University of Technology, Sydney

A Criminalistic Approach to Biological Evidence:

Trace DNA and Volume Crime Offences

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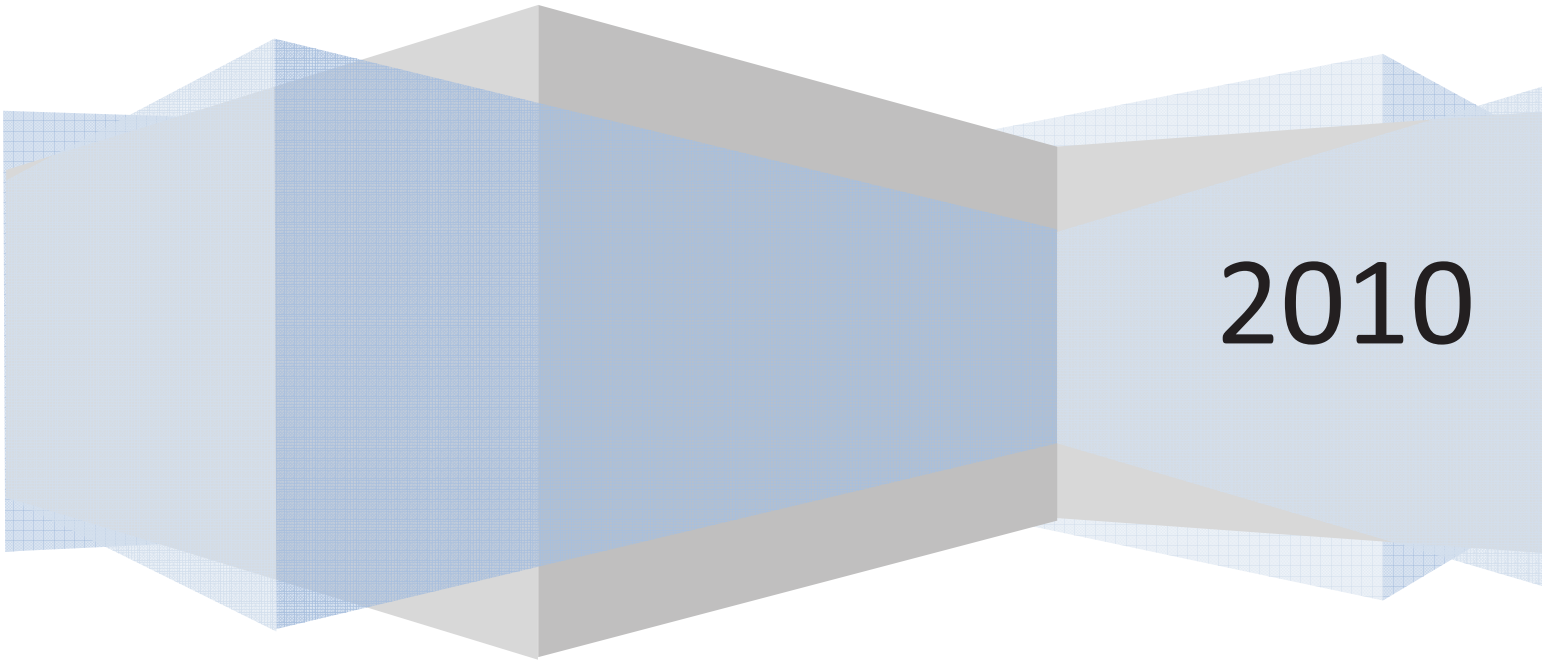
A thesis submitted for the
Degree of Doctor of Philosophy (Science)



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Certificate of authorship and originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all the information sources and literature used are indicated in the thesis.

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DATE: 9 June 2010

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Abbreviations

ACT	Australian Capital Territory
AFP	Australian Federal Police
ANOVA	Analysis of Variance
ANZPAA	Australian and New Zealand Policing Advisory Agency
BNs	Bayesian Networks
BSAG	Biology Specialist Advisory Group
CCTV	Closed circuit television
CODIS	Combined DNA Index System
COPS	Computerised Operational Policing System
DAB	Diaminobenzidine
DAL	The Division of Analytical Laboratories
DFO	1,8-diaza-9-fluorenone
DNA	Deoxyribonucleic acid
dsDNA	Double-stranded DNA
EDTA	Ethylenediaminetetraacetic acid
FBI	Federal Bureau of Investigation
FPs	Fingerprints
FSG	Forensic Services Group
FSS	Forensic Science Service (UK)
IT	Information Technology
LCN	Low copy number
LCV	Leucocrystal Violet
NAFIS	National Automated Fingerprint Identification System
NAS	National Academy of Sciences
NCIDD	National Criminal Investigation DNA Database

NIFS	National Institute of Forensic Science
NSW	New South Wales
NT	Northern Territory
NZ	New Zealand
PCR	Polymerase chain reaction
POE	Point of entry
QLD	Queensland
RFU	Relative Fluorescence Units
SA	South Australia
SMANZFL	Senior Managers of Australian and New Zealand Forensic Laboratories
SOCO	Scenes of Crime Officer
STR	Short tandem repeat
SNP	Single nucleotide polymorphism
TAS	Tasmania
TE	Tris-EDTA buffer
UK	United Kingdom
USA	United States of America
UV	Ultraviolet
VIC	Victoria
WA	Western Australia

List of Papers

This thesis is based in part on the following publications and conference presentations.

Published Articles

- **Trace DNA: An underutilised resource or Pandora's Box? A discussion of the use of trace DNA analysis in the investigation of volume crime.**
  Raymond, J.J., Walsh, S.J., van Oorschot, R.A.H., Gunn, P.R., Roux, C. *Journal of Forensic Identification,* 54 (6), 2004, 668-686.
- **Trace DNA analysis: Do you know what your neighbour is doing? A multi-jurisdictional survey.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Roux, C. *Forensic Science International: Genetics,* 2(1), 2008, 19-28.
- **Assessing trace DNA evidence from a residential burglary: Abundance, transfer and persistence.**
  Raymond, J.J., Walsh, S.J., van Oorschot, R.A.H., Gunn, P.R., Evans, L., Roux, C. *Forensic Science International: Genetics Supplement Series,* 1(1), 2008, 442-443.
- **Trace Evidence Characteristics of DNA: A Preliminary Investigation of the Persistence of DNA at Crime Scenes.**
  Raymond, J.J., van Oorschot, R.A.H., Gunn, P.R., Walsh, S.J., Roux, C. *Forensic Science International: Genetics,* 4(1), 2009, 26-33.
- **Trace DNA success rates relating to volume crime offences.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Gunn, P.R., Roux, C. *Forensic Science International: Genetics Supplement Series,* 2(1), 2009, 136-137.
- **Trace DNA and street robbery: a criminalistic approach to DNA evidence.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Gunn, P.R., Roux, C. *Forensic Science International: Genetics Supplement Series,* 2(1), 2009, 544-546.

Conference Presentations

- **DNA: Just any other trace evidence?**
  Raymond, J.J., Walsh, S.J., Gunn, P. R., Van Oorschot, R.A., Roux, C., In: the 17th International Symposium of the Australian and New Zealand Forensic Science Society (ANZFSS), 2004, Wellington, New Zealand
- **Trace Evidence Characteristics of DNA: Abundance and Persistence studies.**
  Raymond, J.J., Gunn, P., Walsh, S.J., Van Oorschot, R.A., Roux, C. In: International Association of Forensic Sciences (IAFS), 2005, Hong Kong, China.
- **Trace DNA Analysis: Australian and New Zealand methods survey.**
  Raymond, J.J, Van Oorschot, R.A., Walsh, S.J., Roux, C. In: the 18th International Symposium of the ANZFSS, 2006, Fremantle, Western Australia.
- **Assessing trace DNA evidence from a residential burglary: Abundance, transfer and persistence.**
  Raymond, J.J., Walsh, S.J., Van Oorschot, R.A., Gunn, P.R., Evans, L., Roux, C. In: the 22nd Congress of the International Society for Forensic Genetics (ISFG), 2007, Copenhagen, Denmark.
- **Trace evidence characteristics of DNA: background levels and transfer of trace DNA in volume crime.**
  Raymond, J.J., van Oorschot, R.A., Walsh, S.J., Roux, C., Gunn, P.R. In: the 19th International Symposium of the ANZFSS, 2008, Melbourne, Victoria.
- **Trace evidence characteristics of DNA: the persistence of DNA in volume crime scenes.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Roux, C., Gunn, P.R. In: the 19th International Symposium of the ANZFSS, 2008, Melbourne, Victoria.
- **A criminalistic approach to biological evidence: trace DNA and volume crime.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Gunn, P.R., Roux, C. In: the 5th meeting of the European Academy of Forensic Science, 2009, Glasgow, United Kingdom.

- **Trace DNA success rates relating to volume crime offences.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Gunn, P.R., Roux, C. In: the 23rd congress of the International Society for Forensic Genetics, 2009, Buenos Aires, Argentina.
- **Trace DNA and street robbery: a criminalistic approach to DNA evidence.**
  Raymond, J.J., van Oorschot, R.A.H., Walsh, S.J., Gunn, P.R., Roux, C. In: the 23rd congress of the International Society for Forensic Genetics, 2009, Buenos Aires, Argentina.

Abstract

Volume crimes such as burglary and street robbery present an enormous cost to the Australian community each year. These ubiquitous crimes traditionally have a low resolution rate, but the use of information gathered through DNA databases provides another avenue of investigation. The forensic response to these crimes could be increased with the use of trace DNA; however the lack of awareness of forensic science as a holistic discipline focusing on the study of traces, often leads to a lack of knowledge into the trace evidence characteristics of DNA. This problem is compounded by practical and interpretive difficulties. The main hypothesis tested through this study is that, with an increased understanding into the criminalistic properties of trace DNA, it may prove to be more useful and effective evidence in the investigation of volume crime than is currently the case.

The project encompassed three parts. The first component was a detailed survey sent to every jurisdiction in Australia and New Zealand to benchmark methods and protocols, education and training of personnel, and opinions and uses of trace DNA. The second involved the analysis of the results of 250 trace DNA swabs collected from New South Wales crime scenes, in order to provide a comparison point to the experimental work. The final section comprised preliminary experimental work to investigate the abundance, transfer and persistence of trace DNA within the context of residential burglary and street robbery offences.

The methods survey helped to identify methods to be used in the experimental component of the project, but also highlighted issues in the field including a lack of training and proficiency testing. The absence of data collation across the jurisdictions was also a point for concern, and prevented the identification of factors that may affect trace DNA success rates. The pervading outcome of the survey was the need for effective data management systems and strong communication lines to facilitate best practice. From the analysis of the casework data a success rate[1] in the order of 15-20% was identified for New South Wales trace DNA swabs, with an average of 1.7ng of DNA recovered. Subsets of the data were used to directly compare to the experimental results in terms of transfer and persistence.

[1] Defined here as swabs resulting in a profile with 12 or more alleles, and therefore suitable for inclusion on the state DNA database.

The experimental work gave an insight into the behaviour of trace DNA in crime scene scenarios. The level of background DNA on surfaces encountered in forensic investigations was varied; for example residential doors were found to hold more background DNA than windows. Whilst the level of DNA on personal items such as bags and wallets was found to be relatively high, DNA from the offenders of simulated robberies could still be detected in usable quantities on these items. DNA was found to persist in sheltered locations for at least six weeks, but declined more rapidly in outdoor environments, with profiles not recovered after two weeks. This information may help to assist the interpretation and presentation of trace DNA evidence when the judicial question is one of activity, rather than source. The data also may be used in the education of crime scene examiners to assist them to target the most probative evidential samples. With further work in this field, trace DNA will be more easily applied to investigations.

Trace DNA may be a useful tool in volume crime investigations, but individual jurisdictions should assess their capacity to manage the evidence to ensure results can be disseminated and actioned in a timely manner, otherwise the investment may prove to be fruitless. Effective and ongoing training programs and functional data management systems should be implemented to maximise both the investigative and intelligence value of trace DNA evidence. A holistic approach to the implementation of forensic evidence, encompassing the groundwork of theoretical analysis, review of capabilities and logistical and technical improvements, would greatly increase its value in policing and the criminal justice system.