Investigation into the Factors Influencing Trace DNA Recovery from Unfired and Fired Ammunition

by Elisha Prasad

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy (C02031)

under the supervision of Prof. Dennis McNevin,
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Certificate of original authorship

I, Elisha Prasad, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Science, School of Maths and Physical Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Statement of thesis structure and format

This thesis is submitted as a thesis by compilation and is comprised of core chapters that have been published or submitted for publication (Chapters 2, 3, 4, 6, 7) or are unpublished work formatted for potential publication (Chapters 5, 8). All research work and publications for this thesis were completed after enrolment, unless otherwise referenced or acknowledged.

Publications and presentations

This thesis is a compilation of the following publications and conference presentations.

Publications:

- **The effects of soaking for DNA recovery on the striation patterns of fired cartridge cases**

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- **Evaluation of soaking to recover trace DNA from fired cartridge cases**

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- **DNA recovery from unfired and fired cartridge cases: A comparison of swabbing, tape lifting, vacuum filtration, and direct PCR**

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- **Trace DNA recovery rates from firearms and ammunition as revealed by casework data**

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- **Touch DNA recovery from unfired and fired cartridges: Comparison of swabbing, tape lifting and soaking**

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Presentations:

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- **Trace DNA from cartridges and cases: A study of the comparative success rates of swabbing, taping and vacuum filtration**

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Statement of contribution of authors

For **Chapter 2** of this thesis, based on the following publication, my extent of contribution to the research and authorship was as follows,

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List of abbreviations

ABIN	Australian Ballistics Identification Network
ACIC	Australian Criminal Intelligence Commission
CBC	Cartridges, Bullets and Cases
CSE	Crime Scene Examiner
DNA	Deoxyribonucleic acid
EO	Ethylene Oxide
FCC	Fired cartridge case
FIU	Firearm Identification and Tracing Unit
FTP	Firearms Trace Program
GSR	Gun Shot Residue
IBIS	Integrated Ballistics Identification System
IED	Improvised Explosive Devices
ILS	Internal Lane Standard
IPC	Internal Positive Control
ISHI	The International Symposium on Human Identification
NSW	New South Wales
PCR	Polymerase Chain Reaction
POI	Person(s) of Interest
PPE	Personal Protective Equipment
RFU	Relative Fluorescence Units
RNA	Ribonucleic Acid
SOP	Standard Operating Procedure

STR	Short Tandem Repeat
TPPR	Transfer, persistence, prevalence and recovery
VNTR	Variable Number Tandem Repeat

Abstract

Within many jurisdictions, including New South Wales (Australia), fired cartridge cases (FCCs) recovered as part of criminal and coronial investigations are not routinely examined for DNA. This is because the success of obtaining useful DNA profiles from FCCs in casework is very low, potentially due to low amounts of DNA transferred onto cartridges during handling actions, high firing temperatures and/or loss of DNA during extraction. Recent research efforts have been directed toward finding a method for DNA recovery from FCCs, however, there were few studies comparing methodologies and assessing any potential loss of DNA.

This project encompassed a holistic review of DNA recovery from FCCs, with the aim to find an optimised DNA recovery method to improve casework outcomes in NSW and elsewhere. It was composed of several key components: a review of casework data, comparisons of DNA recovery methods, investigation of factors such as calibre, firing and metal composition on DNA recovery, and finally, an assessment of DNA transfer from FCCs during evidence collection.

A review of historical NSW casework data revealed that the chance of obtaining a useful DNA profile from unfired and fired cartridges was ≤ 5%, conforming with anecdotal evidence. Further, it was shown that firing reduced the percentages of useful profile to ≤ 2% and metal cartridges generated lower percentages of useful profiles than shotgun cartridges, which are predominantly plastic.

A comparison of DNA recovery methods using cartridges that were spiked with DNA and others that were handled showed that tape lifting yielded the most DNA and a higher number of alleles compared to swabbing, soaking, vacuum filtration and direct PCR. Additionally, calibre was shown to have no influence on DNA recovery whilst fired cartridges and brass cartridges yielded significantly lower amounts of DNA.

Finally, an investigation of DNA transfer in a mock crime scene scenario showed that very low amounts of DNA are transferred from unfired and fired cartridges to the gloves handling them during their retrieval and to the internal side of evidence packaging.

The results of this research suggest tape lifting as a suitable alternative to swabbing. Other findings include higher yielding firearm and ammunition samples to prioritise for DNA analysis,

influential variables affecting DNA analysis from cartridges, and measures to minimise DNA-loss and prevent contamination. Adoption of the suggested improvement opportunities should significantly improve the yield of useful DNA profiles from unfired and fired cartridges during forensic investigations of criminal activity.