .		. . .		1	
business	. . .		1		. . .		. . .	
Crime scene								
inside	25		10		9		3	
outside	10		3		4		4	
Things		16		22		23		11
Bags	. . .		1		1		. . .	
Bats, pipes	2		. . .		1		. . .	
Cigarette pack	1		1		. . .		. . .	
Clothing items	1		1		1		1	
Furniture items	1		2		1		. . .	
Guns	. . .		. . .		1		. . .	
Hats, masks	7		1		1		. . .	
Spent bullet	. . .		. . .		1		. . .	
Tools	1		. . .		1		. . .	
Vehicles	4		3		2		1	

described; and people, places, and things can be implicated or eliminated. All this is achieved without the aid of an eyewitness. It is a powerful source of information indeed, and one that is barely utilized in our criminal justice system. It is the author's sincere hope that this study has helped to show statistically the significant occurrence of trace evidence in casework, and that these results will further encourage the increased use of trace evidence on a routine basis.

References

[1] Locard, E., "The Analysis of Dust Traces, Part I," *American Journal of Police Science*, Vol. 1, 1930, pp. 276–298.
[2] Locard, E., "The Analysis of Dust Traces, Part II," *American Journal of Police Science*, Vol. 1, 1930, pp. 401–418.
[3] Locard, E., "The Analysis of Dust Traces, Part III," *American Journal of Police Science*, Vol. 1, 1930, pp. 496–514.
[4] Palenik, S., "Microscopic Trace Evidence—The Overlooked Clue, Part I. Albert Schneider Looks at Some String," *The Microscope*, Vol. 30, 2nd Quarter, 1982, pp. 93–100.
[5] Palenik, S., "Microscopic Trace Evidence—The Overlooked Clue, Part II. Max Frei—Sherlock Holmes with a Microscope," *The Microscope*, Vol. 30, 3rd Quarter, 1982, pp. 163–169.
[6] Palenik, S., "Microscopical Trace Evidence—The Overlooked Clue, Part III. E. O. Heinrich—The 'Wizard of Berkeley' Traps a Left-Handed Lumberjack," *The Microscope*, Vol. 30, 4th Quarter, 1982, pp. 281–290.
[7] Palenik, S., "Microscopic Trace Evidence—The Overlooked Clue, Part IV. Arthur Koehler—Wood Detective," *The Microscope*, Vol. 31, 1st Quarter, 1983, pp. 1–14.
[8] Kirk, P. L., "Microscopic Evidence—Its Use in the Investigation of Crime," *The Journal of Criminal Law and Criminology*, Vol. 40, 1949–1950, pp. 364–366.
[9] Peterson, J. L., "Utilization of Criminalistics Services by the Police: An Analysis of the Physical Evidence Recovery Process," U.S. Government Printing Office, Washington, DC, 1974.
[10] Grieve, M. C., "The Role of Fibers in Forensic Science Examinations," *Journal of Forensic Sciences*, Vol. 28, No. 4, Oct. 1983, pp. 877–887.

Address requests for reprints or additional information to
Nicholas Petraco
New York City Police Laboratory
235 East 20th St.
New York, NY 10003