Visualization of latent fingerprints on the surface of quail eggshells

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Abstract

The paper presents the influence of quail eggshell morphology and pigmentation on the visualization of latent fingerprints. Electron microscopy showed that quail eggshells have a smooth surface, allowing for good fingerprint deposition. Techniques used for identification of latent fingerprints were black magnetic powder, cyanoacrylate fuming method, and ninhydrin method. Among these, the best visualization was obtained with black magnetic powder. This technique allows fast, cheap and good quality visualization of fingerprints and easy donor identification. The cyanoacrylate fuming method proved to be the least effective method, and as such is not recommended for use on quail eggs. The pink prints obtained by the ninhydrin method were poorly noticeable on the pigmented surface of quail eggs, though the good print quality allowed for unambiguous donor identification.

Key words: *eggshell; identification; latent fingerprint; quail*

Introduction

The avian eggshell is a porous system whose formation is one of the fastest calcifying processes known in biology (Maxwell et al., 2012). The mineralized shell is about 96% calcium carbonate. The remaining components include the organic matrix (2%), magnesium, phosphorus and a variety of trace elements (Nys et al., 2004). A cuticle is present on the eggs of most avian species, and is deposited onto the calcareous portion of the eggshell. The chemical composition of cuticles vary across taxa, but may contain proteins,

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polysaccharides, lipids, pigments, calcium carbonate and calcium phosphates (Iglice et al., 2015). Latent prints are impressions formed when the body's natural oils and sweat are deposited on another surface. Latent prints are invisible to the naked eye under ordinary light, and detection often requires the use of physical, chemical and optical methods. From a chemical point of view, components of the fingerprint are divided into intrinsic, such as metabolites, medications and drugs; and extrinsic components, such as blood and dirt (Ahmad and Musa, 2002; Cadd et al., 2015). The intrinsic components of a fingerprint account for of 95–99% of the composition, while different organic and inorganic compounds account for around 5% (Lewellyn and Dinkins, 1995). The majority of organic compounds are proteins, amino acids, glucose, lactate, urea, pyruvate, fatty acids, sterols, and triglycerides. Traces amounts of creatine, creatinine, glycogen, uric acid, and vitamins may be found (Iglice et al., 2015). Inorganic constituents are divided into metal and non-metal ions. Among these, the major inorganic compounds are chloride, sodium, potassium, iron, calcium, bicarbonate, sulfate, phosphate. Fluoride, iodide and bromide may appear in microgram quantities, while magnesium, zinc, cobalt, and others may be found in trace amounts. The chemical composition of the fingerprint is determined by gender, age, race, health and metabolism (Girod et al., 2015). The choice of the technique, or sequence of techniques, for the visualization of latent prints depends primarily on the nature of the surface (porous, semi-porous, non-porous; rough or smooth) (Lennard, 2001). Additional factors that affect the choice of methods are the presence of extrinsic components (e.g., blood, oil, dust), environmental factors (e.g., wet, dry, dirty) and the age of print. Surfaces are generally separated into two classes: porous and non-porous. Porous surfaces absorb organic and inorganic materials from fingerprints. On a wet porous surface, upon which a water-soluble component is not present, physical developer is the method of choice. On a dry porous surface, applicable techniques include 1,8-diazafluorene-9-one (DFO) or ninhydrin solutions, iodine fuming and metal salt treatment. Non-porous surfaces do not absorb organic and inorganic materials from fingerprints. Cyanoacrylate fuming method, dye stains, powders, and vacuum metal deposition are applicable methods for dry non-porous surfaces. Wet non-porous surfaces can be treated with a suspension of molybdenum disulfide in a detergent solution. Semi-porous surfaces partially absorb fingerprint residues, and therefore all the above methods are applicable for fingerprint visualization on these surfaces. A latent fingerprint is also used as a source of donor DNA. DNA is molecule present in all nucleated cells of the body. One human cell contains approximately seven pg of DNA (Tiersch et al., 1989). According to the literature, people shed about 400,000 epithelial cells per day, making skin a valuable source of DNA (Wickenheiser, 2002). With the current technology, it is possible to obtain a full DNA profile from approximate 100 pg or less of DNA (Oostidk et al., 2014), corresponding to fewer than 20 cells. The amount of DNA left on the surface mainly depends on the amount of organic and inorganic material of individuals, the morphology and structure of the surface, and environmental conditions (Phipps and Petričević, 2007). Visualization problems arise when latent fingerprints are deposited on difficult surfaces such as food, fabric, skin (human, animal), feather or eggs. Eggs are not a favourable medium for the development of prints, and to date few articles have been published on this subject. Ferguson et al. (2013) succeeded in visualising latent prints on the surface of chicken eggs using different powders, while Darby et al. (2015) succeeded in visualising prints from the surface of wild bird eggs using the superglue fuming method with fluorescence dyes.

The objective of this study was to examine the influence of morphology and pigmentation of quail eggs on the visualization of latent fingerprints. In recent years, consumption of quail eggs has increased due to their nutritional qualities, as a rich source of proteins, antioxidants, lysozyme, vitamins, and minerals (Tunsaringkan et al., 2013). Also, their nutritional value is 4-5 times higher than in chicken eggs. Quail eggs are an important dietary supplement and it is of crucial importance that all steps from the breeder to grocery store (collection, transport, and storage) be supervised, to prevent theft or contamination with chemical or biological agents. For food producers, including consumer egg producers, EU and national guidelines on food and food safety, commonly referred to as the Hygiene Package, are important, as they contain relevant data on dangers related to production and control measures (Zdolec, 2007).

Materials and methods

Biological materials. Quail eggs (25) were randomly collected from dairy shops in Zagreb. Collected samples were transferred to the laboratories of Ivan Vučetić Forensic Science Centre. In the laboratory, given the number of visualization techniques, eggs were divided into three groups (A, B and C) each with seven eggs. The remaining four eggs were used in electronic microscope analysis. Eggs were gently cleaned with a cloth to remove old fingerprints (98% ethanol) and other organic material, before deposition of new prints on the eggshell. As previously stated, prints are impressions formed when the body's natural oils and sweat are deposited onto another surface. Persons for whom it was previously established that they leave quality fingerprints (undisputed fingerprint) were selected as donors. Eggs were taken with the thumb and forefinger and held for a minimum of 10 seconds, applying approximately the same pressure to each egg. All procedures used in this research were in compliance with the European guidelines for the care and use of animals in research (Directive 2010/63/EC) and with approval of the Ethics Committee for Animal Experimentation, Faculty of Veterinary Medicine, University of Zagreb, Croatia (record no.: 640-01/16-17/15; file no.: 251-61-01/139-16-2).

Electron microscopy. The surface of the quail eggshells was visualized with the scanning electron microscope (SEM Philips XL 30 with EDX detector).

Visualization techniques. Latent fingerprints were visualized with

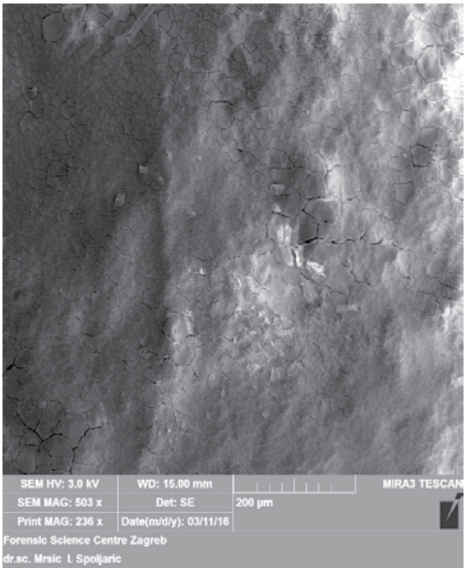

Figure 1. Surface of the quail eggshell visualized by electronic microscope SEM Philips XL 30 at the Ivan Vučetić Forensic Science Centre

black magnetic powder (group A), cyanoacrylate fuming method (group B) and the ninhydrin method (group C). Black Magnetic Powder (BMP) and ninhydrin solution were purchased from Bureau voor Dactyloscopische Artikelen, Netherlands. The cyanoacrylate fuming method was processed in the fuming chamber MVC 5000 with cyanobloom glue according to the procedure of Ferguson et al. (2013). After fuming, eggs were removed from the chamber and allowed to stand in the fumehood for a further ten minutes to ensure the removal

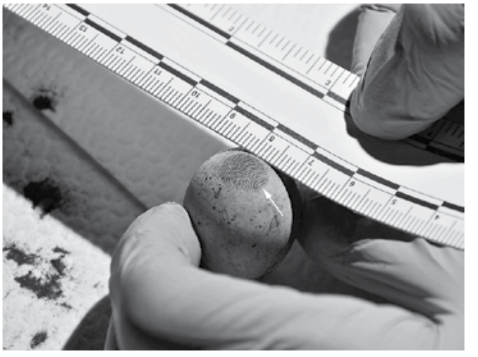

Figure 2. Fingerprints on quail eggs after treatment with black magnetic powder

Table 1. Comparative analysis of a donor's fingerprint patterns (A, B, C, D) in 12 identification points depending on the visualization method

Groups of eggs according the visualization method	12 IDENTIFICATION POINTS											
	1	2	3	4	5	6	7	8	9	10	11	12
A1*	A	B	B	C	D	D	D	B	C	B	B	B
A2*	A	B	B	C	D	D	D	B	C	B	B	B
A3*	A	B	B	C	D	D	D	B	C	B	B	B
A4*	A	B	B	C	D	D	D	B	C	B	B	B
A5*	A	B	B	C	D	D	D	B	C	B	B	B
A6*	A	B	B	C	D	D	D	B	C	B	B	B
A7*	A	B	B	C	D	D	D	B	C	B	B	B
B1**	/	/	/	/	/	/	/	/	/	/	/	/
B2**	/	/	/	/	/	/	/	/	/	/	/	/
B3**	/	/	/	/	/	/	/	/	/	/	/	/
B4**	/	/	/	/	/	/	/	/	/	/	/	/
B5**	/	/	/	/	/	/	/	/	/	/	/	/
B6**	/	/	/	/	/	/	/	/	/	/	/	/
B7**	/	/	/	/	/	/	/	/	/	/	/	/
C1***	A	/	B	C	/	/	D	B	C	/	B	B
C2***	A	B	B	C	D	D	D	B	C	B	B	B
C3***	A	B	B	C	D	D	D	B	C	B	B	B
C4***	/	B	B	/	/	D	D	B	/	B	/	B
C5***	A	B	B	C	D	D	D	B	C	B	B	B
C6***	A	B	B	C	D	D	D	B	C	B	B	B
C7***	A	B	B	C	/	D	D	B	C	B	B	B

* - fingerprints on quail eggs after treatment with black magnetic powder (A 1-7); **-fingerprints on quail eggs after treatment with superglue (cyanoacrylate fuming) (B 1-7); ***-fingerprints on quail eggs after treatment with ninhydrin solution (C 1-7).
- shapes of papillary lines: point (A), end of line (B); branching (C); break the line (D).
/ - not detected

of all harmful fumes. Cyanobloom glue was purchased from Foster and Freeman, England. The ninhydrin test was conducted in the ninhydrin chamber NiNcha S321 according to the procedure of Crown (1969). Eggs were sprayed with ninhydrin solution and heated for 60 minutes at 42 °C until prints appeared. All developed prints were observed by the naked eye.

Unique identification profile. This method was based on a match of 12 identification points of papillary lines between the disputed and undisputed fingerprints (Kujundžić et al., 2014). Testing was done at the Ivan Vučetić Forensic Science Centre, Ministry of the Interior of the Republic of Croatia, Zagreb.

Results and discussion

SEM Philips XL 30 scanning electron microscope with a magnification of 503 times was used to examine the quail egg surface (Figure 1). The photograph showed a mostly smooth surface with small uneven areas. Creased/wrinkled areas of an irregular shape appearing between smooth surfaces resembled cracked dry earth. A smooth surface allows better and more homogeneous deposition of organic material from donor fingers, making them a good source of latent fingerprints.

It is known that fingerprint visualization depends on egg morphology, visualization technique and the age of the print (Ferguson et al., 2013; Darby et al., 2015). Techniques used for the visualization of latent fingerprints in this study were black magnetic powder, cyanoacrylate fuming method, and the ninhydrin method. From the literature is known that powders are very effective visualization tools (McMorris et al., 2015). The principle of this method is the adsorption of the powder material onto the fingerprint constituents. In terms of their magnetic properties, powders are roughly divided into magnetic (e.g., iron powders), and non-magnetic (e.g., aluminium powder, copper powder, graphite). The black magnetic powder used in this study provided the best ridge visualization of fingerprints and enough information for conclusive donor identification (Figure 2, Table 1). It is apparent from Table 1 that all fingerprints visualized by black magnetic powder coincided in all 12 identification points with an undisputed fingerprint donor: point (A), end of line (B); end of line (B); end of line (B); branching (C); break the line (D); break the line (D); break the line (D); end of line (B); branching (C); end of line (B); end of line (B); end of line (B). Only in four of seven fingerprints visualized by ninhydrin was the shape of the papillary line clear enough for comparative analysis. The analysis showed that all the disputable prints coincided in all 12 identification points with an undisputed fingerprint donor (Table 1). Due to poor visibility of papillary lines visualized by the cyanoacrylate method, the obtained prints were not used in donor identification.

However, the black magnetic powder was the only technique that did not provide DNA profiling. This is likely due to a loss of a certain amount of DNA during the deposition and removal of excess powder. The second physical

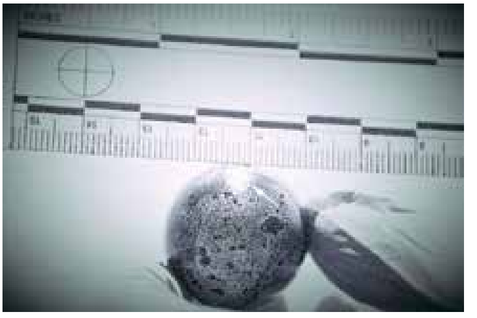

Figure 3. Fingerprints on quail eggs after treatment with superglue (cyanoacrylate fuming)

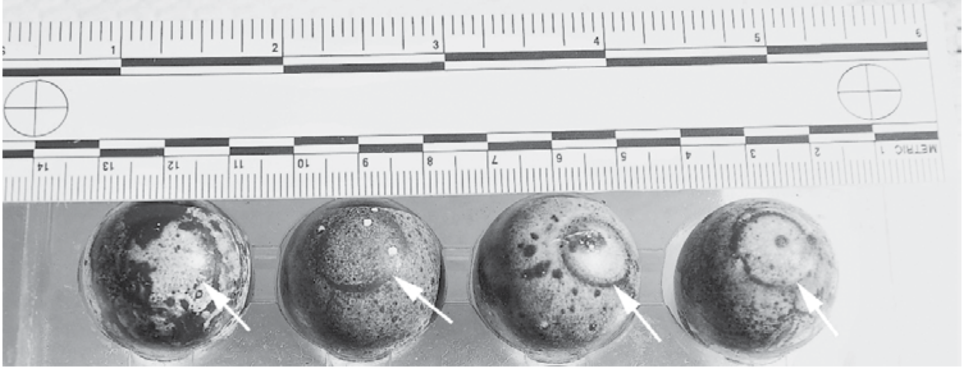

Figure 4. Fingerprints on quail eggs after treatment with ninhydrin solution

method was the cyanoacrylate fuming method (Figure 3). The cyanoacrylate fuming method (often called the super glue method) is another physical process in which cyanoacrylate vapour reacts (polymerizes) with water and the fingerprint constituents to form a crystalline white deposit along the fingerprint ridges. Although the exact mechanism remains unknown, it is suspected that the super glue fumes are catalysed by the tiny amount of moisture attracted by sodium chloride residues in the latent fingerprints (Thompson and Fritchman Thompson, 2012). Darby et al. (2015) used this method together with fluorescent dyes for visualization of latent prints on the surface of wild bird egg shells. In the present study, this method proved to be least efficient as the latent prints were developed as white impressions. Due to the low level of detail, prints appeared more like white spots than fingerprints and therefore were not useful for donor identification.

The third methods used in this study was the chemical, ninhydrin method. Ninhydrin reagents have proven to be an excellent choice for visualization of latent fingerprints deposited on numerous surfaces (Drochioiu et al., 2013). Chemical techniques are based on a chemical reaction between the reagents and one of the constituents of latent fingerprints. Ninhydrin reacts with the amino acids deposited on the surface of the quail eggs, resulting in the formation of a purple reaction product called "Ruhemann's Purple" (Grigg et al., 1989). The pigmentation of quail eggs reduced the clarity of prints and therefore it was difficult to notice them (Figure 4), but the detailed structure of prints provided sufficient information for conclusive donor identification. In addition, it was easy to conduct DNA profiling from prints visualized by the ninhydrin method (Špoljarić et al., 2017).

Conclusions

Scanning electron micrographs of quail eggs revealed the smooth eggshell texture. A smooth texture allows for good adhesion of organic and inorganic material, making it a good source of prints. Black magnetic powder and the ninhydrin method can be used for fingerprint visualization on quail eggshells. The only difference was in the clarity of prints due to the pigmentation of quail eggs. Between them, black magnetic powder proved to be a better technique. This technique provides prints with a high level of detail, regardless of the egg surface structure and pigmentation. Also, it is cheap, easy to handle and can be applied anywhere. Purple prints obtained by the ninhydrin method were difficult to notice on the pigmented quail eggs, though the clear papillary lines allowed for unambiguous donor identification. This method is best to use on less pigmented eggs. The second physical method, cyanoacrylate fuming method, was least efficient due to the low print quality. Additionally, the ninhydrin and cyanoacrylate methods allowed for DNA profiling, which was not achieved by black magnetic powder.

Author contributions

IS (first author) and DŠ (main author) conceived and designed the study and made a substantial contribution to acquisition, analysis, and interpretation of data and also gave final approval of the version to be published. MP, GM, BP and MMKP participated in the study design, coordinated the experiment, made substantial contributions to interpretation of data and drafted the manuscript. MJ, KV and ASV (corresponding author) were involved in manuscript writing and its revision. MK participated in manuscript writing. All authors read and approved the final manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest concerning the research, authorship, and publication of this article.

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Vizualizacija latentnih otisaka prstiju na površini ljuske prepeličjih jaja

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U radu je prikazan utjecaj morfologije i pigmentacije ljuske prepeličjih jaja na vizualizaciju latentnih otisaka prstiju. Snimke dobivene elektronskim mikroskopom prikazuju glatku površinu ljuske jaja koja omogućava lako deponiranje otisaka. Tehnike korištene za identifikaciju latentnih otisaka prstiju bile su crni magnetski prah, ninhidrinska metoda i metoda izazivanja otisaka cijanoakrilatnim parama. Među navedenim metodama, najbolja vizualizacija otiska je postignuta crnim magnetskim prahom. Ova tehnika omogućava brzu, jeftinu i kvalitetnu vizualizaciju otisaka i jednostavniju identifikaciju donora. Metoda vizualizacije otisaka cijanoakrilatnim parama pokazala se najmanje učinkovitom metodom i kao takva nije preporučljiva za uporabu na prepeličijim jajima. Ružičasti otisci dobiveni ninhidrinskom metodom slabo su vidljivi na pigmentiranoj površini prepeličjih jaja, ali dobra kvaliteta otisaka omogućuje jasnu identifikaciju donora.

Ključne riječi: *površina jaja, identifikacija, latentni otisak prsta, prepelica*