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A REVIEW ON THE RELIABILITY OF FORENSIC CANINES AND ITS JUDICIAL ADMISSIBILITY

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Abstract: Odourology, the science of odour formation, spread, and identification, has long been used for recognizing different odours including the human beings. Through the use of properly trained canines to compare odours from a variety of persons, including suspects or victims, forensic odourology is a technique for identifying human scents. A detection dog, sometimes referred to as a sniffer dog or canine, is a dog that has been taught to use its senses to find different objects, including explosives, illicit drugs, wildlife, money, blood, and contraband gadgets. Detector dogs are becoming an increasingly common tool in crime investigation and have been used in several forensic research domains. Using the sensitivity of a dog's nose to identify a wide range of objects and substances, canine forensics is an essential tool in investigations. Although it is astounding, the ability of forensic dogs to locate human decomposition sites is not well understood, described, or standardized. Dogs have been successfully trained to recognize pathological illnesses in humans, such as COVID-19. For researchers in behavioural studies and brain research, canine olfaction offers a wealth of interdisciplinary opportunities for study. Owing to their accurate scent detection skills and keen sense of smell, forensic dogs in India are becoming more and more important in forensic investigations. But in Indian courts, judicial admissibility causes a thorough comprehension of scientific principles, training methods, and canine behaviour. In Indian legal procedures, the admissible requirements for canine testimony will be shaped by further research and an evaluation of case law.

Keywords: forensic odourology, canine forensics, detection dogs, forensic investigations, judicial admissibility.

INTRODUCTION

Canines, known for their macrosmatic abilities, possess an extraordinary sense of smell and an impressive memory to match based on the phenomenon of Volatile Organic Compounds (VOCs) coming out of the surface of materials of interest like explosives, contraband drugs, human remains, etc. (1). This ability is being used in various fields including human search & identification, explosive detection, cadaver detection, contraband detection, medical detection, etc. (2). Using canines for forensic and anti-terrorism purposes has garnered spotlight in recent years because of its accuracy, promptness, and reliability. However, reliability of canines is frequently questioned outside and inside the court of law based on the variations among different species, varieties, training methods, and quality of trainers.

Classification of forensic canines

Canines, named because of the presence of the pointed conical canine tooth, include the members of Canidae family of dogs, wolves, jackals, foxes, and coyotes. However, because of the domestication capabilities dogs are most preferred partners of human beings and are often used forensic purposes. K9s can be broadly classified into two categories – a) patrol dogs, and b) detection dogs (Fig. 1). Patrol dogs are associated with the police and are used for patrolling, chasing, and hunting criminals and can be further divided into three categories of police security dogs, search & rescue dogs, and trailing dogs. Detection dogs

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are used for search, detection, and identification of specific substances or articles. These include tracking dogs, cadaver dogs, assault dogs, wildlife conservation dogs, bomb detection dogs, narcotics dogs, arson dogs, and substance detection.

Detection dogs, also known as forensic dogs, have been used in several forensic investigations to help find and identify certain odours associated with criminal activity. The dogs that have received extensive training exhibit extraordinary olfactory capabilities, enabling them to effectively aid in the detection of evidence such as narcotics, explosives, and human remains (3). Both the legal and scientific sectors have expressed a great deal of interest in and discussion over the use of dogs in forensic investigations. Forensic dogs have been extensively studied and examined in the realm of forensic science because of their ability to identify odours and locate evidence (4). Trail dogs create a plume-like trail by following the scent of evaporative materials, released by organic chemicals and human skin, whereas tracker dogs detects both scent as well as ground distortions and marks (5).

Over the past few decades, search, and rescue (SAR) dogs are an effective tool in the hunt for people who have vanished from sight, are buried beneath debris, or are trapped in debris (6-7). In a study, locomotive characteristics of canines in various terrains were examined. It was observed that although, the dogs faced difficulty in difficult terrains, SAR dogs were much more efficient and quicker in these terrains. Difficult terrain reduced the effectiveness and lengthened the time required for SAR teams to conduct a thorough search of an area (8).

METHOD

Bibliometric analysis

In order to examine and analyse the citations of academic publications, bibliometric analysis integrates a variety of frameworks, tools, and techniques. This has resulted in the development of many metrics to provide information about the theoretical framework of a wide range of academic disciplines. Analyse the significance of research findings, studies, and scientific publications appropriately (9). Because of limited studies on the investigation of "odour fingerprints" using analytical techniques such as gas chromatography – mass spectrometry (GC-MS) and ultra performance liquid chromatography (UPLC), the forensic K9s have received a lot of attention in recent years (10). There has been a steady rise in using forensic canines' deployment in forensics and jurisdiction. Statistical data on the research publication from 2015 to 2024 which includes publication in journals of PubMed, Nature and UGC Journal List Group II and specially only those which are available online for review, supports this claim (Fig. 2).

Bibliometric co-authorship network

Bibliometric data analysis was conducted on the latest advanced tool VOSviewer (11), the data was collected and screened by Dimension.ai software which included research articles, papers, books published in

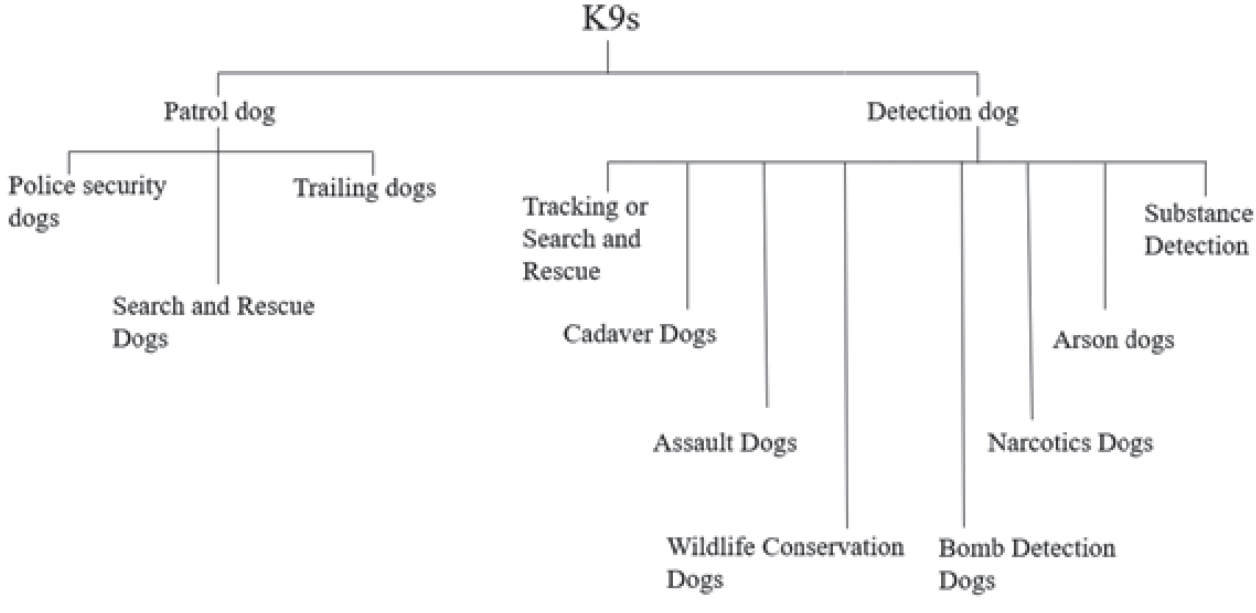

Figure 1. Classification of K9s.

journals of PubMed, Nature, and UGC Journal List Group II and specially only those which are available online for review. Using this data extracted by Dimension.ai a co-authorship network was deduced which included 71 authors from the journals mentioned above with co authorship link of 159, total co-authorships are summed to 163 formed in 16 clusters. Excluding publications with over 25 authors, we get a co-authorship network in VOSviewer as shown in Figure 3.

Bibliometric coupling and co authorship density visualization

In VOSviewer software, bibliometric coupling with full counting methods for countries was conducted with dataset derived from dimension.ai with maximum limit of 25 countries per document. Documents includes research articles, papers, book, and conference proceedings with timeline range from 1998 to 2024. Documents specifically include only open access articles. Minimum of 5 document was set for each country on the title of detective dogs and canine forensics, after applying all the limits 45 countries were screened out and a network between countries was created with cluster of 5 and 870 links as shown in Figure 4. Similarly, co- authorship among various organization presents worldwide working on canines were considered of study and analysis with full counting method and excluding large dataset and taking maximum 20 organization per document. Minimum of 5 document from each organization were considered after limiting total of 179 organization were screened. For each of the 179 organizations, the total strength of the co-authorship links with other organizations calculated as 498. The organizations with the greatest total link strength were then selected which came out to be 168 and a density visualization network was created as shown in Figure 5.

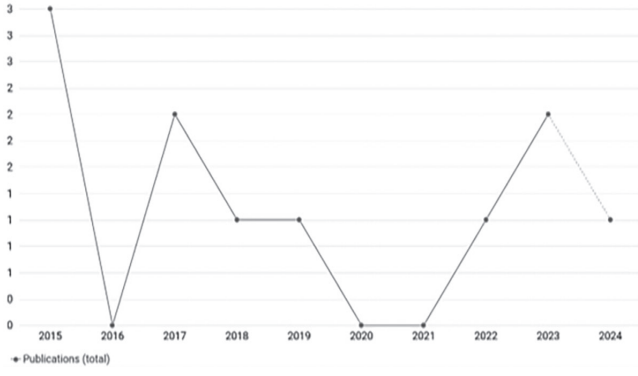

Figure 2. Demonstrating publication on forensic canine (2015-2024).

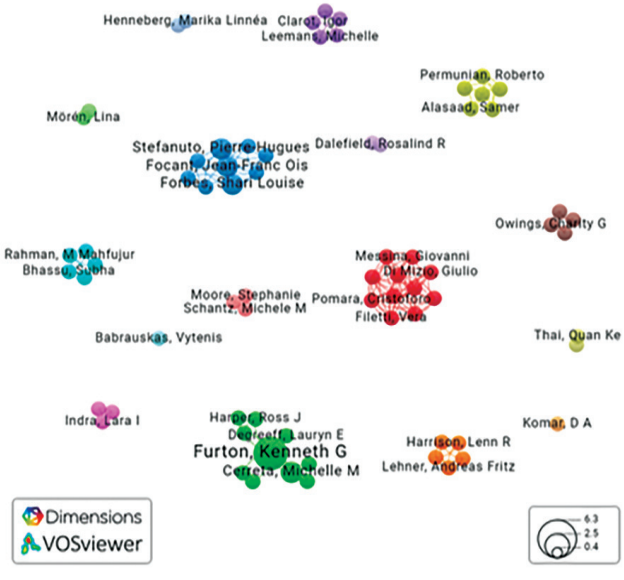

Figure 3. Demonstrating co-authorship network.

Result of bibliometric analysis

Bibliometric analysis provides insight of the literature survey and work conducted by various authors, countries, and organization in world with co-relation among them. Many authors among various parts of world share similar research profile but in a collective form there is still minimal research study and development work in canine forensics. Bibliometric analysis of data shows that various countries including United states, China, Germany, and Japan are actively studying the morphology, anatomy, psychological behaviour, and development of the standards for usage of canines in forensics and its judicial admissibility

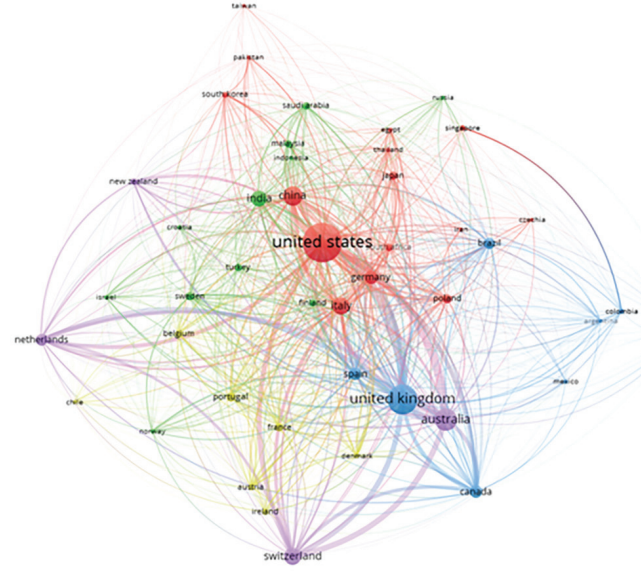

Figure 4. Bibliometric network of countries in forensic canine research.

(Fig. 4). In order to ensure the court admissibility of Forensic K9s, it is crucial to establish uniform standards, and with ongoing and dedicated efforts, this goal will eventually be achieved. Network density distribution map between the organisations across the world based on the co-occurrence in research on detection K9s shortlists the universities primarily working in this direction (Fig. 5). Central south University, University of Lausanne, University College London, Netherlands Forensic Institute and University of Sydney are leading the scientific research in field of K9s.

Factors affecting the reliability of canines

Detection of any compound by its smell is under the preview of high control on olfactory receptors which are found in high concentration in dogs. Canine on comparison to other living creatures possess some advantages in terms of sensitivity as canine may detect odours even in low and minute concentration. Crime scene investigation is a tedious process in mobility of feature on canine would be beneficial additive to its olfactory excellence. Crime scenes not suitable for investigation and search using on spot and other forensic techniques like bomb detection and trail detection become a hurdle in criminal investigation, but forensic canine could be used for such search and investigation with the aid of training adaptability to recognize a wide variety of odours including explosives and blasts, human cadaver remains, drugs and live human scent. Canine detect odours without physically contacting with the sample, thus preserving the integrity of the scene and evidences and providing non-contact sampling (12). Trained canines survey an area in least time possible and give immediate indications of scent detection, which is valuable in time-sensitive investigations. Training and standardizing guidelines will continue to improve the reliability and admissibility of scent evidence obtained by canines in forensic science (12).

The reliability of forensic canine evidence heavily depends upon the qualification of the handler. The handler with more training and experience can decipher the correct information from the canine behaviour. Breed of dog and their training in tracking and trailing also contributes towards its acceptance in the court of law. Different varieties of dogs have variable sense of smell which affects their capabilities of detection. Courts seldom recognize the distinction that handlers and trainers make between tracking and trailing dogs. Circumstances regarding trails and the other factors like vegetation, time of day, humidity, and rain, atmospheric and surface temperature and target & suspect factors are considered while admitting the canine evidence. Human scent recognition assumes that each person has a unique aroma that remains consistent throughout time (10, 13). The validation process is crucial for the canine team to ensure reliability, providing credibility and confidence in the intelligence value of their responses. These validation processes develop accurate conditions and opportunities which could benchmark and also assesses both the canine and the handler (14).

The accuracy and dependability of forensic dogs in recognizing scents and detecting particular

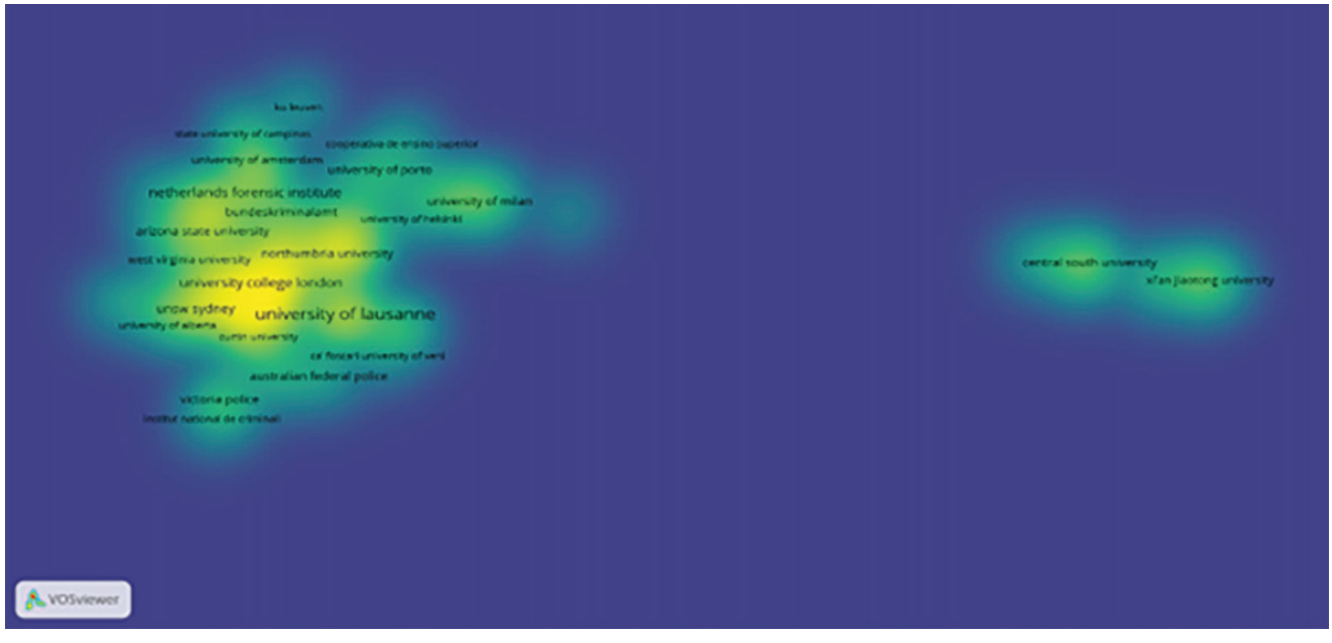

Figure 5. Detection dogs' research co-occurrence network density distribution.

odours linked to criminal activity have been the subject of several studies. It is known that dogs' sense of smell can be helpful in locating objects that people might find challenging to locate (15). Research studies have shown irrefutably how amazing trained dogs can be at identifying even minute levels of odours, frequently outperforming sophisticated technology detection techniques. Differences in canine physiology, handling, training, and analytical techniques have a significant impact on the ability of canines to identify objects through smell (16). A thorough grasp of canine behaviours, training procedures, and potential influencing variables is necessary for interpreting canine results and their admissibility in court. A detailed analysis of the scientific concepts supporting the dependability of forensic canines is required under the legislative framework guiding the acceptance of canine evidence in Indian courts.

The validity of forensic canines and the admissibility of their results as evidence in court cases have received a lot of scrutiny in judicial admissibility in India. Assessing the dependability and court acceptability of forensic canines in India requires an understanding of the nuances of canine olfaction, its training, and certification, and the scientific confirmation of their detection skills. In addition, reviewing precedents and case law concerning the use of forensic dogs in Indian courts might shed light on how the law is developing regarding the acceptance of canine testimony.

Scientific working group on dog and orthogonal detector (SWGDOD) guidelines

Scientific Working Group on Dog and Orthogonal Detector (SWGDOD) Guidelines provides an insight on the procedural steps to train canines and improve the methods used by canine detection in criminal investigation. These guidelines aim to develop a standardized protocol for deploying and training detection dogs, indirectly ensuring accuracy and consistency in the results. By adhering to these guidelines, there is a high probability that the reliability of canine detection will be enhanced, as the dogs are trained and assessed using rigorous, scientifically-supported approaches. This will raise the validity, credibility, and reliability of the forensic use of K-9s. To overcome handler's bias and to increase the effectiveness of the team, rigorous, advanced, and extensive training is required. The training of handlers is equally important to the training of the canines. Guidelines also include conditions for assessing the proficiency and performance of canine teams, increasing the quality and reliability of the canine evidence. These guidelines have brought a lot of positive change in the perception of K-9s in the court of law, however, these guidelines must be regularly updated with the latest research to bring about more validity and credibility to the K-9s in courtroom (12).

Challenges to Judicial Admissibility of Canine Evidence

Probative value of any evidence is beneficial only if it is admissible in the court of law, as judiciary must consider the evidence during trial. Canine evidence judicial admissibility is of controversial issue as some developed countries accept it as evidence while some not. India is still in debate to allow it as evidence or not because the reliability on such evidence which could be misleading and misinterpreted. Supreme court in its benchmark statement in Dafedar v State of Maharashtra, Ramesh v State of Assam and in Borthakur v State of Assam in 2008 held that: "The law in this behalf, therefore, is settled that while the services of a sniffer dog may be taken for the purpose of an investigation, its faculties cannot be taken as evidence for establishing the guilt of an accused."

Court upholds objection related to canine evidence which included manifest that the dog cannot go into the box and give his evidence on oath, and consequently submit himself to cross-examination, the dog's human companion must go into the box and report the dog's evidence, and this is clearly hearsay. Second, there is the feeling that in criminal cases the life and liberty of a human being should not depend on canine inferences. Courts in the United States have allowed evidence from police dogs to be admitted after establishing foundational elements related to the dog and handler's training and reliability, how the scent was collected, the timing of the tracking in relation to the crime, and the specifics of the tracking path (5).

However, there has been resistance to applying strict scientific standards for the admissibility of such evidence, despite advances in research related to canine olfaction and behaviour. This shows a hesitancy to fully equate canine scent tracking with other types of scientific evidence due in part to the variability in dogs' abilities and the circumstances of each case. As science continues to shed light on dogs' tracking abilities, the legal system may require additional safeguards to avoid prejudice, especially for direct identification of a suspect by a dog (5).

Canine Training and Training Aids

Experience is the vital component of learning

for both the canine and the handler. Research has shown that canines could recover human remains and trace the human scent in a complex environment, recover samples and evidence easily, which would rather be difficult by using traditional methods. Training develops this robustness and accuracy in the canine. Annual certification for validation assessment by many agencies to certify canine team with the standard. Certification and assessment involve odour inventory and discrimination.

Canines have been effectively taught and used to identify pathological illness in people. Explosives detection canines were trained to detect COVID-19 odour in patients' perspiration and could effectively filter out 3249 people from a cohort who tested negative for SARS-CoV-2 of 3290 people. By employing Bayesian analysis, the K9 test's sensitivity was discovered to be more effective than the RT-PCR test using nasal swabs from a group of 3134 individuals, because of its great sensitivity, quick recovery, affordability, little invasiveness, and because of its simplicity of use, the detection dogs test is a superior substitute for the RT-PCR for screening asymptomatic people for SARS-CoV-2 (17-18).

Terriers go through extensive training to become subservient, socialized effectively members of teams in a variety of settings, including law enforcement, therapy, and search and rescue. However, their training assumes a more specialized focus on forensic investigations. These exceptionally talented canines are trained to recognize particular scents associated with forensic evidence, including blood, accelerants, and human remains.

These dogs go through an intense and rigorous training regimen. They receive basic obedience training first, where they pick up discipline and learn orders. As they advance, they are exposed to a variety of fragrances linked to forensic evidence as part of scent detecting training. They are taught to associate certain smells with positive reinforcement - treats or playtime, for example.

Hounds are trained to exhibit distinct behaviour to signal when they have found the intended smell. This could be a sit, bark, or other acceptable behaviour. For obtaining, storing, using, and discarding training aids, handlers need to follow the right protocols. They also have to make sure that rules like those pertaining to human tissue are followed. In order to guarantee optimal mission efficacy, handlers receive training on how to organize and carry out high-confidence searches as well as how to interpret the behaviour of the dog in the field. Workers that handle objects on the ground may be trained to recognize clues that point to possible grave sites or human movement. It is recommended that handlers possess a solid theoretical understanding of canine olfaction, scent chemistry, and the fundamentals of odour migration, besides practical experience (19).

To determine their operational preparedness, canine teams are put through frequent proficiency testing. This could be done by creating fictitious settings that reflect actual search circumstances. Legal procedures and the canine team's reputation depend on maintaining correct training records and recording all alarms during training sessions and searches. In the end, forensic canine training seeks to build trustworthy teams that can function effectively in the demanding and complicated settings of crime scene investigations, guaranteeing that they can provide invaluable support to forensic experts in locating crucial evidence (20). Interpreting the canine's responses in forensic detection dogs is essential to assisting investigations. There are five primary categories for the responses:

When the dog responds in a recognized way to a known and verified positive stimulus, such the definite scent of decomposing human flesh, referred to as positive response. Whereas, ineffective positive response happens when the dog responds in the end even though there was no clear, immediate stimulus, and the reaction wasn't always wrong. An illustration could be the identification of an odour consistent with human decomposition in the absence of blood or recoverable human remains. When a dog responds in the end to a known-to-be-negative stimuli, such as animal bones or carcasses, rather than human remains. This is termed as false positive.

Negative response occurs when a dog knows a scenario is blank or negative and does not respond in the end. It's difficult to verify a real negative in practical settings, though. In false negative a dog cannot respond at all to a recognized positive stimulus. There could be several reasons for this, such as smell thresholds, problems with the surroundings, or mistakes made in handling or technique.

When interpreting these answers, it's important to consider things like how the dog was handled, the surroundings, and further forensic evidence. To offer responsibility for the additional dogs in the squad when their handlers are away, they should make acquaintances with one or two of the other dogs. Every handler should have a reciprocal setup like this. They have an obligation to follow and obey their supervising officers' directions. They will handle all of the dog training regimens and be present at roll calls. They cannot leave the headquarters without the authority's approval.

Strong mental associations are built up between a dog and its handler that go beyond easy directions. It is such because it is founded on mutual respect, free communication, and trust. Dogs have been involved in search and rescue missions; therapy programs; and law enforcement partnerships. Dogs can work together on tasks other than obedience and rely on their humans for guidance, support, and leadership. Successful training and effective communication are crucial in maintaining a healthy dog-handler relationship. Handlers also need to be fully informed of the strengths and weaknesses of each other and the unique requirements, body language, and conducts exhibited by their canines. When a dog and its handler perform well together, they merge into one functioning unit that performs incredible tasks. Thus, their ability to have close relationships with their handlers. A dog has more than just basic signals or orders to give its trainer; it has an affectionate bond with him/her. A strong emotional bond is part of this connection that goes beyond language and a common sense of purpose. This breed of human-animal partnership between a dog and its handler is unique and commanding based on mutual respect, communication, and trust. Dogs have proved valuable partners in many fields such as law enforcement, therapy, or search and rescue because of coexisting with humankind for thousands of years. Similarly, handlers expect dogs to take directions from them, motivate them and also lead them. Dogs can engage in other types of activities with their handlers apart from the usual obedience or task completion exercises. In relation to this point excellent dog-handler teams are described by such levels of coordination and union. In terms of communication and training, there cannot be a strong bond between the two parties a dog and its handler (20).

Lack of Scientific Studies on Training and Validation

Proper and adequate Training and validation of the dog and handler are essential components of the detection canine validation procedure. It must be incomprehensible, considering generalization and discriminating based on fragrance or odour in operational circumstances. More controls could be added which should be in a unique spot and get dogs' attention more quickly. Although canine olfactory detection is not a precisely quantified science, search managers, and investigators can benefit from its intelligence.

Professionals of canine detection have benefited from the training and validation data given by the scientific community. That being said, research carried out by novices is not as credible or supported. Inaccurate data and harmful conclusions have been produced by flawed experimental designs and improper testing procedures that included unvalidated dogs, raising doubts about the overall capabilities of detection dogs and dogs. Courts have frequently held that the acceptance of dog tracking evidence is not appropriate for the criteria of Frye and Daubert (21-22), which normally apply to expert testimony based on scientific principles or techniques. Among the primary explanations given are:

Examining Methodology Beyond Scientific Principle: Within the scientific world, the employment of a trained dog is viewed more as an exploratory method than as a widely accepted scientific practice. Because of this, a Frye or Daubert hearing—which would scrutinize the scientific validity and acceptance of the evidence—is often deemed unnecessary.

Behavioural Nature: Dog tracking is considered a collection of behaviours and circumstances rather than a hard science. It's not analogous to experiments in more controlled settings, which determine matches of fingerprints or DNA.

Lower Potential Prejudicial Impact: Evidence from canine scent identification may be perceived as less prejudicial than evidence from more precise, mechanical instruments which may be seen as incapable of error, while dogs, being more "human-like," are understandably subject to lapses in judgment or perception. This lower potential for prejudice against the defendant means that the evidence is subject to a less stringent standard.

Reliability of the Dog: Before considering canine evidence, it is required that the particular dog has a proven track record and previous case lineup experience to establish the reliability of its powers of discrimination and identification.

Lack of standardized selection tests and admissibility guidelines

When examining the admissibility of such evidence, courts focus on laying a proper foundation for the dog tracking evidence rather than applying the scientific rigor demanded by Frye or Daubert standards (12,17). From a judicial perspective, canine evidence is often perceived as less reliable and less predictable than evidence from mechanical instruments. Judiciary considers many factors before considering any evidence for its probative value and admissibility in the case (5).

Canine tracking relies on the behavioural responses of a dog, which can be influenced by various factors including environmental conditions, the dog's health and stress levels, the skill, and biases of the

handler, and the method used during tracking. With mechanical instruments, subjectivity, and variability are not present to the same extent. When calibrated and operated correctly, mechanical instruments can yield findings that are precise, reliable, and repeatable. Because the measurements are accurate and repeatable, courts consider this kind of evidence to be more trustworthy. The foundation of mechanical devices is frequently found in well acknowledged scientific ideas. Example the clear scientific foundation of electrochemical fuel cell analysis and infrared spectroscopy serves as the foundation for blood alcohol testing equipment. Which is lacking in case of forensic canine evidence. Strict methods may be followed to calibrate and maintain mechanical devices, hence enhancing their dependability. Sustaining the dependability of a dog's smell detecting abilities requires continued instruction and more subjective, less uniform evaluations.

For mechanical tools, there's usually more standardization because they're designed to do certain things in a certain way. For example, for tracking dogs and scent identification, there can be a lot of variation from one law enforcement agency to another and from one handler to the next. In error rates, mechanical tools usually have a known error rate that can be measured. It's a little more difficult to measure how reliable and error-prone a dog's performance is, but we've made some progress in setting up certifications and maintaining training that can help provide some standardization and measure a dog team's reliability.

Courts often demand a different level of review for canine evidence, and may require evidence that has a proven track record of reliability, certification, and a well-defined methodological basis for both the dog and the handler team before allowing such evidence, although courts rarely use the rigorous scientific criteria of Frye & Daubert that apply to mechanical instruments. Canine teams' track and scent identification success rates vary and depend on a variety of factors, including the dog's training, the handler's experience, environment conditions, and the tracking scenario's context. Exact track and scent success rates are hard to determine and can vary based on these factors.

Scientifically, canine success rates should ideally be documented to determine the reliability of individual dogs and handlers as a team. For instance, the Arizona Court of Appeals suggested that "a record of failures should be kept to substantiate the continued reliability of the dog" (Ensminger, 2010). The records and documentation of a canine team's performance serve as one way to assess and ensure their proficiency for legal and practical purposes. Certification bodies also have their criteria and success rates that can influence the judicial perception of a canine team's reliability.

Criteria for training and certifying canine teams are recommended by certification bodies, such the Scientific Working Group on Dog and Orthogonal detector Guidelines. These criteria can aid in determining and sustaining the success rate of these teams. Certifications, according to SWGDOG, typically have a one-year validity period, and in order to guarantee ongoing dependability, regular performance reviews are necessary. Different approaches and failure tolerances, however, can still result in varying success rates even with certifications. The legal system appreciates and assume that certified dogs and handlers have had sufficient training and are dependable.

Still, in court, the specifics of the dog's performance and certification details can be scrutinized, and the overall success rate may be only one factor among many when determining the admissibility and weight of canine evidence (5).

The reliability of tracker dog evidence is of serious concern as risk of the dog being distracted and providing a false-positive identification, meaning the dog might erroneously signal a scent match. Possibility of a misunderstanding between the dog and its handler, which might lead to incorrect interpretations of the dog's behaviour. Inability to cross-examine the dog, which is an issue as the court relies on the handler's interpretation of the dog's actions, akin to hearsay evidence. Uncertainty about the constancy of a dog's behaviour and the extent of potential errors, which undermines the scientific basis for legal inferences drawn from the dog's scent tracking abilities (19).

Police breeds are used by law enforcement to combat illicit drugs and to establish probable cause for warrantless searches. Défense lawyers, meanwhile, continue to contest the accuracy of dogs. Research on canines that detect drugs have been conducted in a variety of ways, with an emphasis on breed, genders, training level, kind of drug, and location. According to research, the combined accuracy rate of single- and dual-purpose dogs was 92.5%, underscoring the need of training and certification in the identification of illicit drugs (17).

Role of Dog Trainer

Dogs are very skilled in recognizing variety of scents, especially that of human beings. With proper training and validation, this ability can be used for detection, identification, and discriminating human beings, and other substances of extreme importance.

However, the quality of training can severely enhance or deteriorate the dog's ability of scent identification. Trainers and dog handlers play a significant role in proper training of dogs. Because of their intimate working relationship and comprehension of the distinctive behaviours of the dogs, handlers are essential in interpreting canine responses in forensic investigations.

Trailing is a technique used by bloodhound handlers to train dogs to distinguish a particular human odour trail from all other odour trails within a search region and identify suspects, and missing & absconding persons. In this technique, the is provided with the scent from the person's belonging, which dog then uses to track the person by excluding all other scents.

The effectiveness of the dog squad and the overall health of the dogs heavily rely on the dedication and sincerity of the dog handlers, who are undeniably the most vital members of the team. In order to maintain hygiene standards, it is imperative that they take necessary measures to keep both the kitchen and kennel impeccably clean, and that the kennel workers handle the dog food with great attention to detail. It is recommended that individuals take personal responsibility for the feeding, washing, grooming, and overall care of their own pets instead of assigning these duties to someone else. In the event that their dogs become ill, sustain injuries, or are involved in an accident, they are required to promptly inform the person in charge of the dog squad within the SI and ensure that the measures are taken to provide the dogs with the required medical help. In order to take on the responsibility of caring for the extra dogs in the squad during their handlers' absence, it is important for them to establish relationships with one or two of the other dogs. It is recommended that every handler should have a reciprocal setup similar to this one. It is their duty and responsibility to always follow and obey the directions given by their supervising officers. All of the dog training regimens will be expertly handled by them, and in addition, they will be present at all roll calls. In order to leave the headquarters, they must first obtain approval from the authority.

In order to maintain the integrity of the inquiry, they meticulously document the specifics of the search, carefully record the dog's actions, and meticulously note the reactions, all intending to provide accurate information. Handlers who are involved in court cases may find themselves required to give testimony. This testimony often encompasses a wide range of topics, including the qualifications, training, and reliability of their dog, along with specific information about the dog's behaviour and actions relevant to the specific case being discussed. The search tactics that handlers employ reduce handler bias and increase the accuracy of the dog's responses. As an example, searches could be conducted discreetly without the handler's awareness to avoid inadvertently signalling the dog. Handlers have the duty to ensure that their dogs are both physically healthy and mentally prepared for their work. It is important to identify signs of weariness or tension in the dog as these factors can significantly affect its performance.

The purpose behind documenting these things is twofold: to obtain valuable information and to ensure the investigation's integrity remains intact. When appearing in court, dog handlers may find themselves obligated to provide evidence regarding their dogs' qualifications, training records, and reliability, in addition to the fact that their actions are also scrutinized in this regard. Handlers are trained to employ search tactics that can help minimize handler biases as well as enhance the accuracy of the dog's responses. For example, searches can be done without the knowledge of the handlers so as not cueing accidentally for the dog's use in a case. It is upon handlers therefore to ensure that their dogs are fit and healthy for work. This might involve identifying signs such as tiredness or tension in a dog which can impact on its performance.

Behavioural differences and signal interpretation

Animal trainers receive training on how to effectively identify and interpret signals and cues exhibited by their animals. To provide an instance, people possess the skill to differentiate between a dog's genuine curiosity towards a smell and its eventual response, which may involve actions like sitting down, barking, or any other discernible behaviour that signifies its detection of the scent. In order to keep their own and the dogs' proficiency, handlers have such things as recurrent trainings and appraisals like single- double-blind drills, certification tests, and validated operational outcomes. By utilizing their understanding of search areas and dog behaviour, handlers can discern between an authentic alarm and a probable false positive. For instance, given factors like odour migration, they may still conclude that the warning is valid based on how the dog behaves even if human remains are not instantly visible. There is usually substantial evidence for them to support dog alerting indications. Investigators' understanding of forensic canine's response helps handlers to perform more investigatory acts like concentrating search further or gathering additional types of facts. The handler must record every single detail of the dog's responses with great care, as this documentation may be vital for future

investigations or legal procedures.

The handler's responsibility largely revolves around ensuring that the dog provides answers that are trustworthy for the criminal investigation. Presently, there is a concerted effort between moderate makers and technologists to address misinterpreting K9 answers in investigation operations, and one way they are doing this is through data-sharing. Experts use trainer's data to study the progress in training of dogs. It is also important to study if the dog gave any critical warnings during the training. The accuracy and specificity of the description are critical factors in generating further hypotheses in these situations. Handlers often work with forensic specialists on the searches which helps in reducing the chances of destruction and contamination and increasing the probability of the successes. This can be achieved by creating a perfect coordination between the canine squad, their handler, and the forensic scientist. Experts use this information, along with understanding human decomposition, crime scene dynamics, environmental conditions, and other scientific aspects that might affect the search result and interpreting the dog reaction, while handlers rely on their knowledge of the dog's ability. Detective dogs often make the forensic experts take the tangible evidences, such as fibres, DNA samples, and fingerprints (20). The link between the forensic discoveries and the canine alarms infers the behaviour of the dogs and raises additional research suggestions.

Alert Response by Forensic Canines

The keen sense of smell possessed by forensic canines is invaluable for investigating crimes. This is because they can find and identify evidence that human investigators might overlook, reducing the margin of error in crime scene searches and investigations. It is truly impressive how proficient these canines are in their detection abilities, as they can identify even the smallest traces of many substances, including explosives, narcotics, and even human remains. They are a priceless resource for forensic teams and law enforcement organizations because of their extraordinary smelling talents. Forensic dogs can not only locate tangible evidence but also offer valuable clues in situations involving missing persons and help follow the whereabouts of suspects. Because of their remarkable ability to track smell trails across various types of terrains, these dogs are extremely valuable for searching for individuals in both urban and rural settings.

The popularity of incorporating forensic dogs in criminal investigations has risen because of their aptitude for providing significant evidence and aiding in resolving complex cases. With the continuous progress of training techniques and technology, it is expected that the demand for these incredibly skilled canines in forensic investigations will only increase. Forensic dogs undergo intensive training that focuses on improving their sense of smell and equipping them with the skills to navigate various environments. By exposing them to a wide range of aromas and scenarios, these dogs are extensively trained to detect and follow various odours even in challenging real-world situations.

The application of forensic canines has been proven to be beneficial not only in the uncovering of physical evidence, but also in creating crucial leads that have played a significant role in resolving cases that were previously considered unsolvable. Dogs have showed their essential role in law enforcement by their remarkable capacity to detect minuscule amounts of chemicals, as well as their relentless commitment to tracking scent trails, both of which have proven invaluable in supplying actionable leads and evidence. The demand for the services of forensic canine teams is on the rise, leading to their deployment in diverse settings such as crime scenes and disaster zones. In these various contexts, their exceptional abilities, and unwavering determination play a crucial role in enhancing investigations and search-and-rescue operations. The growing recognition of the importance of forensic dogs in criminal investigations underscores the value of their capabilities and the crucial role they play in delivering justice and resolving intricate circumstances. The combination of ongoing technological advancements and increasingly rigorous training procedures ensures that these remarkably capable canines will continue to play an increasingly vital role in the future of forensic investigations.

Indian Scenario

The issues surrounding the demonstration of a tracker dog's reliability in terms of its abilities and behaviours are underscored by the examination of the admissibility and evidential significance of expert testimony concerning tracker dog scent recognition in criminal cases. The reliability of identification through the use of forensic canines has come under scrutiny because of the potential for false positives and the inherent difficulties in interpreting the mental processes of the dogs during the tracing process. Faulty interpretations of tracker dog's behaviour during initial cases have resulted in wariness among the English, Scottish, Canadian, Indian, and US judiciary about the

validity of forensic canines. This has raised the need to have universal standards for the admissibility of tracker dog identification for demonstrating the dog's dependability. It is also important to alert the jury about the limitation of tracker dog evidence. The opinion of many judicial authorities was swayed in favour after the works of Freckelton I., who extensively investigated the admissibility of canine evidence. Although in recent times a positive change has been observed, it is still a long way before a unanimous consensus is built among the judiciary, forensic, and police professionals about the applicability, reliability, and admissibility of forensic K9s.

Evidence revealed by the tracking dogs are now admissible in most of the US states if proper conditions are met during the process which is a step in right direction. Countries like Germany are currently using canines for trailing aids in which court has ordered for training, certification, expert assessment, and document negative control of the canine (4). In India a thorough review and documentation of canines age, breed, history, success rate and handlers' testimony ae taken into consideration while using trailing and tracking dogs (19). In France canines are used for both tracking and as scent evidence in courtroom as the procedure for testing the reliability are governed by an accreditation body in France: French Accreditation Committee (Comit´e Français d'Accr´editation, COFRAC. Scientific accreditation body for formulation of such procedures should be established in India also and need for more research are pressing priorities. Indian statement cases which used canine evidences are tabulated in Table 1.

Inability of dogs to testify and cross-examined in court of law and their dependability on the trainers for interpretation, sometimes considered as hearsay evidence, are major concerns raised by the Indian judiciary. These concerns are exacerbated by high chances of false positives, deceit, and self-deception. As a result, the significance of forensic canine evidence has been diminished.

However, opinions changed, as seen by the 1993 case of Shaikh *vs* State of Maharashtra, in which tracker dog testimony was judged more admissible. The court remarked that a tracker dog's inability to be persuaded benefited it, making this form of evidence more dependable, particularly in scenarios such as drug detection or tracing fresh smell in robbery or murder cases. In this context, the court accepted that, while dogs occasionally fail in detection owing to limiting conditions, when they successfully follow an object or a perpetrator, they are dependable. The Shaikh court also issued guidance on the admissibility of such evidence, emphasising that there must be a reliable and complete record of tracking in order for it to be admissible as well as ensuring that any discrepancies between recorded data and handlers' statements at trial are not established (19).

Scientific Issues in Detection and Legal Criticism

K9s use principal smell, used as the main stimuli for tracing and tracking, and differentiate it from other smells. A variety of objects, including clothing, saliva, cigarette butts, breathing air, and more, can be

Table 1. Key cases focused on the canine evidence

Year	Case	Landmark judgement
AIR 1969 2 SCC 234	Abdul Rajak Murtaja Dafedar v. State of Maharashtra	The evidence of dog tracking was unjustified, citing the dog's incapacity to take an oath under cross-examination and the unfair notion that human liberty should not be deduced from dog behavior.
AIR 1993 SC 1723	Surinder Pal Jain v. State of Delhi	Conditions that would prevent any other individual from being implicated and only affect the accused's guild, leading to error.
1993 Cr LJ 2808	Shri Ashok Garade v. State of Goa	Documentation of success rate, past, reliability, testimony of expert must be done for admissibility of canine evidence.
1993 Cri LJ 3883	Gade Lakshmi Mangraju v. State of Andhra Pradesh	Evidence of screening and sniffing by dog proved to be necessary in this case to find the accused.
1993 CriLJ 2808	Shaikh v. State of Maharashtra	Canine evidence, which includes circumstantial evidence, must be documented with prior scrutiny and adhered to the guidelines.
AIR 2008 5 SCC 697	Dinesh Borthakur v. State of Assam	Canine can be used only for investigation not for guilt establishment.
2001 Cr LJ 4006	Vishnu v. State of Delhi (NCT)	Dog squad does not lead to positive conclusion of identifying the culprit in this case.
AIR 2001 6 SCC 205.	Ramesh v. State of Assam	Because of the likelihood of a mistake by the dog or its handler—which is not accepted in the legal system.

used as scent articles by well-trained dogs. When a dog is tracking or trailing, its ability to detect specific human smell trails is mostly based on the principal smell, which is one of the main stimuli for individual scent tracing. The success rate of projects has been positively correlated with both the training method employed and the level of operational experience of the teams involved, as showed by research (23). Specially trained police canines have an average success rate of 82% in tracking a person and 97% in detecting the absence of an odour track under different situations. The success rates of private rescue dogs were lower, averaging 65% and 75%, respectively. This shows that a well-trained handler team has a low potential error rate and can be an effective tool for law enforcement. Saliva was a good reference smell source for the investigation. The study's findings show the elements and components found in saliva, axillary perspiration, and DNA taken from whole blood are adequate and can be used as an important stimulus for specific canine search operations (23).

Human fragrance may be recovered from post-blast objects removed from the blast site, it has been shown to withstand the severe mechanical and thermal consequences of an explosion involving a concentrated peroxide-based explosive. Canines trained to detect human scent have proven to be a valuable tool in the fight against terrorism and can be dispatched to areas where improvised explosive devices have detonated quickly. Using post-blast debris, human scent-specific canines can identify people who have come in touch with IEDs with an average success rate from site response of 82.2%, confirming that this technology has significant criminal, investigative, and military applications (24). However, there is a chance that a dog will match one of the scent samples in a lineup only by serendipity. The validity of the results increases with decreasing likelihood (23). Factorials are included in Koziol and Sutowski's (25) work to calculate the theoretical probability of correct hits by random;

$$P = \left[\frac{k!(n-k)!}{n!}\right]^{lm}$$

Where, P = probability of accurate identification by chance in repeating trials several times with several dogs; k = number of target samples in the lineup; n = number of stands in the lineup; l = number of dogs used; m = number of trials conducted.

The dogs may pick up on which samples in the lineup are target samples or decoy samples from one trial to the next, which poses limitations to this technique. This implies that successive trials of smell lineups are not totally separate from each other. If the same smell samples are used for more than one dog, the lineups are not independent because a previous alert may have left cues on a sample that a later dog may respond to. (26).

The discovery of an incidental scent left behind by an object can occur without human contact, showing that human scent can be identified even when its source is above the object. These results show that human scent can be dispersed on items 5 cm away without direct touch with the object and yet be precisely matched by trained canines, even if the amount of odour that would permit detection has not yet been determined (27). Techniques that adhere to scientific principles should be used by animal forensic analysts, along with empirical testing that makes use of suitable controls, standards and known/possible error rates. Independent verification, peer review, and publication are necessary processes for these techniques. Legal and scholarly criticism of detection canine efficacy is growing as demand grows for their use in national security and law enforcement operations (28-29). However, the scientific community acknowledges that detection dog reliability is a topic with a lack of research and a wide range of technique (16).

In conclusion, role of forensic canines has strengthened significantly which has led to increase in their utility in forensic investigations of missing/absconding person, bombs, and other evidence. The remarkable olfactory abilities of trained canines and the extensive research showing their accuracy in detecting scents and locating evidence highlight their potential as valuable tools in forensic investigations. However, the reliability and judicial admissibility of forensic canines are significant areas of concern for the legal and scientific communities, especially in country like India. Many factors including dog variety, experience of the trainer & handler, breed, age, environmental aspects, terrain condition, wind, and temperature, fatigue and masking on contraband devices can increase or decrease success rate of dogs. It is imperative that the dogs are trained efficiently to improve their olfactory senses. Various studies suggest that with proper training, forensic canine can be revolutionary in identification, detection, and discrimination. Forensic agencies must take extensive steps to ensure that proper protocols along with proper rules & regulations are developed

to ensure their admissibility in the court of law. Dogs are silent evidence and require the handler to interpret their testimony. Therefore, the handlers must be trained in the process of courtroom testimony. With proper training, significant strides could be made in the terms of admissibility of forensic canines in courtroom.

Conflict of interest

The authors declare that they have no conflict of interest.

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