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# Forensic Ornithology: Enlightening People

**Drishti Patel[1], and Dr. Arushi Chawla[2]**

[1] Student, Institute of Applied Sciences (Department of Forensic Science), Parul University, Vadodara, Gujarat, India.
[2] Head of Department, Institute of Applied Sciences (Forensic Science and Forensic Odontology), Parul University, Vadodara Gujarat, India.

Correspondence should be addressed to Dr. Arushi Chawla; arushi.chawla82130@paruluniversity.ac.in



**ABSTRACT**: Ornithology is a division of zoology which is concerned with the scientific studies of bird. Ornithologists study the morphology, anatomy, habitat, behavior, taxonomy, systematics, evolution, eating and breeding habits of birds. Birds are often the victims of heinous crimes and aircraft accidents. Forensic ornithology is a branch of ornithology, which deals with the identification of the specific bird species from the fragmentary remains at the site of incident. Forensic Ornithologists use physical microscopic and DNA bar-coding techniques for comparing the fragmentary remains and identification. Identification of the species of the bird helps to understand their true nature, their habitat, and thus manifest how they can be conserved and protected from crimes. A bird strike can cause significant damage to an aircraft and thus to human life. The data on birds provided by forensic ornithologists can also be used to stop them from coming to airports and avoid accidents. The purpose of this review article is to promote the importance of birds and also the field and scientific techniques of forensic ornithology and enlighten people about the same. Birds help to support the climate by going about as hunters, pollinators, scroungers, seed dispersers, seed hunters, and biological system engineers. This makes them of decisive and crucial importance to humans as well as our planet. The right application of forensic ornithology can lead to safer travels both of humans and birds.

**KEYWORDS**: Bird Strike, Forensic Ornithology, Fragmentary Remains, Scientific Techniques, Zoology.

## I. INTRODUCTION

Ornithology is a discipline of zoology concerned with the "methodological study and subsequent understanding of birds with everything that related to them," according to Wikipedia. Because of the great visibility and aesthetic appeal of birds, ornithology differs from similar subjects in many ways. It has also been an area where amateurs have made significant contributions in terms of time, resources, and financial assistance. Ornithology is the study of birds and is a branch of zoology. The bulk of the writing at the time is more narrative than logical, although it does give a wide reinvention of information, including a ton of old stories, upon which to build further examination. Many works of the middle Ages in Europe managed the Earth parts of ornithology, especially the falcon and the game bird The Executives. From the mid-eighteenth century to the end of the nineteenth century, logical subspecies gathered in tropical regions rich in bird species, with significant spotlights on the characterization and characterization of new species. Despite the fact that the science of many species was practically unclear in the mid-20th century, researchers still had solid control of most birds. In the last part of the nineteenth century, the internal life structures of birds were largely investigated for systematic reasons. In the first half of the 20th century, physical examination was eclipsed by the creation of the fields of environment and ethics (conduct investigation), although it returned during the 1960s with an emphasis on the utilitarian changes of birds [1]–[3].

Nonprofessionals make significant contributions to ornithology, which is one of the few scientific domains in which this is trueMany of the explorations are completed at colleges and historical centers, which house and maintain the bird skins, bones and preserved examples on which most taxonomists and anatomists depend. The field research is carried out by two experts and beginners, with the last option giving important data on conduct, environment, appropriation and transfer. Although the presentation of equipment and strategies, for example, bird grouping, radar, two-way radios and improved grades, handheld sound hardware has helped exceptionally in many areas of ornithology, instruments such as bird banding, radar, radio transmitters The development of the telemeter, and raised, convenient sonic gear, has helped significantly in many areas of ornithology. Bird banding (or ringing), which traces all the way back to the mid-1800s, is still a well-known method of finding out in relation to a bird's lifespan and relocation designs. Consistently, an assortment of nations' banding programs label countless birds with numbered foot groups. The use of sensitive radar has also fundamentally favored the investigation of the transfer of birds. Individual bird development has also been observed continuously using small radio transmitters attached to or embedded in the bird. Visual markings, for example, feather colors and plastic labels on the legs or wings, bring to mind visual specific evidence without the tedious undertaking of catching a

singular bird, and allow expert beginner bird-watchers to help him or her. provide power. Unpretentious bird. With the presence of better grade, convenient sound hardware, the investigation into the nature and meaning of bird calls has begun. In this reference book, 'odontology' can be interchanged with 'criminological dentistry' and 'measurable odontostomatology'. There are no words to describe what has become one of the most rapidly developing miniature claims to fame in the field around dentistry. In any case, a criminological odonatologist is one who understands the importance of the intersection of regulation and dentistry and can explain to courts the intricacies and nuances of dental evidence along these lines, as in exceptionally restricted definitions. Each one is recommended. The supervisor's ability to give discovery and subsequently a perspective is based on what courts the supervisor considers the master position. This may require performance capability at each event according to the general inclination of the appointing authority from the outset in an unfair legal framework. In practice, court oversight is thought to be a mixture of instruction, preparation and experience applied to the current issue, thus having a significant impact on the choice of history. The Criminological Odonatologist in particular must not be a talented authorized or enlisted clinical dental specialist, although the person in question has the ability to notice, record, collect, preserve, and evaluate dental evidence to be valuable in court. There should also be an option. This, as in other compelling master supervisors, requires a set of abilities, one of which is the ability to clearly and compulsively deliver in both oral and written reports. For a number of reasons, criminal chisels, formerly a well-known process of final choice for reproducing the approximation of dead facial features from skull information, have a restricted future. To the point when different replicas are distributed using identical skulls and context-oriented information, there are many plausible and down-to-earth examples of tremendous discrepancies in discoveries achieved by infallible professionals. These results unquestionably go against the wholly logical assessment that most criminal method courts hold. Measurable methods derived from a consolidated informational collection of surface investigations of facial highlights combined with registered tomography images of the fundamental skeleton, then again, the computerized age of the most perceptible face into any CT or laser geographic output of an obscured skull will allow to fit. The factual structure represents a more remarkable test for the validity of the facial chisel [4]–[6].

With their overall social and similar race/other race undercurrents, these morphometric perspectives on facial distinctiveness, memorization and acceptance and brain science research share a great deal for all intents and purposes. Long after they have been destroyed or consumed, dental materials and innovations are used to produce exceptionally appropriate physical depictions of the remaining parts of the human skeleton that can be used as helpful memoirs for pathologists and court evidence. as can be done. These capabilities may be explored until three-layer printing, which is still in its early stages, becomes far-reaching and consequently economical. This pattern has effectively begun, and from now on this view will change radically. In short, a criminological odontologist is a dental specialist with significant clinical competence, who additionally has a broad understanding of the law and the courts, as well as an emphasis on the ethics of dentistry and the direct as a whole. When faced with the treatment of a specialist's unfortunate behavior or allegations of physical or sexual malignancy caused by a dental specialist in a clinical setting, police often seek a criminological odontologist.

Experts consider the individual in question to be a sound, non-partisan and widely experienced skilled fellow who is respected for appropriate current clinical practice in dentistry before deciding whether a case of all appearances exists. Further examination and possibly implying. Criminological odontologists investigating illegal, unregistered professionals and the offices from which they work may indicate health and safety issues for on-scene specialists as well as the valid status of prescriptions recommended by the on-scene physician. can, should be involved. Other important issues such as agreeing to therapy, classification, entry into records, abuse, prosecution, risk reduction, and evidence-based practice certainly deserve attention in more modern clinical school educational programs where legitimate drug divisions are prescribed. Huh; These are just two models. These enhancements are currently being reflected in dentistry, and criminological odontologists will be on the bleeding edge of these leaps forward and the benefits they bring to our general public. Wings are one of nature's most exquisite creations, and they have evolved to satisfy an assortment of abilities. While the body of a solitary bird consists of several types of quills, the shaped feathers are most demonstrative to spontaneous eyewitnesses. The plumage (a composite term for every single quill covering a bird's body) is probably the most widely recognized way we recognize a wide range of birds. The individual quills (which make up the feathers) are quite contrasting across species and even inside the body of a single bird. For example, a male mallard duck has a wide range of shapes, surfaces, sizes and examples of shading on almost all aspects of its body. In addition, each shaped plume is characterized by an assortment of spikes: 1) the pennaceous points are inflexible and form quill veins, which give the plume its tone, predilection and surface; 2) The plumuleaceous (fleece) thorns are cushioned, the delicate points seen close to the foundation of most form feathers and are believed to help with protection. Despite the fact that these two kinds of barbs have similar structures, light microscopy shows them to be significantly distinct. The causes for these morphological distinctions are unknown, however they may be attributable to functional restrictions on each feather portion. Alfred Newton defined ornithology as the ‘the methodological study and consequent knowledge of birds with all that relates to them’[7]. There are almost ten thousand different species of birds residing on our planet, summing up to a population of over three hundred billion individual birds. The lives of humans and birds have been interlinked for a great many years now. Birds are of unequivocal and significant significance as they add to every one of the four kinds of biological system administrations [8], [9]. Birds provide stacks of services which contribute to both nature and humans. Their foraging activities make them predators, pest

controllers, seed dispersers and pollinators. Many birds are hunted for consumption and sport and many species are hunted for sustenance in underdeveloped areas of the world, they are often essential components of human diet. Bird feathers provide bedding, insulation, and ornamentation. The scavenging species of birds help regulate the spread of human diseases by consuming the rotting carcasses. Birds also have an aesthetic and cultural importance in human lives as they are a made a part of art, photography, religious custom[8]. Bird watching is quite possibly the most well-known open air movement; it has an extraordinary conservative effect with bird-watchers putting into this leisure activity. This explains the need of conservation and protection of birds Figure 1.

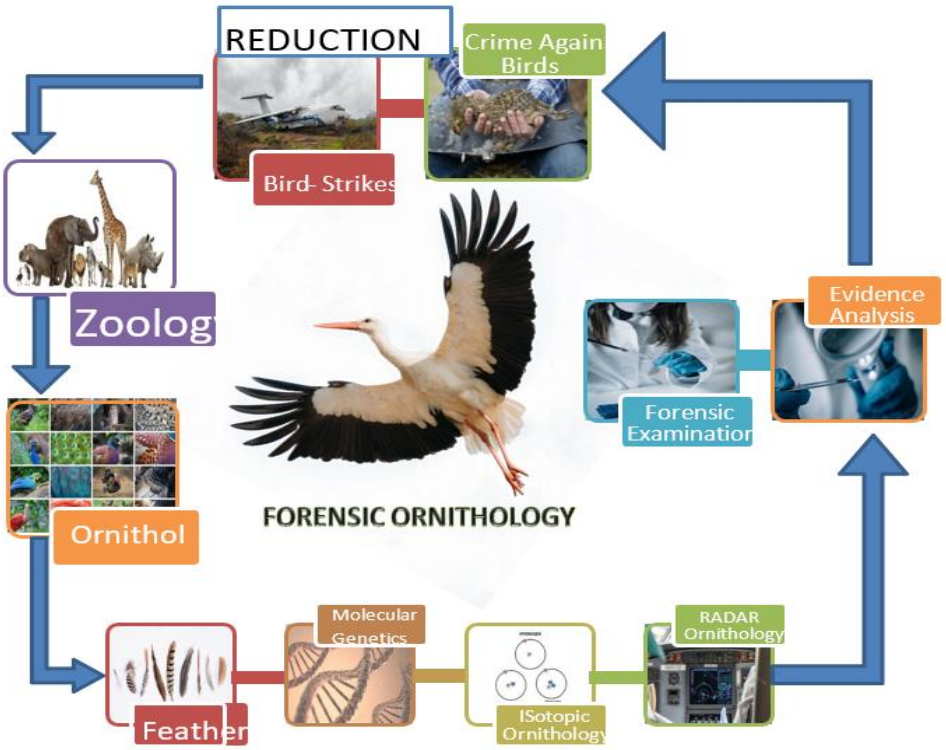


Figure 1: Illustrates the flow diagram of Forensic Ornithology.

Birds are often the victims of heinous crimes like poaching, illegal capturing and trading, poisoning. Birds are also victims to nest and egg robbery. Birds like golden eagle, hen harrier, peregrine and exotic migratory bird species are a target to persecution all over the world.(Wild Birds and the Law - The RSPB, n.d.) Birds are the casualties of natural life wrongdoings as well as of mishaps like airplane bird strikes, wind turbine bird strikes, power line bird impacts, correspondence tower bird crashes and tall structure bird collisions.6 Such crashes and strikes can prompt genuine inadvertent blow-back and financial misfortune.

The most commonly examined accidents are aircraft bird collisions, also worldwide. Bird-strikes cause huge material losses and endanger the lives of humans as well the birds. A bird strike in which a bird with a particular weight travelling at a particular speed collides with the aircraft which already has very high speed, has the capability to cause colossal damage to the structure of the aircraft and If that bird is replaced by a migrating flock of fowls then the damaged to the aircraft is horrifically multiplied. (Forensic Ornithology: Bird Detective | Smithsonian Science How | PBS LearningMedia, n.d.) This makes the flight and the people in it extremely vulnerable. Birds are the setbacks from regular life bad behaviors as well as of disasters like plane bird strikes, wind turbine bird strikes, influence line bird impacts, correspondence tower bird accidents and tall construction bird collisions.6 Such crashes and strikes can provoke certifiable unintentional after-effect and monetary adversity[11].

Criminological Ornithology is that particular part of ornithology which tries to distinguish birds from feathers, bones, snouts, claws, eggs, egg shell pieces or other follow confirmations in regulation implementation cases and Forensic Ornithologists represent considerable authority in the procedures of recognizing the avifauna from these remaining parts. They aim at the identification of the specific species of the bird from the fragmentary remains of the incident. Identification of the species of the bird, helps to understand their true nature, their habitat, their migratory patterns, their foraging and feeding habits and thus, helps to know how they can be stopped from coming to a particular place and how can accidents be avoided. There are many techniques used by forensic ornithologists for identification of the bird species including identification through feathers, DNA barcoding techniques and also the combination the two [12] Isotopic ornithology is used to derive the dietary

information as well as the area of origin of a particular species These techniques are further discussed in this article.

### *A. Methods Used*

Identification of the species through Feathers A single bird has more than 20,000 feathers on its body. Feathers enable many functions like flight, insulation, communication, camouflage, sound production, protection, water repellence, support, chemical defense, etc., for birds [12]. All birds have many types of feathers, including down feathers, contour feathers (body feathers, wing feathers, and tail feathers), flight feathers, rectrices, bristle feathers, filoplumes and each of these types are morphologically diverse. The feathers significantly differ in form, shape, size, texture, color and the pattern of color orientation upon them, among different species. Therefore, the study of their morphological structure helps in identifying the lowest possible taxonomic level to which the bird belongs. Criminological Ornithology is that specific piece of ornithology which attempts to recognize birds from feathers, bones, noses, hooks, eggs, egg shell pieces or other follow affirmations in guideline execution cases and Forensic Ornithologists address significant expert in the methodology of perceiving the avifauna from these leftover parts. The collected feathers are examined under high accuracy compound light microscopes or comparison light microscope. However, it turns out to be harder to determine the accurate bird species this way, as the microscopic characteristics of the species of same order or family are often similar. Hence, the microscopic along with the macroscopic characteristics of the whole feather (including the color, texture and patterns) are analyzed and compared to the reference specimens. Once a match has been established between the positively identified specimen and the sample, the species can be determined. The circumstantial evidence (locality, date, habitat) are also cogitated while establishing a match. The structure of the feather consists of a long and slender central shaft, also known as Rachis which holds on to the rest of the fibers coming of the feather. There are fiber-like projections which branch out of the rachis which form the barbs of the feather. Each barb is further branched into barbules. There is transparent finger-like projection at the base of barbules, known as villus (villi in plural), which is characteristic to some species of birds. The barbules also consist of nodes which may or may not be pigmented. The total of all the barbules on each side of the shaft of a single barb forms a vanule (Project Beak: Adaptations: Feathers: Feather Parts, n.d.). During the microscopic examination, following things are measured, examined and matched to the reference data:

- Barb length
- Barbules length
- Node shape
- Node distribution
- Pigment pattern and distribution
- Asymmetrical vanules
- Presence of villi

These are the characteristics which when examined accurately and thoroughly aid in identification of the bird species.

### *B. Molecular Genetic methods*

It is not always possible to acquire feathers and examining them to determine the species. Sometimes the incident can be so brutal that only blood and tissue remains are available and no significant feather evidence can be recovered and morphological identification is not possible. In such cases, identification can be established through genetic methods, primarily DNA-Barcoding . DNA barcoding is the use of small nucleotide sequence from standardized portion of mitochondrial genome for species identification and evolutionary studies (What Is DNA Barcoding?, n.d.)[13]. Based on standard sequences of the COI gene, DNA bar-coding was supposed to provide a universal technique for cataloging and identifying animal species. The process of DNA bar-coding includes collection, extraction and isolation of DNA from the remains, amplifying the preferred DNA sequence using a Polymerase Chain Reaction (PCR), sequencing the amplified DNA fragment from PCR and comparing the sequenced DNA strands with reference database for obtaining a match. The mitochondrial gene, Cytochrome oxidase subunit 1 (CO1) is known as the barcoding gene and is most popularly used for DNA barcoding as it has the potential to discriminate the wide variety of plants and animals species. When only blood or tissue is available, Whitman FTA cards may be used to gather DNA samples. Various techniques and kits may be used to extract and isolate DNA. DNA extraction from collected blood swabs and tissue remains can be carried out using the Qiagen DNeasyt Blood and Tissue Kit (Qiagen, Inc., Valencia, CA) or the Qiagen BioSprintt 96 DNA Blood Kit, QIAamp tissue kits, and the Prep Filer ExpressTM Forensic DNA Extraction kit in the Auto Mate ExpressTM DNA Extraction System (Applied Biosystems) (Qiagen). The freely accessible databases of DNA sequences BoLD (DNA barcoding and the Barcode of Life Database) and GenBank are utilized to identify a match of the found DNA sequence. DNA analysis may also assist in determining the diet of the species involved in the occurrence. Coghlan, et al.[14], used next-generation high-throughput DNA sequencing (HTS) to analysis the DNA extracted from the GastroIntestinal Tract (GIT) using three different genes, 16S rRNA, 12S rRNA and COI gene (for detection of mammal and fish species, bird species and insect species, respectively, consumed by the bird). DNA can also be analyzed for determining the sex of the bird species from the remains. An J. et al.,[15] identified the sex of illegally hunted female pheasants from the DNA extracted from the meat packets in the suspect's refrigerator, using the Chromo-Helicase-DNA-binding (CHD) gene.

### *C. Isotopic Ornithology*

Forensic ornithologists can also use the help of Stable Isotope Analysis (SIA) in obtaining beneficial knowledge about a bird. Isotopes are different forms of a signal element, distinguished due to the difference in the number of neutrons between each form of that element. Stable isotopes remain intact and do not decay over time (unlike radiogenic isotopes) (Inger & Bearhop, 2008). The mass and abundance of each of the distinct form is also different. For example, the ratio of deuterium (2H, heavier form of hydrogen) to

hydrogen (1H) in sea water on an average is approximately 1:6500. However, the original stable-isotope ratios tend to fluctuate in different geographic locations owing to the diversified environmental conditions like ambient temperature, altitude, precipitation rates etc., and also due to difference in the reactivity and diffusion of the isotopes.
This is known as isotopic fragmentation. An organism constantly interacts with the environment in which it subsists and incorporates elements from that environment in the form of food and water, this leads to the development of an isotopic signature within that organism corresponding to that environment[16]. These isotopic signatures are manifested in the tissues of animals. Generally liver, blood plasma, muscle, whole blood, bone collagen and keratinous (metabolically passive) tissues like hair, nails, feathers and claws are used for SIA. Due to the unique isotopic signatures present in these tissues SIA give us information about the organism's origin, habitat, diet, trophic relations with other organism, foraging patterns and places, migratory patterns and strategies [16]. Like any other organism all these information can also be established for birds as well and this can prove a great benefaction for forensic ornithology.

### *D. RADAR Ornithology*

RAdio Detection And Ranging, the expansion of the term RADA, uses electromagnetic signals and detect the same electromagnetic signals once they are reflected from any hindering object in the way of the initial propagation of those electromagnetic signals. The reflected signals which are known as echoed signals are used to estimate the range, height, size and speed of the hindering object. These signals are collected by the receiver and are presented upon the display. Radars are being used for the descriptive study of the migration of birds across the globe. Radar has made the detection, monitoring and quantification of the movement of birds in the day as well as at night and flight strategies of birds possible. Different types of radars are used to detect different types of birds and different aspect of the movement of those birds. For example, birds travelling at a range of a few kilometres are detected and monitored using low-powered surveillance radars whereas the birds flying at a range more than 240 kilometres observed with the help of radars like high powered weather and airport surveillance radars. The data collected about the time, distance, location, and height of the bird movement can potentially help in the conservation of migratory birds by prevention of bird-strikes and other accidents which make the birds and architecture hit by them, vulnerable.

## II. DISCUSSION

Identification of species of birds, their habitat, diet and eating habits and their migration patterns is possible using these above mentioned techniques and thus each of the techniques deduces a result which has a remarkable forensic utility, if applied niftily. Individually these methods require a different skill-set for its application and if a forensic ornithologist masters all of them, her or his work can be significantly reduced and the results can be enhanced markedly. The feather analysis demands accurate knowledge and experience from the examiner in order to be precise and beneficial for the investigation. Analysis and digital comparison of segments of DNA for identification requires comparatively less of an expertise and has a potential to unwaveringly identify the specific species [17].
Identification techniques from feathers and DNA are considerably used by the forensic ornithologists but isotopic ornithology and radar ornithology are not first-handedly used to solve cases. The latter techniques serve as an aid to the investigation because they have a rather indirect implication as they provide details such as migration statistics, their diet, their place of origin, and detection of their approach etc. these types of data about different species can be cumulated and then utilized for understanding avian temperament and then discovering facts about the mishap or crime that took place and often avoiding them.

## III. CONCLUSION

All of the strategies listed here are aimed towards identifying the birds involved in the occurrence, either directly or indirectly. Identification of bird species reveals their genuine character and environmental preferences, which may be quite beneficial, as Carla Dove once observed, "If people know the source of a problem, they can do something about it." A good explanation for this would be the use of the data collected by forensic ornithologists using these techniques by aircraft engineers to design better engines and architects for the aircraft so that it is more sustainable and strong enough to withstand a birdstike, and by airport managers to alter airdrome habitats to discourage bird activity along the take-off and landing pathways, for example, by removing all food and shelter sources or by creating sunning areas. This might be an excellent use of the information offered by forensic ornithologists, particularly that obtained by radar ornithology and isotopic ornithology. This new subject of forensic ornithology might be highly useful for wild-life forensics and have a big influence once it's widely used throughout the globe.

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