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The retrieval of fingerprint friction ridge detail from elephant ivory using reduced-scale magnetic and non-magnetic powdering materials

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ABSTRACT

An evaluation of reduced-size particle powdering methods for the recovery of usable fingermark ridge detail from elephant ivory is presented herein for the first time as a practical and cost-effective tool in forensic analysis. Of two reduced-size powder material types tested, powders with particle sizes ≤ 40 μm offered better chances of recovering ridge detail from unpolished ivory in comparison to a conventional powder material. The quality of developed ridge detail of these powders was also assessed for comparison and automated search suitability. Powder materials and the enhanced ridge detail on ivory were analysed by scanning electron microscopy and energy dispersive X-ray spectroscopy and interactions between their constituents and the ivory discussed. The effect of ageing on the quality of ridge detail recovered showed that the best quality was obtained within 1 week. However, some ridge detail could still be developed up to 28 days after deposition. Cyanoacrylate and fluorescently-labelled cyanoacrylate fuming of ridge detail on ivory was explored and was less effective than reduced-scale powdering in general. This research contributes to the understanding and potential application of smaller scale powdering materials for the development of ridge detail on hard, semi-porous biological material typically seized in wildlife-related crimes.

1. Introduction

The illegal procurement and trade of elephant ivory recently reached its 16-year high in 2011. The latest figures generated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) under the Monitoring the Illegal Killing of Elephants (MIKE) programme, estimate 22,000 elephants were illegally killed in Africa alone in 2012. In 2011, the mortality estimate via illegal routes was 25,000 animals, and with potentially increased estimates expected for 2013, this suggests that such activity remains critically high [1].

There is an increased demand for ivory, particularly across Asia. The legitimate trade of ivory in countries where elephants are indigenous is often used as a means to maintain economic stability and also perhaps paradoxically to fund conservation projects. However, the sector has become increasingly populated by major organized crime syndicates [2], which promote, amongst others, corruption, terrorism, slavery and the trafficking of weapons and drugs. Unfortunately, the lucrative nature of this market seems to outweigh the risk of prosecution. Several tonnes of raw ivory are now seized on an annual basis globally [3,4]. Lessening of the global trade restrictions has made it easier to transport large amounts of contraband around the world. It is a logical assumption that with the extensive variety of forensic tools now available that more effort would be invested into more effectively implementing existing techniques. Unfortunately this does not appear to be the case for fingermarks. Retrieval of ridge detail or latent fingermarks is rarely considered when ivory or ivory-containing items are seized. There are many reasons why an examination is not conducted. Not least are the challenges in developing ridge detail on this type of material. When a suitably receptive surface is touched by an area of the friction ridge skin (e.g., the undersides of the hands, fingers and soles of the feet), an impression of the ridge detail, is left behind on the surface. The texture, colour and porosity of the substrate surface assist in determining the most appropriate development method, but there are many factors that influence their effectiveness. To the best of our knowledge, only one relevant scientific paper has been published on the detection of latent fingermarks on African elephant (*Loxodonta africana*) ivory in the past thirteen years [5]. In this work, Azoury et al. found that latent fingermarks on ivory were unstable and did not persist for periods of up to two weeks. This mark instability is to some extent due to the complex physical and chemical structure of the ivory. These authors evaluated a number of widely used development techniques, including powders, small particle reagents (SPR), cyanoacrylate fuming (using a range of dyes) and vacuum metal deposition (VMD). The selected

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methods, except VMD, performed satisfactorily for fresh fingermark deposits, but only a sequential treatment procedure using cyanoacrylate and black magnetic powder developed any depositions after two weeks. An in-depth assessment of the quality of ridge detail for successful search and/or comparison was not presented as part of this work. It is now critical to extend efforts towards a more comprehensive assessment of fingerprint development on ivory-based materials.

One of the oldest, simplest, cost effective and most commonly used technique for the development of latent ridge detail is via contrasting powders. The preferential adherence of a fine powder to a range of components within the latent deposit enables sufficient contrast between the deposit and the underlying surface to be able to visualise the friction ridge detail [6,7]. This development method continues to be the focus of on-going research and application in other areas of wildlife-related crime [8]. Where successful, it could present a viable and sustainable approach to the retrieval of forensic evidence in situ and especially at source such as air or shipping ports. The development and application of novel materials for powdering has recently received particular attention [9,10]. In comparison to traditional powders, a range of reduced-size powder particles are now available for fingermark development purposes. These offer many potential advantages, not least that reduced particle sizes could offer enhanced resolution and allow better discrimination of finer characteristic detail within the friction ridges at the micro- or nano-metre scales. Furthermore, the chemical nature of smaller particles can also be tailored to enhance practical application. For example, powders grafted with fluorophores [9] or near infra-red absorbing materials [11] have recently improved fingermark detection on low-contrast surfaces. In some cases, application of selective powder materials has revealed additional information regarding the depositor (e.g., the presence of drugs or metabolites) [12,13].

The lack of translational research, and owing to the poor prosecution rate of those involved in the illegal wildlife trade with its link to organized crime, has led the Metropolitan Police Service in London to conduct an investigation into efficient methods for the recovery of identifiable friction ridge detail from ivory obtained from a number of different species. The aim of this work was to perform an independent assessment of the potential benefits offered by reduced particle size powders for the retrieval of ridge detail from elephant ivory in comparison to a conventional powder. The objectives were:

(a) to compare the physicochemical properties, sensitivity and practicality of two reduced-size powders (≤40 μm average particle diameter) relative to a conventional powder material (>100 μm average particle diameter) for potential deployment in the field;
(b) to perform an assessment of enhanced ridge detail quality with respect to location on a tusk and the age of deposits; and
(c) to compare reduced-scale powders with fluorescent/non-fluorescent cyanoacrylate and to evaluate any benefits of sequential treatment.

This work, for the first time, presents the most comprehensive assessment of a new method for the recovery of usable ridge detail from elephant ivory tusks and performed within an accredited forensic case-work laboratory environment. Furthermore, the value of such an approach also lies in providing a potentially viable, field deployable tool to combat illegal elephant poaching at source.

2. Experimental

2.1. Materials

The development powders used in this study were SupraNano Black Magnetic and SupraNano Black Powder (ARRO SupraNano Ltd., Newcastle upon Tyne, UK) and also Jet Black magnetic powder (WA Products Ltd., Essex, UK). Standard squirrel brushes (Tetra Scene of Crime Ltd., Essex, UK) or metal magnetic brushes/wands (Tetra Scene of Crime Ltd.) were used for powder application. Adhesive tape (Warrender Products, Gwent, UK) was used for the lifting of all developed areas of ridge detail. Exposed photographic paper (FUJIFILM Europe GmbH, Düsseldorf, Germany) was chosen as the control surface for all donor depositions (i.e., a smooth, glossy surface). Three seized elephant tusks were loaned for this study from the Wildlife Unit of the MPS with the following dimensions: length: 96–112 cm; weight 5.78–6.45 kg. Tusk circumferences were between 9–10 cm at the tip (~2 cm from the end), 25–30 cm across the mid-section and 25–34 cm at the severed end. It was unknown whether the tusks were from African or Asian elephants. All tusks were thoroughly cleaned before each use using ethanol-soaked disinfectant wipes (Premier Healthcare & Hygiene Ltd., Tyne and Wear, UK). One of the tusks was a polished tusk and was only used for the assessment of ridge detail quality across its length for comparison with results obtained from a similar study using the other two unpolished tusks (Section 2.2.5). All developed areas of ridge detail were photographed using a Nikon D4 camera (Nikon Corporation, Tokyo, Japan) fitted with a 105 mm Macro Nikkor lens. The lighting technique for the powdered areas was either specular or oblique lighting [14] and for the fluorescent CNA (Lumicyano Solution™, Global Forensics Ltd. Lab, Coventry, UK) and a 532 nm laser (Laser Innovations, Cambridge, UK) was used. This was carried out in accordance with validated standard operating procedures. The images were captured in the RAW file format and post-production was carried out using Adobe Photoshop CS5 (Adobe Products, UK).

2.2. Comparison of powdering materials

2.2.1. Comparison of powder materials for fresh latent ridge detail on glass, photographic paper and ivory

To study the interaction of powder materials with the skin deposits, sebaceous and amino acid print pads (Armor Forensics, FL, USA) were used initially. A single donor was used for this experiment for this first phase of testing. Hands were washed and contact made with a sebaceous pad using each finger ten times before depositing $n = 6$ fingermarks from different fingers on clean glass slides (Menzel-Gläser, Thermo Scientific) using minimal pressure for 1–2 s and each slide then developed with a different powder material following a 30-minute ageing period [15]. This procedure was subsequently repeated using amino acid pads and then natural fingermarks. Though mild risk of skin irritation existed from contact with amino acid/sebaceous pads (as per manufacturer's material safety datasheets), hands were washed with water thoroughly after depositions were made. Natural marks were produced by refraining from hand washing for at least an hour prior to deposition while continuing on with normal activities.

To initially investigate powder effectiveness for natural marks on ivory, a single donor deposited a full set of marks and repeated this on photographic paper as a control. To examine the interaction of powders with the ivory surface, powders were gently applied on multiple ivory sections and across the length of the tusks and observed. As the most promising candidate for ridge detail enhancement on ivory, an extended examination of SupraNano Black Magnetic powder was performed using three different types of fresh deposits (natural, sebaceous and eccrine) for $n = 40$ areas of ridge detail across 4 donors per deposit type. Deposits were spread evenly across the tusk surface and length.

All deposits were aged for 30 min under ambient conditions, powdered and then any developed ridge detail lifted using adhesive lifting tape. All lifts were transferred to individual cobex (acetate) sheets (Tetra Scene of Crime Ltd.), photographed, examined and scored at the Fingerprint Bureau at New Scotland Yard. Throughout the study, all developed ridge detail was visually examined and assessed based on the contrast between the developed detail and substrate, clarity, definition and visibility of ridge detail. All scoring and observations were made using a fingerprint magnifying glass whilst viewing the original lifts on a flat 'Medalight' white light box. Scoring was based on the scale given in Table 1. The grading system deviated from that proposed

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