Ewa Jakubiak, PhD.
Lomza State University of Applied Sciences
Faculty of Social Sciences and Humanities, Chair of Law and Administration
Urszula Staśkiewicz, PhD.
Higher School of Criminology and Penitentiary Science in Warsaw
Institute of Security Studies

Physical Sources of Evidence - Forensic Science in Theory and Pactice

Preface

Forensic science gathers and researches information about the past, which could later be used in court proceedings. Forensic technicians analyze fingerprints, handwritten signatures and hair samples of particular people, as well as other pieces of physical evidence. Most of forensic research takes place in laboratories, though sometimes it is also conducted on crime scenes.

Evidences can confirm commitment of offenses and is the most important aspect of the forensic science, as it focuses on gathering, preserving and analyzing evidence during an investigation.

This paper consists of two parts. The first is the result of a research into the current knowledge of forensic science. The key research problem was to establish current the state of theory within the subject matter scope. Conducted inquiries had two objectives : exploration - to better understand the subject matter and discover possibilities for broader research; description - to serve as an introduction to explaining complexity of the subject, if only for the fact a scientific description is more precise and detailed than an informal one. Thus, the first part defines forensic science and characterizes the most common physical sources of evidence analyzed within its scope. To that end, the monograph had been utilized as the key research method.

The monograph method covers gathering detailed data on the subject matter. As noted by J. Apanowicz, its objective is the "scientific examination of isolated properties and qualitative elements of a given structure, system or process, defining their character and extent, as well as describing its functioning and further development".[1]

The second part of this paper is the result of research into application of forensic knowledge in the actual work of the officers from the Municipal Police Station in Ostrołęka. The key research problem of said inquiry was to find an answer to the question of: “Which methods and types of trace are being utilized on crime scenes by the policemen of Ostrołęka Municipal Police Station?”

The inquiry utilized the research method of surveying, consisting of answering in writing to a deliberate, logical, consistent and cohesive series of questions meant to resolve a given thesis or specific research problem. According to the definition

[1] APANOWICZ, J. *Metodologia ogólna.* Wydawnictwo Diecezji Pelplińskiej „BERNARDINUM”, Gdynia, 2002.

of J. Apanowicz, "surveying is a technique consisting of answering in writing to a deliberate, logical, consistent and cohesive series of questions meant to resolve a given thesis or specific research problem".[2] The research tool used in the research was a self-report questionnaire given out to the respondents.

Forensic science in subject literature

Definition, structure and functions of forensic science

The term 'forensic science' came from the Latin word *forensis*, which refers to a Roman *forum.* The forum was a place where the gatherings of civil society were held, which included debates concerning current criminal cases. The prosecutor and the defender met at the forum and their arguments were presented for judgment.

Forensic science is a relatively new branch of knowledge, compared to other scientific disciplines. Its scientific basis and systems originate from the latter half of the 19th century. The concept and role of forensic science has changed along with its development. Thus, forensic science lacks an unequivocal definition. According to H. Gros: *"Forensic science consists a part of natural science in the criminal law; that which it knows, proves and strives to unveil, that which it teaches and presents is based on strict basics of observation. The scope of its research, its services is the reality of the criminal law in the widest sense."*[3] Meanwhile, T. Hanusek has defined forensic science as *"the science of tactical rules and solutions, as well as technical methods and means of recognizing and unveiling negative social phenomena defined by law, particularly crimes and their perpetrators and proving an existence or lack thereof of links between people and occurrences, as well as preventing crime and other negative, but legally relevant phenomena. Said science is also concerned with the strategy of foreseeing and future recognition and combating of these phenomena, particularly through prevention of their occurring and development*[4]". According to Z. Czczot and T. Tomaszewski, *"Forensic science is a practical science, creating rules of effective operation, utilization of technical means and laboratory research methods to prevent committing of crimes, unveiling them and establishing facts of evidential value in criminal proceedings (both preliminary and court) or of another type of proceedings (e.g. civil law)."*[5]

Forensic science might involve DNA analysis, taking fingerprints, autopsies, pathology and toxicology, all of which can be used to determine the cause of death and links between a suspect and a crime. Both the court experts and law enforcement authorities utilize the most up to date scientific methods in order to collect and analyze evidence during the investigative process.

Both crime researchers and laboratory technicians utilize specialist skills and tools to collect, analyze and present evidence to solve crimes or effectively prosecute the perpetrators. Increased application of scientific methods to gather and analyze evidence has led to closing of many criminal cases, which were impossible to solve

[2] APANOWICZ, J., op. cit…, pg. 84.
[3] GROSS, H. „*Archiv fur Kriminalantropologie und Kriminalistik*". 1998.
[4] HANAUSEK, T. *Kryminalistyka. Zarys wykładu*, Kraków, 2005, pg. 23.
[5] CZCZOT, Z.; TOMASZEWSKI, T. *Kryminalistyka ogólna.* Toruń, 1996, pg.16.

using solely traditional detective work. The new testing methods are even used in unresolved cases from many years before.

Forensics covers various areas

- Tactics, which concern itself with:
  - how the criminals commit crimes;
  - methods used by the law enforcement to detect crime, as well as to discover and apprehend the perpetrator;
- Technology, which concerns itself with physical and chemical means:
  - used during perpetration of criminal acts;
  - utilized to detect the crime and to discover and apprehend the perpetrator;

Another author, J. Sehn, highlighted the role of tactics in the forensic science, though he limited himself to the topic of evidence: "forensic science is the knowledge of deliberate, tactical means of detecting and securing evidence and means and technical methods for their deliberate use in evidential proceedings in order to establish objective truth, particularly within the scope of combating crime".[6] B. Hołyst took yet another stance, proclaiming that „*forensic science is a science concerned with establishing the facts of a crime, the way in which it had been perpetrated, detecting its perpetrators and preventing future crimes".*[7]

In court proceedings, forensic science is incredibly important even during court proceedings alone, as it is during this stage that one:

- utilizes personal and physical sources of evidence,
- decides on veracity and applicability of submitted pieces of evidence,
- undertakes confrontations and other special interrogation forms,
- conducts a formal examination,
- appoints experts, the extent of their expertise and judges their conclusions,
- undertakes forensic experiments and sometimes decides to warrant a search, wiretap, interception of correspondence or an arrest of a person.[8]

Summarizing, forensic science can be defined as a science concerned with gathering information through systematic experimentation and observation. The science is often linked to detailed analysis of a natural or man-made process to understand how and why something is occurring. Sometimes the scientific process requires only observation and linking concepts and ideas together, but other times it might require the use of technology and experimental approaches.

Development of forensic science and the traits of modern forensics

Forensic science is one of the auxiliary sciences of the legal theory - results of forensic research can be of great importance for the legal practice. The terms 'forensic

[6] KASPRZAK, J.; MŁODZIEJOWSKi, B.; KASPRZAK, W. *Kryminalistyka. Zarys systemu,* wyd. Difin, Warszawa 2015, pg.27.
[7] HOŁYST, B. *Kryminalistyka.* Warszawa 2010, pg. 41.
[8] KULICKI, M.; KWIATKOWSKA – DARUL, V.; STĘPKa, L. *Kryminalistyka. Wybrane zagadnienia teorii i praktyki śledczo- sądowej*, Wyd. Uniwersytetu Mikołaja Kopernika, Toruń 2005, pg. 36.

science' and 'forensic medicine' are often confused and used interchangeably. Legal auxiliary sciences comprise of several disciplines, such as medicine, toxicology, anthropology, entomology, engineering, odontology and, of course, forensic science.

As technology permeates all aspects of our lives, it should come as no surprise that crime-solving also entails use of the newest technologies. From retinal scans to trace chemistry, real forensic technologies are so advanced that they allow solving crimes that appear as something taken straight from a science-fiction book. Many branches of forensic medicine have developed over the last centuries to help apprehend criminals or prove innocence in a variety of scenarios. These include complex, computer-based recreations of crime scenes, laboratory testing of tissue samples, fibers and DNA, as well as somewhat low-tech observations, such as counting the number and maturity of insects attacking the rotting remains. It is quite common to utilize evidence from different forensic sciences in a single case. Usage of scientific methods to gather, analyze and explain evidence allows the forensic medicine researcher to reconstruct past events and identify the victims.

Forensic science also ceases being solely a focus of law enforcement authorities - or, in other words, ceases strictly related to police work. More and more often, high levels of forensic knowledge are to be found among judges and attorneys (often referred to as forensic tactic and forensic defense method). This trend should be considered to be a positive development, as it enables to use the basic principles of criminal proceedings.[9]

Forensic science includes a wide assortment of disciplines. The usually include tests of weapons, firearms, fingerprints, tire marks, soil, fibers, glass, paint, serial numbers, light bulbs, narcotics, scrutinizing documents, researching fires, explosions, biological fluids and - last, but not least - crime scenes. Forensic science also concerns itself with ordinary physical evidence that is not being tested directly by another auxiliary legal discipline. The key objective of forensic science is to implement scientific methods in investigating evidence, to help the justice system to establish that a crime had been committed, identify its victims and perpetrators and finally establish the method by which it had been committed. Forensic science makes use of other scientific disciplines to inspect physical evidence. These include chemistry, biology, physics and mathematics. People who conduct forensic science are called forensic scientists.

Work at the crime scene is complemented by a detailed crime scene investigation and detecting, recognizing and collecting appropriate evidence, as well as continual documentation of the state of the crime scene. Fingerprint testing involves detecting and exposing fingerprints from various surfaces and comparing them to other fingerprints, such as those taken from the suspect, in order to establish a possible link. Tool and tire mark tests involve registration and observation of surface impressions to establish a link with a possible tool, shoe or a tire mark. Drug analysis comprises of identification of an abused medicine and its dosage. Biological fluid testing, often referred to as forensic examination, involves detecting, recognizing and gathering of bodily fluids and their subsequent analysis with purpose of identifying the person the samples were taken from. Trace tracking comprises a large number of fine pieces of evidence, such as fibers, glass, soil or paint flakes. The traces are investigated and

[9] GUTEKUNST, W. *Kryminalistyka: zarys systematycznego wykładu.* Wyd. Prawnicze, 1974, pg. 23.

compared with potential sources in order to establish their origin. Testing documents involves their analysis in order to establish their authenticity or discover forgeries and analyzing handwriting (particularly handwritten signatures) in order to identify the person who wrote them. Testing serial numbers involves establishing their authenticity and recovery of erased numbers. Light bulb testing allows establishing whether they were on or off in the moment of their breaking. It is particularly useful when investigating car accidents.

Forensic technology develops particularly strongly in these key directions:

- operational technology - utilizing all new electronic and optical technologies to create equipment for so-called special operations,
- analysis of left traces- increasing use of physical and chemical methods (e.g. DNA testing or identification of psychoactive substances).

Forensic scientists investigate and identify physical evidence and draw conclusions from them. Their key responsibility is to use their knowledge and training to objectively analyze the evidence. A forensic scientist identifies relevant evidence and discards irrelevant evidence. They utilize scientific procedures to determine the value of evidence before identifying, classifying and comparing similar pieces of evidence, which could later be used by police detectives and prosecutors. Drawing conclusions and testing the evidence comprises the key tasks of forensic science, as occurrences taking place alongside the committed crime can be confirmed, along with validation reports. Moreover, a forensic scientists write reports including expert opinions and testify in court.

Today, forensic science develops along with other scientific disciplines and many previously unsolved cases are being solved with the use of modern technologies.

The concept and functions of forensic traces

The term *trace* can be understood in a narrower sense, as objective physical traces, or a wider meaning, which includes both physical sources of evidence, along with their characteristics, and subjective memory traces[10]. A trace could comprise of an impression or blot (for example on the ground, sand, or snow a person stepped on).

Forensic publications recognize a few approaches to the concept of ‘trace’:

- complete omission of defining forensic trace;
- exemplificative and enumerative definition of a forensic trace;
- mentioning enumerative and classificatory descriptions;
- using synthetic descriptions, pointing towards the nature of a trace, its relation to the crime and its function;
- detailed analysis of elements comprising the concept of trace.[11]

Among Polish forensic scientist, a popular definition of evidence is one formulated by J. Sehn, who said that “evidences, in the forensic meaning, is a change in objective

[10] KWIATKOWSKA – DARUL, V. *Formowanie się zeznań jako skomplikowany proces psychiczny wg koncepcji E. Tulvinga,* Warszawa 2003, pg. 283.
[11] KOŁECKI, H. *Pojęcie i klasyfikacja śladów kryminalistycznych.* Zeszyty Naukowe ASW, 1977, issue no. 18.

reality that, as a perceptible mark of the occurrences under investigation, form a basis for reconstructing and establishing their course in accordance with the reality."[12] Another definition says: "evidences is a factual state in the form of phenomena and material objects linked to the investigated occurrence, in a way that is possible and useful for forensic investigative and evidential research".[13].

Subject literature recognizes 10 functions of traces:

1. identification function - establishing identity of an object or phenomenon, based on its most characteristic traits;
2. evidential function - presumption of truth;
3. organizational function - organizing on the basis of the trace analysis during first investigative actions;
4. reconstructing function - aimed at reconstructing the course of the past occurrence;
5. versioning function - establishing a version of the past happening;
6. designation function - some kinds of traces allow for inferring certain traits of the perpetrator;
7. verification function - verifying the sources;
8. registering function - entering information into archives;
9. associative-reactivating function - reactivating previously unsolved cases;
10. preemptive function - some traces allows to understand perpetrator's modus operandi.[14]

Securing evidence in Polish regulation

The most information-rich place, with regards to both the crime itself and its participants, is the crime scene. The perpetrator leaves traces within the crime scene, which can later constitute evidence in criminal proceedings. They should be secured from both forensic and procedural standpoints. Therefore, crime scene investigation should be undertaken as soon as possible after receiving notification of a crime having been committed. Art. 308 of the Code of Criminal Procedure allows for preparation of evidential activities even before a decision to initiate the formal investigation procedure is made. Furthermore, conducting the first urgent investigative activity is considered to be the start of an investigation: *"Within the limits necessary for securing traces and evidence of the crime against their loss, distortion or destruction, the prosecutor or Police may, in all urgent cases, conduct procedural activities, in particular an examination, including experts if necessary, even before a decision to initiate the formal investigation procedure is made.* These might include searching the suspect or undertaking other necessary action towards them, including taking samples of blood and bodily secretions[15]".

The above-mentioned act defines the scope of 'urgency' - the urgent activities should be undertaken within 5 days from taking the first urgent action (art. 303, §4 of

[12] SEHN, J. *Ślady kryminalistyczne. Z Zagadnień Kryminalistyki.* 1960, pg.47.
[13] GRUZA, E.; GOC, M.; MOSZCZYŃSKI, J. *Kryminalistyka.* op. cit., pg. 194.
[14] KASPRZAK, J.; MŁODZIEJOWSKi, B.; KASPRZAK, W. *op. cyt.,* pg. 58.
[15] *Act of June 6th 1997, Code of Criminal Procedure*, (Journal of Laws of 1997 no 89 pos. 555) art.308.

the act). Moreover, that action also defines the time for subsequent pre-trial proceedings (art.308 §5 of the act). These securing activities are a responsibility of the nearest Police unit. These actions are undertaken, in the necessary scope, by the prosecutor, who oversees their course.

According to Cz. Grzeszczyk, "*the examination (operational - investigative - technical) team is able, thanks to the use of technical and forensic knowledge, to infer about the number of perpetrators, their gender, age, motives and tools used for perpetrating the crime as soon as still on the crime scene.*[16]"

A principle confirmed by years of forensic experience says that the success of the entire investigation relies on those crucial earliest activities. Traces gathered during the examination can be used to:

- identify individuals and groups, for example based on teeth marks, footprints, smell;
- identify individual objects, for example a shoe or a tool;
- identify object groups, for example blood type, paint type;
- initiating a chase with a detection dog;
- detecting through operational means individuals and objects whose traits correspond to those exhibited by the collected evidence.[17]

Physical sources of evidence - objective traces

Dactyloscopic traces

Dactyloscopy is both one of the most basic and oldest forensic science disciplines. It concerns itself primarily with identifying individuals based on their fingerprints. Its scientific basis was created on the turn of 19th and 20th centuries, thanks to the research of Henry Fauld, William Herschel, Francis Galton, Edward Henry and others[18]. Dactyloscopy concerns itself with identifying individuals based on the shape of friction ridges of human fingers, as well as detecting traces left by hands and other parts of the body. The term 'dactyloscopy' is based on the Greek language and means 'to observe fingers' (daktylos - finger, skopein - to look).[19] Dactyloscopy can be split into three subdisciplines:

- dermatoscopy (figure 5),
- cheiloscopy (figure 6),
- lophoscopy (figure 7).

Friction ridges exist on the palm side of hands and soles of feet, creating characteristic shapes of varying complexity.[20]

Papillary ridges consist of the small ridges, whorls and valleys on each fingertip. They are created by pressure on the small, developing fingers of fetuses in mother's womb. No two people have been found to share the same fingerprints - they are wholly

[16] GRZESZCZYK, Cz. *Znaczenie techniki kryminalistycznej w wykrywaniu przestępstw.* Problemy Praworządności 1987, nr 1, pg.27.
[17] KULICKI, M.; KWIATKOWSKA – DARUL, V.; STĘPKA, L. *Kryminalistyka,* op. cit…, pg.402.
[18] MOSZCZYŃSKI, J. *Daktyloskopia.* Warszawa 1997, pg.11.
[19] WIDACKI, J. *Kryminalistyka,* Wyd. C.H. BECK, Warszawa, 2008, pg.307.
[20] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. op. cit*…,* pg. 69.

unique. The fingerprints are even more unique than DNA, the genetic material in each human cell. While monozygotic twins may share the same DNA - or at least a majority of it - they do not have the same fingerprints.

Dactyloscopy is also a type of biometrics, which utilizes human physical properties for their identification. Fingerprints are perfect for these purposes, as they are cheap to collect and analyze and never change, even as people age. While hands and feet may have many ridged surfaces that could be used for identification, fingerprints proved a popular form of biometry because of their ease of collection and sorting. They're also readily available.

Fingerprints are taken from groups of ridges called friction ridges. Each ridge contains pores, fixed to subdermal sweat glands. Due to this sweat, humans leave fingerprints on surfaces they touch - e.g. glasses, tables and nearly all objects they touch. All ridges of the fingerprints leave shapes called loops, spirals or arches. Loops begin on one side of a finger, twist upwards and leave on the other side. There are two types of loops: radial, which start on the thumb-side of the finger, and ulnar, which start on the pinky-side of the finger. The whorls form radial or spiral patterns.

Forensic researchers examine the arrangement, shape, size and number of ridges in these patterns to differentiate various fingerprints from each other. They also analyze other very small characteristics, called minutiae, which often cannot be seen with a naked eye. Fingerprints consitute a foolproof way of identifying individuals.

This method of personal identification serves governments across the globe for over a century, providing means of accurately identifying people. Other visible human traits, such as facial features, tend to change significantly as people age, but fingerprints are relatively persistent. Moreover, one should bear in mind the fact that collecting fingerprints is a relatively cheap method of gathering evidence.

Dactyloscopic identification is based on three key properties of papillary lines:

- individuality (uniqueness) - many years of dactyloscopic practice and papillary calculations are individual for each person. This great variety of fingerprint patterns arises from the fact the papillary ridges are created during fetal development as a result of basic skin elements collecting randomly.
- indestructibility - dermal cells possess regenerative ability. In case of minute surface damage to the papillary lines, the ridges regenerate into their original shape. Only damage to the dermis itself is able to permanently damage papillary lines, creating scars.
- immutability - the papillary lines, created around 100th-120th day of fetal development remain unchanged until postmortem decay of the human body.[21]

Forensic dactyloscopy involves taking prints of fingertips and palms. Fingerprints are commonly copied with a black ink onto a fingerprint card. These prints are later used as comparative material for dactyloscopic research or are entered into the AFIS system[22]. When taking fingerprints, fingerprint card forms are typically used:

[21] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. *Kryminalistyka.* op. cit.., pg. 70.
[22] AFIS - Automated Fingerprint Identification System

- card for taking fingerprints of suspects (accused) of having committed crime, unidentified persons or persons attempting to hide their identity, wanted or juveniles committing offenses, as well as corpses;
- card for taking fingerprints to eliminate uninvolved persons, whose traces were left without a connection to the crime.[23]

In Poland, the Central Dactyloscopic Register is located at the Central Forensic Laboratory of the General Police Headquarters in Warsaw. Provincial forensic laboratories are belong to Provincial Dactyloscopic Registers (WRD).[24] Furthermore, Poland's entry into the European Union created the need to link its domestic database to the automated european fingerprint identification system, Eurodac (European Dactyloscopy), active since January 2003.

Mechanoscopic traces

The term 'mechanoscopy' usually refers to a branch of forensic science concerned with investigating and identifying tools and traces left by tools.[25] The subject of mechanoscopy also includes other traces with structural attributes, originating not only from the use of tools, but also any and all deformations, tears, cuts, splinters or flecks caused by the gravity, human muscles or mechanical contact of different objects.[26]

According to K. Kasprzak, "mechanoscopy is a specialized branch of forensic sciences, which includes methods and means used to uncover, secure and analyze for investigative purposes the surface traces created by mechanical operation of various items, tools or static objects and surfaces, within a scope established through practical considerations, specifics of the item in question and research methodology".[27]

The term 'mechanoscopy' comes from the greek *mechane* (*tool*) and *skopeo* (I look). It had been first proposed in 1939 in Czechoslovakia and was introduced to Polish forensic science in the fifties. It bears mentioning that in some countries this branch of forensic science is called traseology - or simply investigating tool traces.

Generally speaking, mechanoscopy is a branch of forensic science concerned with researching and identifying signs of tool use. The first book on this subject was written by Czech police sergeant by the name of Ladislav Havlíček in 1940. It was named "Mechanoscopy: Traces and signs of craft tools". This textbook described methods based on author's practical experience, mainly related to bank robberies.[28]

The size of microscopic traces is varied. We distinguish large traces - visible with the naked eye - and those only visible with the use of optical equipment - magnifying glasses, stereoscopic microscope, comparison microscope or an EMA microscope.[29]

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[23] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. *Kryminalistyka.* op. cit*…,* pg.79.
[24] HOŁYST, B. *Kryminalistyka.* op. cit*..,* pg. 649.
[25] KURCZEWSKI, J. *Rys historii mechanoskopii*, Łódź 1981, pg. 34.
[26] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. *Kryminalistyka,* op. cit.., pg. 113.
[27] Ibidem, pg. 115.
[28] BREBBIE, C. A. *Structural studies, repairs and maintenance of heritage architecture XIII*, WIT Press 2013, pg. 594.
[29] BIENIEK, J. *Badania mechanoskopijne w praktyce kryminalistycznej.* Warszawa 1988, pg. 56.

Based on the above information, one could notice that mechanoscopy is a specialized branch of forensic science, comprising of methods and means utilized for detecting, securing and and analyzing for investigative purposes the surface traces created by mechanical operation of various items, tools or static objects and surfaces, within a scope established through practical considerations, specifics of the item in question and research methodology".[30]

Securing microscopic evidence is fundamentally similar to securing other kind of evidence. This extends to the existence of two key forms of securing evidence: procedural and technical. When describing mechanoscopic traces in the protocol, one should take notice of the following aspects:

- detailed location of the object on which the mechanoscopic trace had been spotted;
- establishing the type and traits of this item, such as hardness, plasticity;
- characteristics of the trace, particularly its shape, size, depth of denting, direction of scratches and general projection of surface microstructure of the relevant tool.[31]

There are several basic principles of securing the mechanoscopic traces. The key principle is to secure the trace in its entirety. It is important to ensure the following requirements have been met:

- all evidentiary material ought to be delivered to the laboratory in the state it was found, it should not be cleaned,
- in case of causing even the smallest of changes to the appearance of the mark, the expert should be notified about it,
- secured traces should be boxed in such a way so that they do not touch each other,
- pieces of glass should be secured separately and one should not attempt to match them,
- varnish flakes, and tool parts should be secured in separate containers.[32]

Phonoscopy in forensic science

Phonoscopy is a forensic technique concerning itself with studying speech and acoustic signals, as well as identifying sounds recorded on any sort of carrier. It also involves correcting the recordings to make them more audible. Such activities are used for the purposes of forensics and ongoing court trials. The term 'phonoscopy' comes from the Greek language (*phone* - sound, *skopeo* - to look).

Phonoscopy became present in Poland in the sixties. The first phonoscopic laboratory was created in the Forensics Department of the Citizens' Militia General Headquarters. Phonoscopy may involve the following operations:

- converting an analog recording into a digital form;
- copying audio data between different recording formats;
- in a limited scope, correcting audio quality to make speech more understandable;
- dating the audio recording;

[30] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. *Kryminalistyka, op. cit*.., pg. 115.
[31] Ibidem, pg. 118.
[32] Ibidem, pg. 118.

- analyzing digital and analog carriers of limited capabilities;
- conduct experiments on the crime scene;
- conduct noise level tests;
- collect speech samples for identification of speakers.[33]

According to E. Napieralska–Ozga, „a given phonetic, acoustic and linguistic characteristic of a statement that is stable and typical for a given person forms a phonoscopic identifying trait"[34]. A modern example of such voice analysis can be found in the ongoing fight against terrorism. In this sphere a common operation is to establish whether underground leaders and organizers of acts of terror, who issue various statements and orders, are the same persons whose voices were recorded with relation to earlier happenings.[35]

Forensic Traceology

In many countries, traceology concerns itself with investigating all sorts of reflections left by one item on the surface of an another item. In Polish forensic science, traceology concerns, more specifically, footprints and tire marks.

Footprints are among the oldest of forensic traces. They can be organized based on the state of the print, either as a surface footprint or a deep footprint. If something has left a trace in the ground, it constitutes a piece of evidence worth securing. There are many methods to do so, the most popular of which are:

- making a cast - used mostly in case of smaller traces, such as footprints. When making a tire mark cast, one should ensure it shows the full tread.
- photographic documentation - is made in most cases, but sometimes is also the only possible method. Such cases might include tire marks on concrete, which cannot be secured in any other way, or particularly large marks, such as the latter wheel of a tractor - which can sport a five meter-long diameter.
- other methods, such as utilizing special gelatin foil or devices emitting electrostatic fields, but they are used less often.

Most of the time, forensic practice uses shoe prints. Shoes have both a number of group characteristics created in the production process (shoe type, size, type, pattern and attachment method of the sole) and individual traits arising from both production process and their use (damages, holes, traits left after repair, etc.). Shoe prints can provide a lot of information about the person that left them: the movement pattern and direction, or shape of the foot[36].

Shoe print tests constitute comparative research, in which an expert is provided with evidence that was found and secured on the crime scene.

In forensic practice, tire marks do not only appear in relation to road accidents, but also the cases in which the perpetrators have used a car to commit a crime.

[33] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. *Kryminalistyka.* pg. 154.
[34] NAPIERALSKA – OZGA, E. *Badania fonoskopijne*, [w:] (red.) W. Kędzierski, *Technika kryminalistyczna,* Szczytno 1995, pg. 56.
[35] KASPRZAK, J.; MŁODZIEJOWSKI, B.; KASPRZAK, W. *Kryminalistyka,* op. cit*.* pg.155.
[36] KEDZIERSKA, G.; KEDZIERSKI, W. *Kryminalistyka.* op. cit., pg. 174.

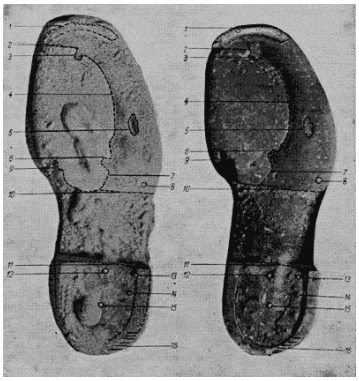
Every vehicle leave characteristic traces when moving. These traces provide means of group or individual identification. These are primarily track marks and skid marks. The visibility of said marks is reliant on the type of surface and the weight of the moving vehicle, as well as size of the tracks. If the vehicle moves on a soft surface, it will leave more or less visible marks. On the other hand, movement on solid surfaces tends to leave poorly visible marks. Based on track marks one can establish the track width, tire type and movement direction of the vehicle.

Tire marks are secured in a similar fashion to footmarks. Surface marks, for example on asphalt, can be secured photographically.

Figure 1 below presents traits of a shoe print and its comparison to a cast.

Figure 1. Shoe print traits. Comparison of a plaster cast and a shoe

Source: http://www.kryminalistyka.fr., accessed 10.12.2019.



Firearms and sings of its use

In Polish law, one of the most important acts concerning firearms, their definition and rules of their possession is the Act of May 21st 1999 *on weapons and ammunition* (Journal of Laws 1999 nr 53 pos. 549).[37] The act "defines the rules for issuing and withdrawing firearms licenses, purchase, registration, storing, selling and depositing weapons and ammunition, transporting weapons and ammunition through the territory of the Republic of Poland, import and export of weapons and ammunition, as well as the rules for weapon possession by foreigners and of operating firing ranges".[38] One should note here that the above mentioned concerns civilians and not the members of uniformed services.

According to this act, a *weapon* is:

1) a firearm, including combat, hunting, sport, gas, alarm and signaling guns;
2) pneumatic weapons;
3) tear gas throwers;
4) tools and devices, whose use might endanger life or health;

a) melee weapons in the form of: - blades concealed within objects not resembling weapons - knuckledusters and nunchucks, bats ending with, or having inserts made

[37] Firearms and ammunition act of May 21st 1999 (Journal of Laws of 1999 no 53 pos. 549), based on: Journal of Laws of 2019, pos. 284, 1214, of 2020 pos. 148, 284. Uniform text.
[38] Ibidem, art. 1.

of, heavy and hard materials, - bats made of wood or another heavy and hard material, styled after baseball bats,

b) bowstring-based weapons, in the form of crossbows,

c) objects intended for incapacitation of people through electric shocks.[39]

Firearms, according to the may 21st 1999 *on weapons and ammunition* act, are: „Any portable barreled weapon that ejects, is intended to eject, or can be adapted to eject singular or multiple projectiles or substances by means of combustible propellant".[40]

According to M. Kulicki „a firearm is a dangerous tool, which due to its construction and intended, by either its creator or user, ability to use the gases created by combustion of propellant, is able to eject a projectile with enough energy to cause death or grievous harm to a human".[41]

A forensic examination of a firearm and its use is somewhat similar to mechanoscopic identification methods. In particular, in involves the issue of identifying the weapon on the basis of marks left on the bullet and its shell during loading and firing of the weapon. There are, however, many more aspects to it beyond a mechanoscopy-styled examination, which is why firearms examination had been separated into their own discipline of forensics.[42]

Firearms examination is a part of forensic science focused on examination of firearms and related objects. Ballistics are a closely related discipline, related to bullet trajectory. It is often associated with forensic techniques used to examine the firearms themselves. This discipline analyzes the bullet's path from the moment it leaves the barrel to the moment it hits its target. During an investigation in which the firearms use is suspected, one can collect a certain amount of material for examination, including the guns themselves, ammunition, traces and any materials damaged by the projectile (if a person has been shot, the wound and the state of the victim can provide a lot of information about the weapon that had inflicted them). Ballistics are a discipline of forensics focused on the firearms. It is a very important branch of forensic science.

Firearms examination can be categorized into interior, exterior and impact ballistics. Interior ballistics refers to the processes inside of a firearm that occur between pulling the trigger and a bullet leaving the barrel. Exterior ballistics focuses on the flight of a projectile in between its leaving the weapon and hitting the target. Impact ballistics concerns itself with the examination of a projectile hitting its target.

Tracking a projectile's flight path can provide the investigators with important details. It is often crucial when reconstructing series of events that had happened during the incident. Establishing bullet's flight path can prove difficult, as one has to take a number of factors into account. Drag and gravity impact projectile's trajectory,

[39] Ibidem, Art. 4.
[40] Ibidem, Art. 7. 1.
[41] KULICKI, M.; KWIATKOWSKA- DARUL, V.; STĘPKA, L. *Kryminalistyka. Wybrane zagadnienia teorii i praktyki śledczo- sądowej.* Toruń 2005, pg. 488.
[42] KULICKi, M. *Kryminalistyczne problemy użycia broni palnej*, Warszawa- Poznań 1972, pg. 34.

causing it to slope downward. Environmental conditions, such as a strong wind, can additionally change the flight path, to a limited extent.

An important path of a ballistic examination is characterizing the projectile. One of the key bullet categorization methods is the caliber. Caliber refers to the bullet's diameter, which can be expressed in millimeters or inches. Bullets are usually made of metal, although sometimes substances such as plastic or rubber can also be used. The projectile core is usually made of lead, due to its high density.

From a forensic standpoint, the essence and operational principle of firearms is the leaving of certain marks on a bullet and its casing, allowing for group and individual identification of a given firearm. The key elements constituting a firearm is a stock with a grip, lock and the barrel. Bullets used by the firearms consist of a projectile and a shell. The marks, left on both projectiles and casings during operation of the firearm in the moment of shooting, can be used in forensics to identify a given firearm.[43]

The above mentioned research are being conducted with the goal of establishing:

- type, caliber, design (model), system and the producer of the firearm,
- type, caliber and the producer of the ammunition,
- caliber, system and design of the firearm, based on the ejected projectile of casing,
- type and source of damage or deformation of the shell or projectile,
- whether a given projectile or casing come from a particular firearm,
- whether the damage (to a body, object) had been caused by a projectile,
- what is the direction of the wound track,
- what is the distance from the place the shot was taken,
- position of the weapon and of the victim at the moment of impact,
- possibility of firing the weapon without having pressed the trigger,
- ballistic parameters (bullet trajectory, energy, muzzle velocity)[44].

Traces of firearms use found on the crime scenes boil down to five categories:

1. firearms and marks on the guns themselves,
2. ammunition traces,
3. traces found on the shooter,
4. traces found on the victim,
5. traces on the accidentally damaged objects.[45]

During the production process, the legally produced firearms are marked with unique serial numbers. These numbers are stamped on the guns themselves. Despite the possibility of criminals trying to erase said serial numbers to avoid the gun being tracked down, it is possible to reconstruct these serial numbers to a legible state.

In Poland, the Mechanoscopy and Ballistics Department of the Central Forensic Laboratory in Warsaw maintains the firearm records. They take form of a digital database, allowing for quick answering of questions such as:

[43] ADAMCZAK, S. Pojęcie broni palnej, Problemy Kryminalistyki. 1997, nr. 66. pg. 12.
[44] KASPRZAK, J., op cit... pg. 129.
[45] Ibidem.

1. where does a weapon come from,
2. where was it bought,
3. was its theft reported,
4. was it used in a crime before.

The importance of ballistics is clearly highlighted by armed crime statistics. Thanks to ballistic research, perpetrators can be detected and the weapons secured. Statistical data has been provided in the following tables:

Table no 1. Crimes committed with firearms in 2016

	Firearms	Gas guns	Pneumatic guns	Other
Murder (including attempted murder)	15	0	2	10
Health damage	18	5	22	17
Participation in a fight or beating	5	2	2	18
Armed robberies	140	22	1	101
Aggregate crimes	178	29	27	146

Source: Self study based on data from Head Police Headquarters

Table no 2. Crimes committed with firearms in 2018

Number of identified crimes - 2018								
	Firearms	Gas guns	Pneumatic guns	Other	Thrown Incapacitating gas	Explosives	Dangerous tools	Dogs or other animals
Murder (including attempted)	25	0	3	18	0	3	279	0
Health damage	16	4	31	10	40	6	640	50
Participation in a fight or beating	7	2	4	10	13	0	110	0
Rape	0	0	0	2	0	1	19	0
Armed robbery	78	17	10	68	151	0	451	1
Aggregate crimes (specified and omitted from the table)	768	235	373	373	262	212	2941	237

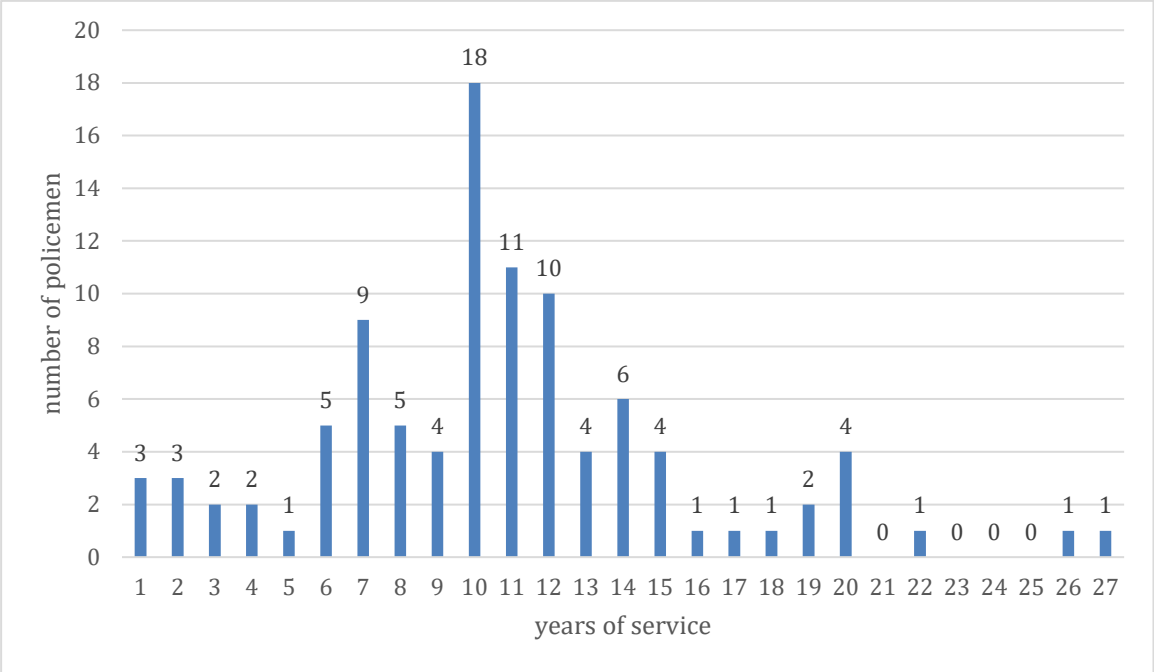
Source: Self study based on data from Head Police Headquarters

Case study - use of forensic methods in the investigative process of the Ostrołęka Municipal Police Station

Respondent profile

Ostrołęka is a district located in the north-eastern part of the Masovian Province, in the north-eastern past of Poland. Participants in the research comprised of the officers of the Ostrołęka Municipal Police Station, headquartered at ul. Korczaka. The research had been conducted in 2018. Back then, the Ostrołęka Municipal Police Station employed 335 officers, of whom a hundred participated in the research. It has been a very diverse group, in terms of work experience, rank, vocational education and service department. Information on the graph below illustrates work experience of the respondents.

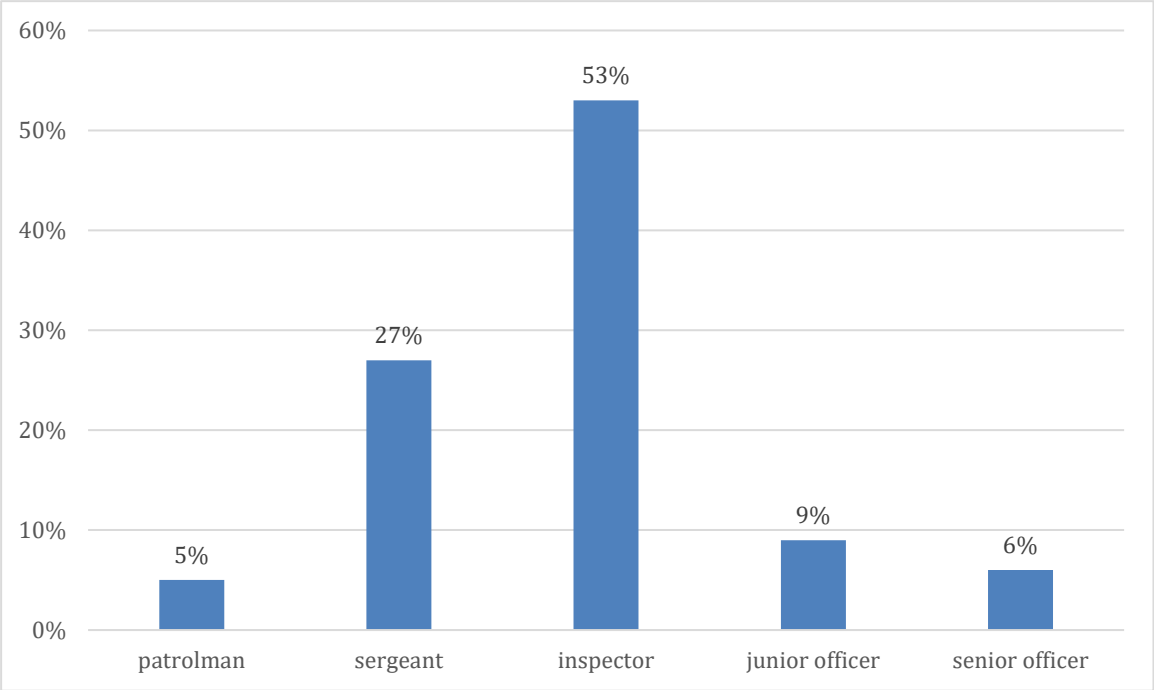
Graph 1. Work experience (in years) as policemen of research participants



Source: Own study based on research

The following graph concerns the rank help by policemen participating in the study (Graph 2).

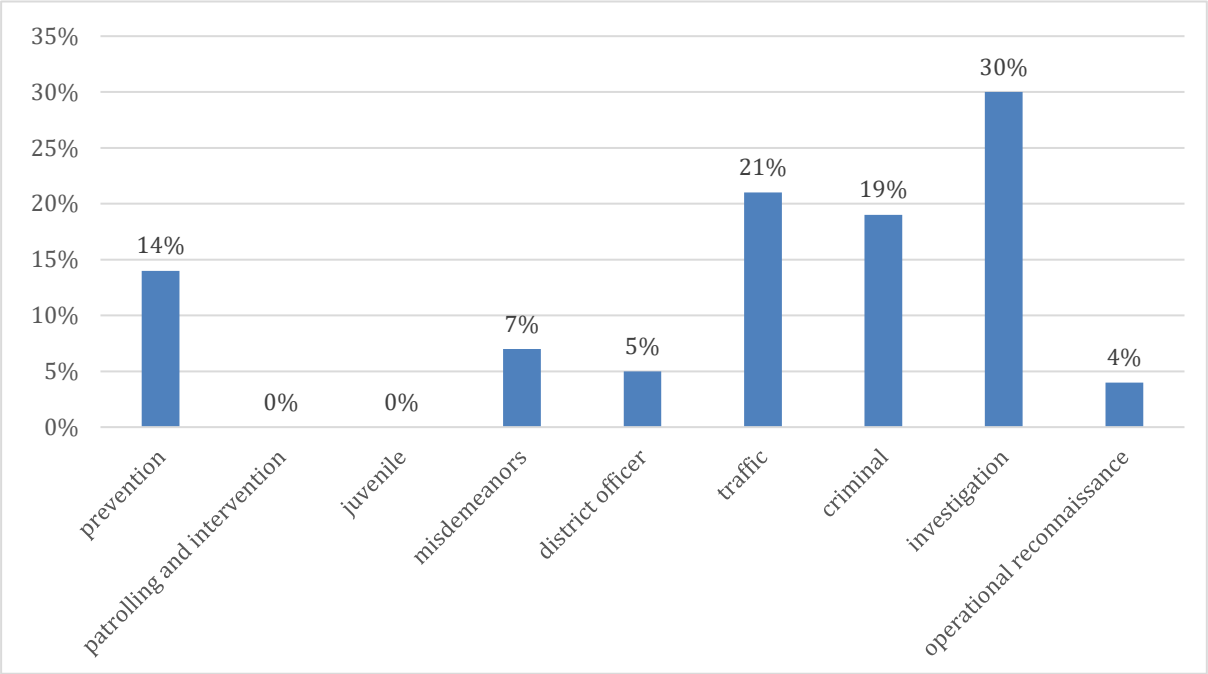
Graph 2. Rank of the respondent policemen



Source: Own study based on research

The data included on Graph 3 presents the departments that respondents worked in at the time of inquiry.

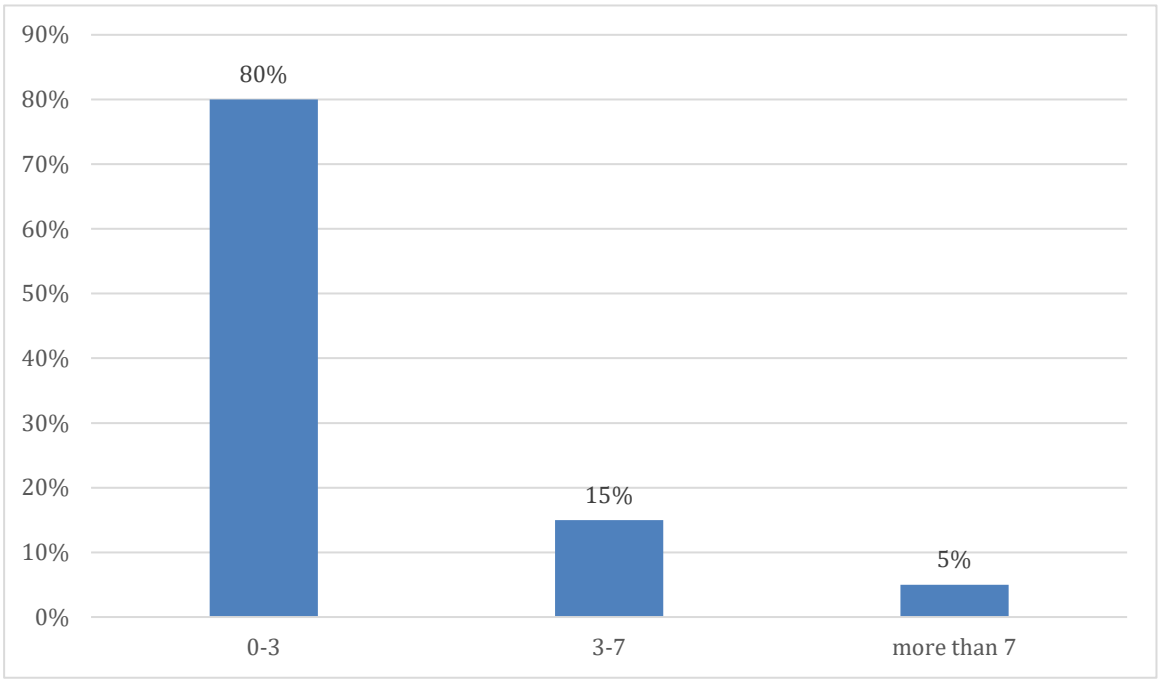
Graph 3. Service department of policemen in the Ostrołęka Municipal Police Station



Source: Own study based on research

The data included on Graph 4 concerns frequency of participation in crime scene investigation. The question was: “How many times a week do you participate in crime scene examination?”

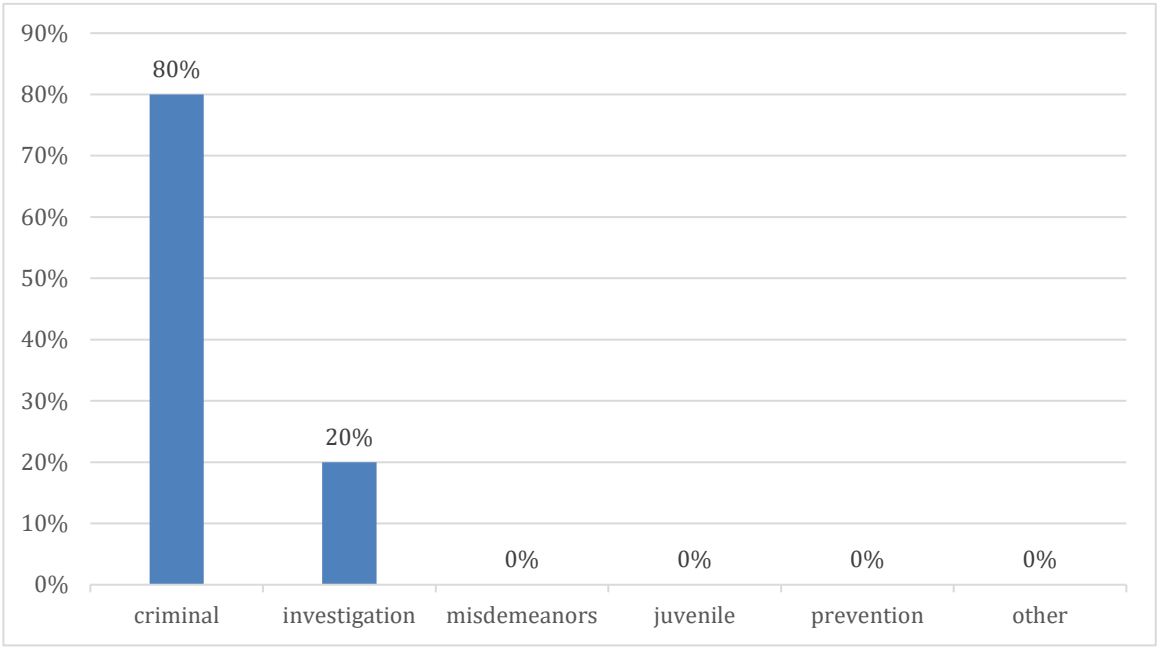
Graph 4. Participation in crime scene examinations / per week



Source: Own study based on research

The data included on Graph 5 shows which department participates in crime scene examinations most often.

Graph 5. Participation in crime scene examinations / per service department



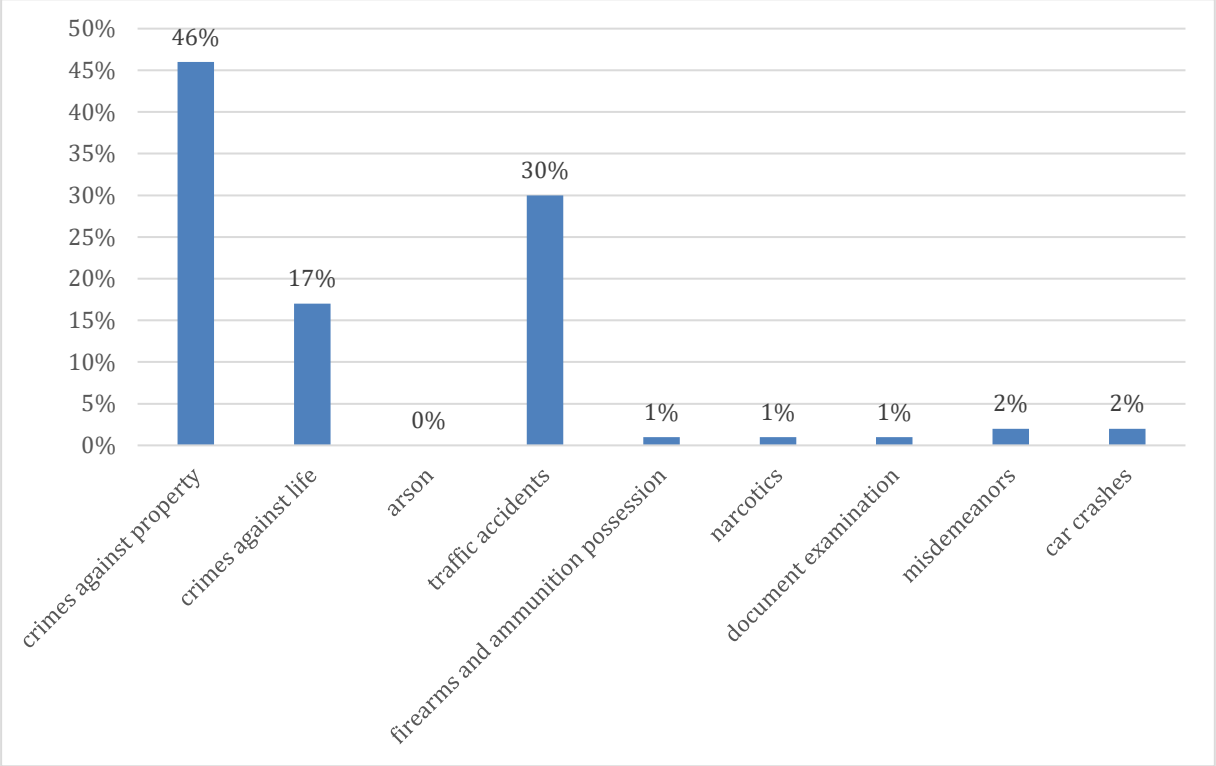
Source: Own study based on research

Analysis of the above graph leads to a conclusion that the vast majority - 80 percent - of officers taking part in crime scene investigations belong to the criminal investigation department. The remaining 20 percent of officers taking part in crime scene examinations belong to the investigation department.

Characteristics of events and traces

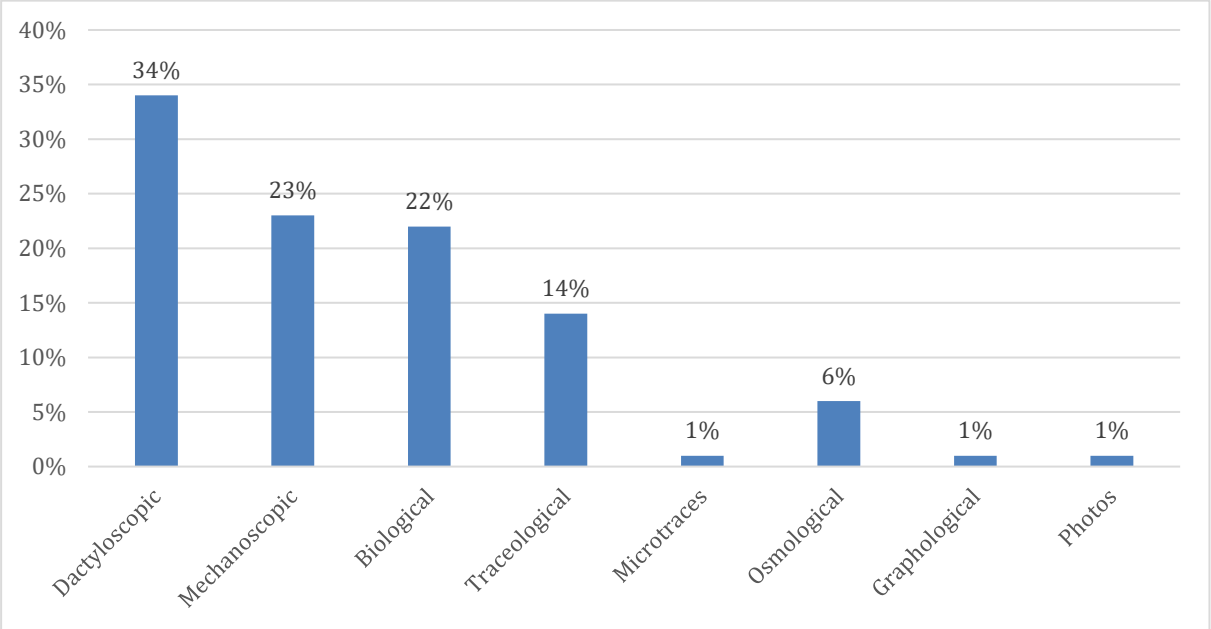
The conducted research involved asking respondents to characterize forensic events and traces in a series of answers. Graphs 6-9 present an analysis of said answers.

Graph 6. Examination event type

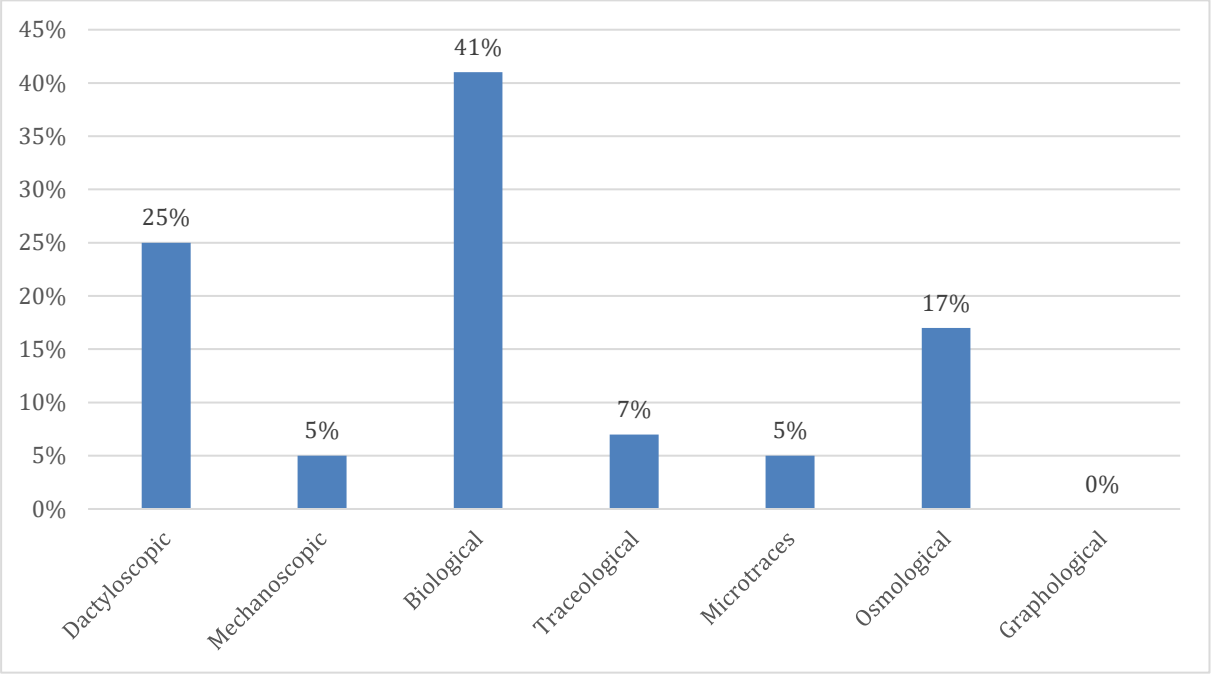


Source: Own study based on research

Graph 7. Types of traces secured with relation to crimes against property.

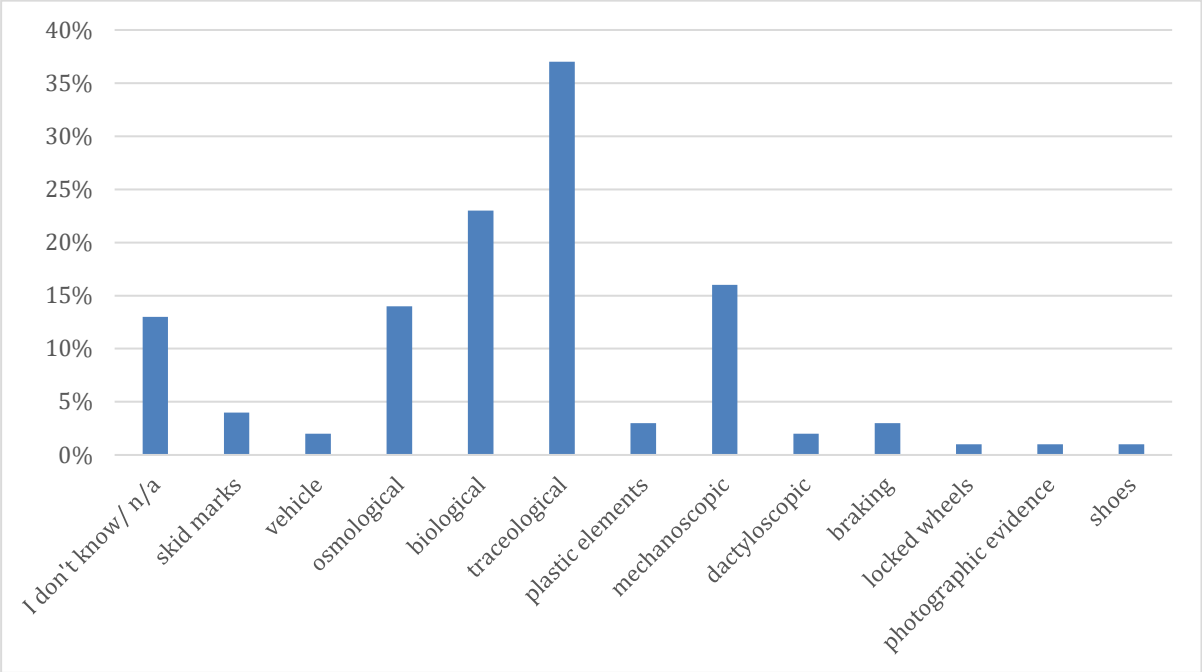


Graph 8. Types of traces secured with relation to crimes against life and health



Source: Own study based on research

Graph 9. Types of traces secured with relation to road accidents



Source: Own study based on research

The conducted analysis leads to the conclusion that the officers of Ostrołęka Municipal Police Station conduct crime scene examination primarily in case of crimes against property (46 %) and road accidents (30 %). Examinations related to crimes against life constitute only 17 % of all crime scene investigations.

The most commonly secured evidence related to crimes against property belonged to the dactyloscopic trace category (34 %), while in case of crimes against life and health, these were primarily the biological traces (41 %).

In case of road accidents, the officers have been securing primarily traceological (37 %), biological (23 %), mechanoscopic (16 %) and osmological (14 %) traces.

Summary

Scientists and researchers are still developing and discovering new means of analyzing and identifying evidence. These methods become increasingly more specialized and the technologies are linked together to create increasingly precise tests.

Forensic techniques include a wide assortment of subjects and experts from many different disciplines, such as biology, toxicology, pathology and psychology. The term ‘forensics’ describes a science concerning methods of establishing the facts of a crime, finding lost people and retrieving lost or stolen data. Forensic science utilizes scientific analysis within the justice system, oftentimes with the purpose of proving the events of the crime that had been committed. Forensic technicians analyze and interpret evidence found on crime scenes. These might include blood, spit, fibers, tire marks, narcotics, alcohol, cartridge cases and others.

This paper presents the results of an inquiry conducted at the Ostrołęka Municipal Police Station (located in north-eastern Poland). Research results confirmed that both in theory and practice, the utilized forensic methods and types of evidences being examined depend in a large extent on the type of crime that had been committed. In case of crimes against life, the officers of Ostrołęka Municipal Police Station primarily analyzed biological traces, while in case of crimes against property, they analyzed primarily dactyloscopic evidence.

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S U M M A R Y

This paper is the result of a research into the current knowledge of forensic science. It defines the terms ‘forensic science’ ‘trace and ‘evidence,’ as well as presents the development of forensic methods. Additionally, the paper presents the results of an inquiry conducted in the Ostrołęka Municipal Police Station (a city district in north-eastern Poland) concerning application of forensic methods in the investigative process.

Keywords: forensic science, dactyloscopy, phonoscopy, trace, evidence.

R E S U M É

JAKUBIAK, Ewa; STAŚKIEWICZ, Urszula: *VĚCNÉ DŮKAZNÍ PRAMENY – KRIMINALISTIKA V TEORII A PRAXI*

Článek je výsledkem výzkumů moderní kriminalistiky. Bylo v něm definováno, co je kriminalistika a kriminalistická stopa a byl představen vývoj metod kriminalistické techniky. V článku byly také uvedeny výsledky průzkumu provedeného na Městském velitelství Policie v Ostrołęce (severovýchodní Polsko) ohledně používání metod kriminalistické techniky ve vlastním vyšetřování.

Klíčová slova: kriminalistika, daktyloskopie, fonoskopie, kriminalistická stopa.