Rapid DNA technologies at the crime scene
‘CSI’ fiction matching reality
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Chapter 3

DNA by the Numbers¹

Locations of usable DNA based on 24,466 crime scene samples

Abstract

Nowadays increasing numbers of evidentiary traces are collected at crime scenes and submitted for DNA analysis at the forensic laboratories. However, almost 50% of the analysed DNA samples do not result in valuable DNA typing information (1) and a few studies show that the possibility to actually obtain usable DNA profiles can depend on the trace type (2, 3). Evaluating the DNA results obtained for various sampled traces can provide us information on which traces are most promising to select for DNA analysis. Such information can guide crime scene investigators in decision-making.

¹The chapter was published as Mapes A. DNA by the Numbers - Locations of usable DNA based on 24,466 crime scene samples. Forensic Magazine, 2015;12(5):8-9. This article is single authored. The study was mainly performed by S. Verheij and T. Sijen. I would like to thank them for their valuable suggestions and recommendations and giving me the opportunity to do research on DNA success rates, which is a key subject in my dissertation. Thanks to this opportunity I came to a first model to potentially assist scene of crime officers in their trace prioritisation and selection process. This led the way for ensuing studies.
3.1 The Study

Six European forensic laboratories\textsuperscript{1} from the EUROFRGEN network, gathered DNA yields from over 24,466 crime-related samples that were categorised based on biological source or sampled item. The category ‘sample type’ includes various biological sources such as bodily fluids and tissues and the category ‘sampled item’ includes several items sampled for either saliva or contact traces.

DNA yield was used to predict the DNA profiling result. Four categories were chosen based on in-house experience: 1) full profile, 2) usable partial or full profile, 3) partial profile possibly useful, and 4) no informative profile. Details on this categorisation can be found in Table 1. These four categories inform us which are the most promising samples to select for DNA analysis.

| Table 1. DNA Yield used to Predict DNA Profiling Result Based on In-house Experience |
|-------------------------------------------------|--|--|---|
| Expectation (standard profiling) | Yield | Input PCR if 1/10 of yield |
| No informative profile | 0 - 0.025 ng | max 2.5 pg |
| Partial profile possibly useful | 0.025 - 0.625 ng | max 62 pg |
| Partial or full usable profile | 0.625 - 5 ng | max 500 pg |
| Full profile | 5 ng | more than 500 pg |

\textit{Multiple donors may be present}

3.2 Observations and Conclusions

A total of 44 categories were made for the overall categories ‘sample type’ and ‘sampled item’ (Figure 1). The number of samples in each category varies from 18 to 7104 (see ‘n samples’ in Figure 1) and the results represent trends. In Figure 1 for each sample category, the percentages of samples with an expected type of profile are shown: dark and middle green bars indicate full and usable profiles; a light bar represents possibly useful profiles and a brown bar marks the category no profile. Within the overall categories, the sample categories are ranked from lowest to highest percentage no profile expected.

When comparing sample types, we see for instance that for blood samples in 93% of the cases a full profile and in 4% no profiles may be obtained. For faeces samples, on the other hand, the percentage no profile is much higher namely 24%. This variation is also observed when comparing various sampled items likely to carry saliva or contact traces: the percentage in the ‘no profile’ category is 2% for balaclavas and 29% for bottle lids and 0% for coat collars and 44% for plastic bags.

\textsuperscript{1} Six EUROFRGEN partners contributed to this study: Department of Forensic Medicine Copenhagen (UCPH, 237 samples, 2013) Netherlands Forensic Institute (NFI, 14,974 samples, 2012/2014), Institute of Legal Medicine Cologne (UHC, 228 samples, 2013/2014), Institute of Forensic Research JU Krakow (JU, 890 samples, 2013), Institute of Legal Medicine Innsbruck (IMU, 8047 samples, Dec 2012 – Nov 2013), Forensic Science Institute USC Santiago de Compostela (USC, 36 samples, 2013).
The proximity, intensity and duration of contact seem to contribute to profiling success as saliva items balaclava, cigarette end, chewing gum and toothbrush and contact items such as collars and headwear give high percentages of full profiles. When regarding all categories, the five most promising samples to select are muscles, blood, coat collars, cigarette ends and balaclavas. On the other end of the spectrum, the five least promising samples are hairs, plastic bags, bullets, touch traces various and grip traces various. Importantly, for all categories full and usable profiles are obtained.

For the sampled item bag plastic for instance 44% of the samples categorise into ‘no profile’ while 43% may result in a full profile. The category ‘partial profile possibly useful’ presents uncertainty as at least a partial profile is expected but it is difficult to predict whether DNA results will be usable for
comparison studies. Aspects such as the number of contributors to a profile and mixture ratios will have a role here. Notwithstanding, this collaborative study gives insight in the DNA results of the several traces and may assist crime scene investigators in their decision-making in which many other aspects such as the context of an item in to crime are relevant too.

3.3 How to use the Figure as CSI?

Figure 1 may assist crime scene investigators in selecting evidentiary traces for DNA analysis for which they currently use their experience. This is particularly useful when multiple traces are at hand. Clearly, selecting evidentiary traces is case-dependent and largely affected by how crime and offender related the evidentiary traces are. This leads to a four-step decision process for the selection of evidentiary traces for DNA analysis:

1) Collect evidentiary traces at the crime scene,
2) Rank crime scene traces based on crime and/or offender relatedness,
3) Use figure 1 to rank the highest crime and/or offender related traces, and
4) Select the most promising traces for DNA analysis.

For instance, at a violent burglary where the victim is injured and the perpetrator has fled the scene, a bloodstain, balaclava, and screwdriver are found. Since it is highly likely that the blood trace originates from the victim, the balaclava and screwdriver have the highest potential to provide an investigative lead towards the offender. From Figure 1 it derives that the balaclava holds more potential for successful DNA analysis than the screwdriver (compare balaclava and tool categories in Figure 1) and it seems most opportune to select the balaclava for DNA analysis in this criminal process. Therefore, for future decisions on selecting crime scene traces for DNA analysis, it is recommended that crime scene investigators use figure 1 and the four-step decision process in their trace selection process.

3.4 References