4 Legal Standards Setting in the Use of Forensics/ DNA Barcode

Evidence for Wildlife Crime Detection and Prosecution in Nigeria

Christie O. Onyia
Godfrey Okoye University

Obianuju P. Ilo
University of KwaZulu-Natal Durban
National Biotechnology Development Agency

Scott E. Miller
Smithsonian Institute

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4.1 INTRODUCTION

Forensic Science or Criminalistics is defined as the use of scientific methods and procedures to solve a crime. It is the application of Science to civil or criminal laws. A crime is an unlawful act punishable by a State or any designated authority (Farmer, 2008). According to Martin (2003), a criminal offence is an act or public wrong, harmful not only to some individual but also to a community, society, or the state. Before the emergence of standardised forensic practices, in ancient times, criminal investigations and trials depended much on forced confessions and testimony of a witness. Hans Gross was the first scientist to apply scientific methods to crime scenes, leading to the birth of criminalistics. Early in the 20th century, Edmund Locard formulated the "Exchange Principle" which stated, "whenever two objects come into contact with one another, materials are exchanged between them", thereby postulating that "every contact by a criminal, leaves a trace" (Roncacè and Nicosia, 2016). It was not until the late 20th century that Smith and Simpson discovered new forensic Science, while Alec Jeffreys pioneered the use of DNA profiling in forensic Science in 1984. The importance of DNA fingerprinting after that became important in assisting police detective work, as well as in resolving paternity and immigration disputes. In the 21st century and modern society, certain procedures should be followed during investigation and trial. The offender, if found guilty, would be punished according to the existing law. Where the offence is criminal, the investigation should follow legal standards of admissible evidence and criminal procedure. The same standards and procedures should be followed in the prosecution of offenders of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Nigeria's network of protected areas includes one biosphere reserve, eight national parks, over 400 forest reserves, 12 strict nature reserves, and 28 game reserves. The total area of land under national parks is about 2.4 million hectares. The game reserves were meant to conserve wildlife as they are important to the ecosystem. However, due to the rapid increase of human population in Nigeria, from about 150 million in 2010 to about 200 million in 2020, there is an increased demand for natural resources, and this poses threats to biological resources. High-level illegal exploitation of these resources endangers their survival and leads to their extinction because of the unsustainable manner in which many species are harvested (Ejidike and Ajayi, 2013). Timber and non-timber forest products (NTFPs) are used for food, medicines, oil, resin, tannin, household equipment, fuelwood, furniture, and building materials. They are therefore being used and trafficked for income generation. Animal species are not left out. Species prioritised for conservation include Pangolins (*Phataginus* spp.), chimpanzee (*Pan troglodytes*), lowland gorilla (*Gorilla gorilla*),

ostrich (*Strutio camelopedalus*), black rhinoceros (*Diceros biocornis*), giraffe (*Giraffa camelopardalis*), pygmy hippopotamus (*Choeropsis liberiensis*), and water chevrotain (*Hyemoschus aquaticus*). There is evidence that some of these species have since become extinct and there is a need for more species to receive special attention. Some of these species have been included in CITES lists I, II, and III depending on their level of endangerment (CITES, 2020) and the International Union of Conservation of Nature (IUCN, 2020).

Nigeria is progressively becoming a transit route for wildlife dealers. For example, Omifolaji *et al*. (2020) stated that there were seizure of 57 pangolin occurrences, comprising an estimated 478,010 pangolins from 2012 to 2019 in Nigeria, while CITES (2012) reported a seizure of 50 elephant tusks in Nigeria meant to be delivered to Thailand. Border inspectors and wildlife officials across nations are constantly monitoring endangered species that are being killed and trafficked in violation of national laws and international treaties. Sometimes many intercepted objects or samples are easily identified, but very often their taxonomic identification may not go beyond family or subfamily level (Sweeney *et al*., 2011), making room for some samples to go unconfiscated. Other limitation in using a morphology-based taxonomic identification tool to assign specimen is the issue of subjective interpretation of the morphological characteristics of the specimen (Ko *et al*., 2013). Many of the samples are concealed or trafficked at a stage that expert taxonomists are not able to identify them (McCullough et al., 2006). For example, certain mammals might have been poached and their tusks and skins, tanned or dyed, and exported for commercial purposes. Endangered plants might have been ground or processed into powder and trafficked for its medicinal use. The integration of DNA barcoding offers a solution to the challenges posed by morphology-based identifications for the fight against illegal trade on CITES species. DNA barcoding is a standardised molecular technique with several uses and applications for the identification of all life stages of animals (including immature stages) and processed products of plants and animals (Hebert *et al*., 2003; Wilson and Schiff, 2010; Frewin *et al*., 2013).

Google in 2012, through Global Impact Award, provided three million dollars ($3 million) administered by the Consortium for Barcode of Life (CBOL) hosted in Smithsonian Institution to check illegal trafficking and poaching of CITES-listed species. Nigeria was one of the six partner countries selected globally to set legal standards, among other agenda items, to demonstrate and adopt the use of DNA barcode evidence in the investigation, prosecution, and conviction of violators of the CITES regulatory framework.

The National Planning Committee (NPC) was set up and mandated to define the agenda and roadmap for implementation of the project, which was to last for 2 years (Appendices I and II). The Legal Standard Workshop was thereafter held for legal practitioners and enforcement agencies in Nigeria to determine the admissibility and effectiveness of DNA barcode data in the legal systems. The workshop brought together scientists and researchers, enforcement agencies, prosecutors and magistrates, and policymakers. The key players included: Federal Ministries of Science and Technology (FMST) and Environment (FMEnv) – CITES Unit; National Environmental Standards and Regulations Enforcement Agency (NESREA); Ministry of Justice; Sheda Science and Technology Complex (SHESTCO);

University of Lagos; University of Maiduguri; University of Port Harcourt; Obafemi Awolowo University – Natural History Museum, Ile-Ife; Raw Materials Research and Development Council; Nigeria Institute of Trypanosomiasis and Onchocerciasis Research, Kaduna; Customs; Immigration; Forestry Research Institute of Nigeria (FRIN), Ibadan; Gashaka Gumti National Park Taraba; Kanji Lake National Park, New Bussa, Niger State; Interpol, Abuja; Nigerian Television Authority (NTA) International; Radio Nigeria; Trust international. An important item on the Legal standards Workshop was the procedures for collecting, documenting, handling, processing, analysing, and presenting barcode voucher specimens and data.

4.2 POLICY, REGULATIONS, AND ENFORCEMENT ISSUES

The Federal Ministry of Environment has the mandate for policy issues that relate to environment and biodiversity and hosts the national Secretariat on CITES matter, while the NESREA has the responsibility of setting standards and regulations for the protection and conservation of Nigeria's biodiversity and natural resources in general, including CITES matters (NESREA, 2011). Their responsibility also includes coordination and liaison with relevant national and international stakeholders on matters of enforcement of environmental standards, regulations, rules, laws, and guidelines.

According to NESREA's regulatory guideline, it is an offence:

i. to import, export, re-export, or introduce from the sea, or attempt to import, export, re-export or introduce from the sea, any specimen of species listed in CITES Appendices I, II, & III and the Schedules to the Endangered Species Act without a valid permit or certificate;
ii. for any person to have in his or her possession or under his or her control, or to offer or expose for sale or display to the public, any specimen of the species listed in Appendices I, II, & III of the Convention or the Schedules to the Act;
iii. to make or attempt to make either oral or written false or misleading statements in connection with an application for a permit or certificate or registration;
iv. to obstruct or otherwise hinder an officer in the performance of his or her duties;
v. for any unauthorised person to alter, deface, or erase a mark used by the Management Authority to individually and permanently identify specimens.

The violator of CITES laws, if apprehended, whether at home or abroad attracts one or more of the following penalties: forfeiture of the specimen; arrest of the offender; heavy fine – not exceeding five million Naira (N5 million) for the individual; and not exceeding twenty million Naira (N20 million) for corporate bodies; imprisonment; or both fine and imprisonment – depending on the gravity of the offence. According to Omifolaji *et al*. (2020), lack of strict punishments may not deter people from engaging in the crime, as the delinquents can effortlessly pay the fine and return to the trade.

4.2.1 Monitoring of CITES-Related Matters

Monitoring and enforcement of CITES matters are conducted through the **Customs' Single Window Platform**, involving the following Stakeholders: Nigerian Customs Service; Nigerian Police Force (INTERPOL); National Drug Law Enforcement Agency (NDLEA); Agricultural Quarantine Services; and the Enforcement Authority – NESREA. Nigerian law provides that exhibit that is in processed form is forfeited to the enforcement agents, the exhibit that is in life form is returned to National Park Service, while non-living exhibits are safely stored in NESREA's facilities (Appendix I).

4.2.2 Procedure for Enforcement and Prosecutions

i. The apprehension of a CITES offender by any of the stakeholders, and subsequent transfer of the case to NESREA.
ii. Institution of criminal action against the suspect at the Federal High Court, which is the arm of the government, vested with jurisdiction for trial of such offences.
iii. Seizure of the CITES specimens for further investigation while the suspect is remanded in prison custody pending trial.
iv. Pre-trial in-house meeting of prosecuting counsel to review the facts of the case and strategies to be adopted in the prosecution – the various factors necessary for the successful prosecution of cases are considered, including appropriateness of the charge filed and whether there is a need for forensic or scientific tool in the successful prosecution of the case.
v. The punishment provided under the National Environmental Protection of Endangered Species in International Trade Regulations 2011 is forfeiture, imprisonment, and/or fine.

4.2.3 Previous CITES Offenders Trial Cases

A fiat was signed in 2008 in favour of the National Parks Services concerning CITES offence. Nigeria had many cases that warranted seizures of CITES specimens. Many of the seized items were either recognisable, live, and processed specimens such as ivory products (worked/semi-worked), whole tusk, cat, and reptile skin including crocodile, stuffed trophies, pangolin product, live turtles, and parrots. A number of the offenders had been tried, convicted, and prosecuted. Based on the presentation made by Barr. Alabo Wakoma, Esq., the Legal Adviser to NESREA at the National Workshop on Legal Standards on Barcode of Wildlife Project in Nigeria held in Abuja on 28 August 2013, it was reported that in 2012, 404 arrests were made in which 90 offenders were compounded and 34 jailed, while from January to July 2013, 70 arrests were made, 29 compounded and 52 jailed. All these prosecutions were based on the admittance of guilt; none of these cases had necessitated the need for scientific/forensic investigation on the seized CITES specimens. With the advancement in technology, culprits are getting tougher and technologically smarter, as well as advancing technologically in their

practice of committing crime and the ability to evade conviction and prosecution in the absence of scientific proof of evidence. There is, therefore, a need for the adoption of scientific/forensic proof for conviction as "confessional statements made under threat or duress" are not admissible in the Nigerian court. In criminal trials, forensic Science is usually applied in contentious areas. Expert opinion is therefore needed where the expert can furnish the court with scientific or other information of a technical nature that is likely to be outside the experience and knowledge of the court.

Two main considerations permissible for the admission of forensic or scientific evidence in Nigeria include:

i. The technique must be relevant to the fact in the issue
ii. The evidence must be presented in court by an expert.

A person is usually accepted as an expert if the person is specially trained and skilled in the field in which the evidence is given or in occasional cases, as decided by the judge based on his discretion.

4.3 ADMISSIBILITY OF DNA BARCODE IN CRIME DETECTION

The first adopted step towards setting standards for the use of DNA Barcode in crime detection by the CBOL was to identify the global area of application. The agreed-upon area was monitoring and control of illegal trade and poaching of wildlife species listed under CITES levels I and II, including endangered species of national importance.

4.3.1 Development of Standard Operating Procedures (SOPs)

Setting legal standards for the use of DNA Barcode to track the illegal movement of endangered species in whatever form requires "step-by-step" procedures to ensure authenticity and legal integrity of the reference samples developed by the Barcode of Wildlife Project Nigeria team. Maintenance of the chain of custody of the samples/specimens and issuance of a unique identifier are essential requirements.

4.3.1.1 SOPs for Mammals/Vertebrates in Nigeria

The SOP for mammal/vertebrate collection was prepared by Mammals Working Group, comprising Staff from National Parks Services, National Biotechnology Development Agency, Abuja, Obafemi Awolowo University, Ile-Ife. The vouchers and tissue biopsies of most mammals and other vertebrates were obtained from protected areas, National parks, open markets, and animal orphanages in Nigeria. The sample kits for animal specimens included Personal Protective Equipment (PPE), spreadsheet data form, immobilising (dart) gun, Global Position System (GPS), camera, surgical kit for the removal of tissues, 95% ethanol, and bar-coded vial. Blood tissues were collected from living animals that were released after collection. The edges of the ears or tail were punctured, and a capillary tube was fixed for suction. Forty microlitres of blood were placed on FTA cards and allowed to

dry before placing the cards in bar-coded vials. Information such as the collector's name, coordinates of the location, date and time, and unique ID were recorded. Voucher specimens were processed for animals collected live for conversion into vouchers. Some of the animals were sacrificed and preserved as either wet specimens or stuffed animals. Ethanol was used for the preservation of wet specimens, while taxidermy was used on stuffed animals. Details related to the collection event for each specimen, such as field number, GPS coordinates, date, and name of collector, were recorded in a field datasheet. The tissue biopsies were put in FluidX tubes containing 90% ethanol. Information such as date, time, and mode of transportation, kind of preservatives used were recorded. On return to the museum, final taxonomic designation and confidence level for each of the taxonomic identification were recorded according to CBOL's Strawman proposal. A catalogue number was assigned. To reduce the denaturation of DNA, samples were protected from sunlight and preserved in a cooler with ice packs until conveyed to the laboratory. The samples were transported to the laboratory as soon as possible and unprocessed tissues were stored at −20°C freezer.

4.3.1.2 SOPs for Plants

The SOPs for plant specimen collection were prepared by the Plant Working Group made up of scientists from FRIN, Ibadan, University of Lagos, University of Port Harcourt, and National Environmental Standards, Regulations and Enforcement Agency. The tools and materials for plant specimen collection were: PPE, GPS, secateurs, plant presses, camera, absorbent paper, envelopes/vials, rope, and tags. Images of the plants showing their taxonomic features were taken. The minimum number and size collected from each plant were in replicates and sufficient to fill a herbarium sheet, which measures 42 by 27 cm. Each plant was labelled with a unique number and collectors′ details. Other information such as location, habitat, description, and collection date were also recorded. On return to the herbarium at FRIN, steps such as pressing, drying, and registration were carried out for storage. Plant tissues were kept in ambient temperature and moisture conditions.

4.3.2 Field Information Management Systems (FIMS)

To ensure reliability, interoperability, and value of biodiversity data, the critical information requirements include the description, the location, and at what time the sample was captured or collected (Deck *et al*., 2012). The Barcode of Wildlife Project-Field Information Management System (BWP-FIMS) is a database that stores information relating to fieldwork such as specimen records, events collection, identification, and images. The specimen metadata made up of many components, such as the name of the species, country code, and unique identifier, were inputted in a BWP-created spreadsheet. The advantages of BWP-FIMS over the traditional spreadsheet are that it helps to validate the field data to ensure that they are in the right format and that all required field data are up to standard, to keep data safe and accessible, as well as to avoid loss of data. Another advantage of the BWP-FIMS is that there is no mandatory set outline; each project determines its list of terms. Therefore, the project was built around the Darwin Core Terms set. This is a common standard that

includes a wordlist of terms anticipated to expedite the sharing of information about biological diversity by specifying identifiers, tags, and meanings (Darwin Core Task Group, 2009). Once the spreadsheet was generated, it was validated to ensure it is of GenBank data standard and uploaded.

4.3.3 Laboratory Information Management System (LIMS)

The objectives of LIMS include standards-setting and procedures for sample collection, documentation, handling, processing, analysing, and presenting barcode voucher specimens and sequenced data. The essence of adopting the system was to minimise manual documentation as well as improve the efficiency and accuracy of data. LIMS software when integrated with a properly calibrated instrument and operated by skilfully trained staff helps laboratories to automate the collection of test data, as well as enabling them to meet regulatory requirements. LIMS has been usefully employed in different sectors, such as in food safety testing, water quality, and treatment plants, pharmaceutical production and testing, and tracking the movement of regulated species and products (Lyal and Miller, 2020). LIMS software program is used in outlining all molecular procedures conducted with each sample and linked to field specimen metadata (FIMS). It detects and re-runs unsuccessful reactions and systematic errors, thereby improving efficiency and quality control. The BWP-NIG laboratory Management data are available at https:// software.mooreabiocode.org/.

4.3.4 Sequenced Data

Out of the 98 plant species listed by the BWP-Plant Working group, 53 plant species were collected and identified by a certified taxonomist and sampled in triplicates, in line with the project's SOP for plant collection and processing. The plants were curated and the vouchers were deposited in the herbaria hosted in the Forestry Research Institute of Nigeria. The sampled animal tissues (including tissues from parrots, love birds, monkeys, civet cats, python, baboon, serrated tortoise and porcupine, elephants, lions, gorilla) were transported to the International Institute for Tropical Agriculture (IITA) for proper storage in −20°C freezer. Laboratory processing was delayed due to the sudden outbreak of the Ebola virus in the West African sub-region in the middle of the project. The steps involved in LIMS include the generation of 96 well extraction plates, Polymerase Chain Reaction (PCR) plates, cycle sequencing plates, and cherry-picking. Three plugins, namely the Biocode plugin, Biocode GenBank Submission plugin, and MySQL connector, are required for the Biocode LIMS. The MySQL connector joins the FIMS and LIMS database, while the Biocode GenBank Submission plugin automatically allows the submission of finalised contigs to make the DNA sequences accessible to the public at the end of the workflow. The BWP-NIG used was the Biocode LIMS which incorporates Geneious to the laboratory workflow; from DNA extraction, PCR, sequencing to consensus assembly. Geneious is a suite of cross-platform bioinformatics software applications with functionality such as sequence alignment, Chromatogram assembly, and accessing databases.

4.4 ACTION PLAN

The adopted project's goals/action plan of the Barcode of Wildlife Project-Nigerian (BWP-NIG) team was systematically implemented in two phases (Appendix II), and the highlight of the level of completion and achievement are hereby discussed:

i. **FIMS** – The list of endangered species under CITES Appendix I and II, including species of national interest, was created. The list contained 201 species that were actively traded, of which 98 were plant species; while 103 were animal species. Specimen metadata, consisting of several elements such as a unique identifier, name of the species, country code, were inputted in a Microsoft Excel spreadsheet (Table 4.1) as there was no internet connectivity in the field/forest. The Institutional code given for the samples is National Biotechnology Development Agency because it is registered as an institutional collection under the Global Registry of Biodiversity Repositories (GRBio). The information was thereafter validated and uploaded to Biocode FIMS. To ensure a successful upload, the data were queried. The Biocode FIMS used for the project is available at https://biscicol.org.
ii. **Resources Surveillance** – Surveillance of taxonomic and forensic laboratory resources was carried out nation-wide. FRIN, Ibadan, was identified as the taxonomic laboratory for plant species, while the Natural History Museum – Obafemi Awolowo University, Ile-Ife, was designated the taxonomic lab for animal species.
iii. Samples Standardisation – Standardisation of sampling and analytical methods were successfully handled by the various mandated institutions, listed above.
iv. Development of SOPs – All participating institutions, including legal practitioners – lawyers, magistrates; regulators; wildlife enforcement officers; scientists; and policymakers were present at the Legal Standards Workshop organised by CBOL under the effective leadership of Mr. David Schindel (the Executive Secretary of CBOL). The main objective of the workshop was to share experiences in the development of SOPs in their areas of jurisdiction. The outcome of the workshop guided the subsequent implementation of the project. Field sampling and data curation were carried out by the herbaria and museum alongside expert taxonomists.
v. **Training of Technicians and Scientists** – Technicians and curators were trained in the Forestry Research Institute of Nigeria, while scientists/molecular biologists and enforcement officers were trained at the University of Lagos and National Biotechnology Development Agency, Abuja.
vi. **Sample Processing** – DNA extraction, PCR, and sequencing of samples were carried out at IITA, Ibadan. Some of the primers used for the vertebrates were: VR1-ti (66.3°C), VF1-ti (67.2°C), HCO2198 (55.3°C), LCO1490 (50.5°C), VF1d – ti (67.4°C), VR1d – ti (66.9°C), VRLi – ti (68.2°C), VFLi – ti (68.6°C), Colbird F1 (59.3°C), Colbird R1 (60.4°C), Bird F1 (59.8°C), Bird R1 (56.9°C), RepCO1F (51.2°C), RepCO1R (55.8°C), RepTBCF (52.6°C),

TABLE 4.1
Specimen Metadata with Unique Identifier

Processing Lab	Sequencing Lab	Extraction Plate ID	Extraction Barcode	Extraction Well	Tissue Barcode	Tissue Rack	Tissue Position	Tissue Type
NABDA	IITA	NABDA_IOP_001	FR06483050	A01	FR05335775	NABDA_IOP_001	A01	SKIN SCRAPING
NABDA	IITA	NABDA_IOP_002	FR06483051	A02	FR05335777	NABDA_IOP_001	A02	BLOOD
NABDA	IITA	NABDA_IOP_003	FR06483052	A03	FR05335776	NABDA_IOP_001	A03	BLOOD
NABDA	IITA	NABDA_IOP_004	FR06483053	A04	FR05335774	NABDA_IOP_001	A04	BLOOD
NABDA	IITA	NABDA_IOP_005	FR06483054	A05	FR05335780	NABDA_IOP_001	A05	SKIN SCRAPING
NABDA	IITA	NABDA_IOP_006	FR06483055	A06	FR05335783	NABDA_IOP_001	A06	BLOOD
NABDA	IITA	NABDA_IOP_007	FR06483056	A07	FR05335782	NABDA_IOP_001	A07	BLOOD
NABDA	IITA	NABDA_IOP_008	FR06483057	A08	FR05335781	NABDA_IOP_001	A08	BLOOD
NABDA	IITA	NABDA_IOP_009	FR06483058	A09	FR05335786	NABDA_IOP_001	B01	SKIN SCRAPING
UNILAG	IITA	NABDA_IOP_095	FR06483144	H11	FR04499594	UNILAG_OTO_002	F05	Leaf
UNILAG	IITA	NABDA_IOP_096	FR06483145	H12	FR04499595	UNILAG_OTO_002	F06	Leaf
UNILAG	IITA	NABDA_IOP_097	FR06483146	A01	FR04499596	UNILAG_OTO_002	F07	Leaf
UNILAG	IITA	NABDA_IOP_098	FR06483147	A02	FR04499597	UNILAG_OTO_002	F08	Leaf
UNILAG	IITA	NABDA_IOP_099	FR06483148	A03	FR04499540	UNILAG_OTO_002	G01	Leaf
UNILAG	IITA	NABDA_IOP_100	FR06483149	A04	FR04499541	UNILAG_OTO_002	G02	Leaf
UNILAG	IITA	NABDA_IOP_101	FR06483150	A05	FR04499542	UNILAG_OTO_002	G03	Leaf
UNILAG	IITA	NABDA_IOP_102	FR06483151	A06	FR04499543	UNILAG_OTO_002	G04	Leaf
UNILAG	IITA	NABDA_IOP_103	FR06483152	A07	FR04499544	UNILAG_OTO_002	G05	Leaf

Preservative	Voucher ID	Institution Code	Collection Code	Catalog Number	Chain of Custody	Year Collected	Decimal Latitude	Decimal Longitude
EDTA	NABDA_MAMMALS_1000	NABDA	MAMMALS	1000	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1001	NABDA	MAMMALS	1001	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1002	NABDA	MAMMALS	1002	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1003	NABDA	MAMMALS	1003	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1004	NABDA	MAMMALS	1004	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1005	NABDA	MAMMALS	1005	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1006	NABDA	MAMMALS	1006	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1007	NABDA	MAMMALS	1007	Yes	2014	9.026222	7.432111
EDTA	NABDA_MAMMALS_1008	NABDA	MAMMALS	1008	Yes	2014	9.026222	7.432111
Silica gel	NABDA_Magnoliidae_2045	NABDA	Magnoliidae	2045	Yes	2014	6.345167	5.355389
Silica gel	NABDA_Eudicots_2046	NABDA	Eudicots	2046	Yes	2014	6.349417	5.343083
Silica gel	NABDA_Eudicots_2047	NABDA	Eudicots	2047	Yes	2014	7.443056	3.897667
Silica gel	NABDA_Magnoliopsida_2048	NABDA	Magnoliopsida	2048	Yes	2014	7.442778	3.897139
Silica gel	NABDA_Magnoliids_2049	NABDA	Magnoliids	2049	Yes	2014	7.392528	3.862139
Silica gel	NABDA_Eudicots_2050	NABDA	Eudicots	2050	Yes	2014	7.392639	3.8625
Silica gel	NABDA_Eudicots_2051	NABDA	Eudicots	2051	Yes	2014	7.391694	3.85775
Silica gel	NABDA_Eudicots_2052	NABDA	Eudicots	2052	Yes	2014	7.3925	3.858056
Silica gel	NABDA_Eudicots_2053	NABDA	Eudicots	2053	Yes	2014	7.39175	3.863028

and RepTBCR (58.8°C). For DNA Barcoding of animal species, Cytochrome c oxidase subunit 1 (CO1) was found generally effective in differentiating species. MATK and rbcl primers were used for the plant species; however, MATK had a higher resolution level. The laboratory management data are available at http://software.mooreabiocode.org/.

vii. **Custody Transfer** – The Customs Single Window Platform which has been in existence for custody transfer of confiscated items was adopted.

viii. **Forensic Laboratory** – There was no forensic lab in Nigeria that could identify the carcasses of dead animals or parts and processed samples. The only Police forensic laboratory was in Lagos, but the police representative at the Legal Standards Meeting could not attest to its functionality. Therefore, NESREA that has regulatory and enforcement responsibility for the protection of CITES-listed species was designated as the host institution. NESREA's environmental and air quality laboratory in Lagos was identified as facility to be re-designed and re-modelled as a wildlife forensic laboratory. The architectural design that would meet the chain of custody requirement was furnished by CBOL; the re-furbishing of the laboratory was still on-going at the time the project grant elapsed at the end of the 2-year target period.

4.5 CONCLUSION

DNA barcodes permit experts to empirically identify endangered species that may have been impaired or industrially processed. However, for any forensic evidence, or in this case, DNA barcode, to be used as proof of evidence in crime detection and conviction, chain of custody protocols and regulations (to eliminate possible sample contamination) for managing evidence until it is presented in court must be put in place. This requires the creation of a laboratory that could conduct DNA barcoding under the chain of custody rules and in compliance with the forensic standard by the Nigerian government. The regulation should be **gazetted** so that the DNA barcode could be a recognised database that could be referenced, indicating how any sample caught with anybody can be handled. Other requirements for acceptance of forensic evidence include certification of personnel and accreditation of the laboratory facility. Organisations involved in the chain of custody should include scientists and technicians, drawn from accredited institutions/organisation or bodies. The enforcers and courtroom officials should be well trained in the handling of specimens. Lastly, since the use of DNA Barcode evidence in wildlife crime prosecution is still new to some members of the judiciary, there is a need for awareness creation and training for lawyers and judges. The Customs Single Window Platform which has been in existence for custody transfer of confiscated items should be expanded to include scientists in specialised disciplines, to facilitate case dismissal or prosecution.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AU: Please expand "OAU".

APPENDIX I: SOME OF THE SEIZED ILLEGALLY TRAFFICKED SAMPLES ARCHIVED IN NESREA

APPENDIX II: PROJECT'S ACTION PLAN – PHASES 1 AND 2

CBOL-BWP-NIG'S ACTION PLAN PHASE 1	CBOL-BWP-NIG'S ACTION PLAN PHASE 2
i. Prioritisation of species	i. Custody transfer
ii. Identification of taxonomic and forensic laboratory resources	ii. Design, remodelling and refurbishing of forensic laboratory
iii. Standardisation of sampling and analytical methods	iii. Library construction
iv. Development of Standard Operating Procedures (SOPs) –Legal Standards Workshop	iv. Adoption of DNA barcode for crime investigation and prosecution
v. Field sampling and data curation	
vi. Training of technicians/scientists and enforcement officers	
vii. Tissue sampling and sample processing – generating sequences data	

APPENDIX III: ROADMAP FOR BWP-NIG PROJECT

NPC Formed	Library Construction	Academic Labs	Enforcement Agencies	Forensic Labs
Phase 1: Planning	• Prioritise species • Identify taxonomic /lab resources • Assess training needs	• Assess capabilities • Strategy for in-country processing vs export • Assess training needs	• Prioritise species • Hold planning workshop • Strategy for in-country processing vs export	• Identify forensic lab • Design specimen flow • Assess capabilities • Assess training needs
Phase 2: Training	• Technicians trained • SOPs developed /tested	• Technicians trained • SOPs developed	• Officials trained • SOPs developed	• Technicians hired/trained • SOPs developed/tested
Phase 3: Testing	• Additional training and proficiency testing if needed; technical support systems finalised Library construction • Tissue sampling • Data curation	• Sample processing • Data sharing	Pilot testing • Field sampling • Custody transfer	• Sample processing • Data sharing
Phase 4: Implementation	Library completion • Tissue sampling • Data curation	• Sample processing • Data sharing	Full Implementation • Investigations • Custody transfer	• Sample processing • Evidence preparation

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