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Trans-Atlantic Introduction of the Anas Mallard Duck (*Anas Platyrhynchos*) into Nigeria Following Mtdna Footprints

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ABSTRACT: Apart from the Nigerian indigenous Muscovy duck breed, which is endemic in the country, the Anas mallard is found in fairly abundant numbers, especially in the Northern part of the country. Although the mallard duck is widely perceived to be of exotic extraction, there is a dearth of information about its origin or how they got introduced into the country, leaving the subject to speculation. Hence this study was carried to trace the evolutionary ancestry of the mallard in Nigeria using the maternally inherited mitochondrial DNA marker. 603bp region of the mtDNA was analyzed following standard extraction and amplification, with specific primers. 20 Nigerian duck sequences in addition to 20 sequences harvested from Genbank representing major native regions of the *Anas platyrhynchos*, were used to reconstruct phylogenetic trees and matrices. The results revealed a strong genetic relationship between the Nigerian and Western European, particularly British ducks, and a weak lineage with ducks of Egyptian, Asian and Australasian extraction. The study reveals that the Nigerian mallard ducks are evolutionary descendants of the British mallard, whose ancestors would have been introduced into the country following the North-South trans-Atlantic maritime routes during the colonial era. The study did not find any evidence of a trans-Saharan introduction of the mallard into Nigeria from Asia via Egypt. Findings from this research sheds further light on the global dispersion of the duck from its original evolutionary epicenter in South-East Asia, and may be used for designing breeding programs.

KEYWORDS: Anas mallard, duck, trans-Atlantic, Nigeria, mitochondrial DNA

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INTRODUCTION

Ducks are thought to be among the first birds to be domesticated by humans (Li *et al.*, 2010). South East Asia is widely believed to be the evolutionary centre of origin of the wild mallard duck considered the progenitor of all duck breeds (Wojcik and Smalec, 2007). Different breeds of ducks exist around the world but the mallard (*Anas platyrhynchos*) is believed to be the most common and widespread especially in the global north (GISD,2024). Although in Nigeria, the indigenous Muscovy duck dominates the sector (Chia and Momoh, 2012; Oguntunji and Ayorinde, 2015), the anas mallards are a fairly common sight in the country especially in the northern part of the country (Oguntunji *et al.*, 2020). Despite their successful local adaptation, the anas mallard duck cannot not be said to be native to the country. Bird Life International (2008) describes the status of the Anas platyrhynchos in Nigeria as cryptogenic, its invasiveness as unspecified and its occurrence as uncertain. With little or no documented evidence, the introductory route of the Anas mallard into Nigeria has long been a subject of speculation (Oguntunji et al. 2020 . However, two major possible routes of introduction of the Anas duct into Nigeria exist (Figure 1). Firstly, this could have been made possible via the trans-Atlantic routes by Europeans most likely during the colonial era of Africa. Secondly, the bird could have been introduced to Nigeria (and West Africa at large) from Asia, the place of its evolutionary origin (Wojcik and Smalec, 2007), through the Middle East by land via Egypt, and form there further south across the Sahara following trans-Saharan trade routes, as the case with the chicken (Tor *et al.* 2024, Tor *et al.* 2021, Adebambo *et al.* 2010, Osman *et al.* 2016, Mwacharo *et al.* 2013 and Liu *et al* 2006). This study therefore sought to trace and hence establish the evolutionary ancestry of the Nigerian anas mallard duck to any of the major regions of its nativity, and consequently reconstruct the possible route of its introduction into Nigeria, using mtDNA footprints.

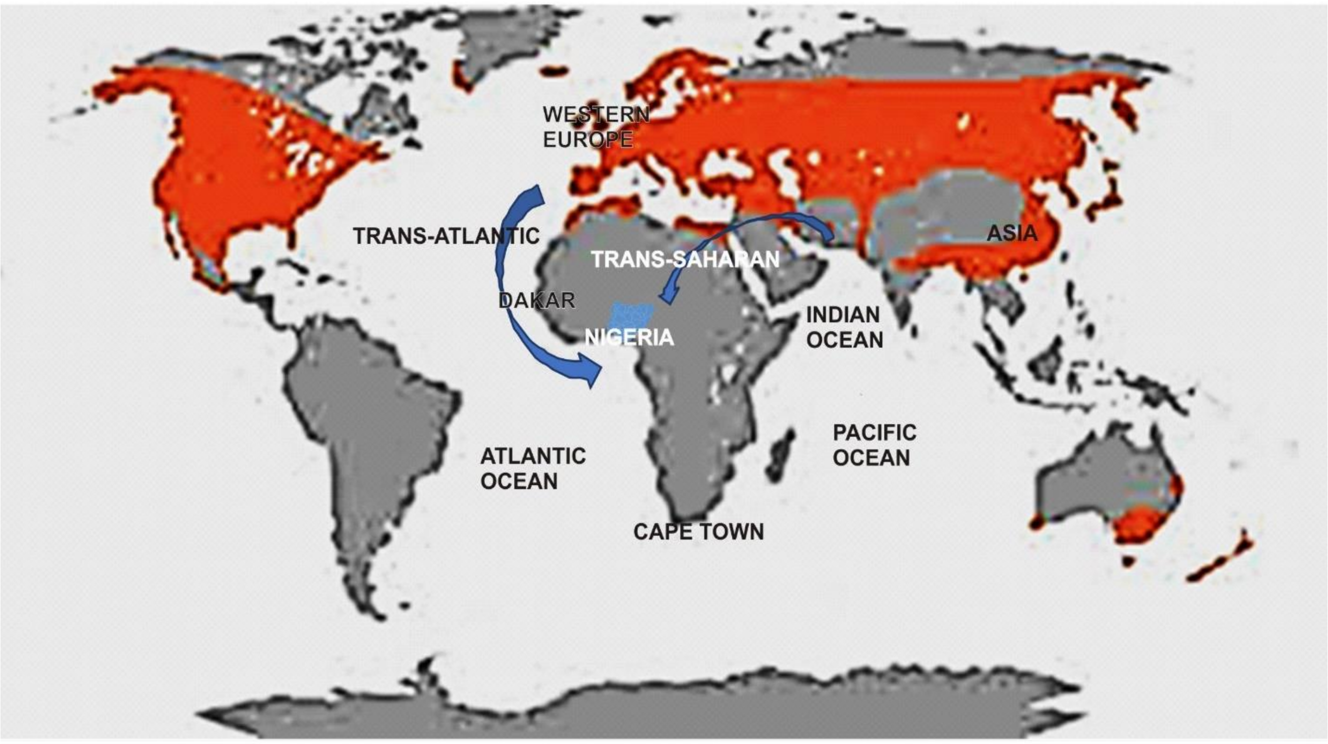

Figure 1: World map showing the native regions (orange colour) of the Anas platyrhynchos with a modification to show the location of Nigeria, major landmarks and the two possible roues of introduction of the ducks into the country (original source: https://www.google.com/imgres/world distribution of anas mallard duck)

MATERIALS AND METHODS

Genomic DNA was obtained from the wing vein 20 free range anas mallard ducks using FTA paper. The gDNA was isolated based on standard procedures (www.whatman.com), cloning of the hypervariable D-loop region of the duck mitochondrial DNA was achieved with the a published primer set F (5' – GTTGCGGGGTTATTTGGTTA - 3') R (5' –CCATATACGCCAACCGTCTC - 3') (Purwantini *et al.,* 2013), using Agilent Surecycler 8800 thermal cycler. Sequencing of amplicons was done following Sanger dideoxy protocol. Chromas 2.5.0 software (www.technolysium.com.au)was used to view and edit all raw sequence files. Sequence alignment to detect SNPs and reconstruct evolutionary phylogenetic trees was carried using Clustal W hosted in MEGA7 (Tamura *et. al.,* 2013) following a replication of 1000 bootstraps. The sequences were trimmed to a uniform size of 603bp inclusive of the hypervariable 1 region the d-loop. DNAsp 6.12.03x64 (Rozas *et al.,* 2018) was deployed in calculating molecular diversity indices, haplotype groups and generation RDF files which were subsequently imported into NETWORK 10.2 for the construction evolutionary network matrices, to ascertain the maternal ancestry of the Nigerian anas ducks. To properly evaluate the global dispersal of the Anas to Nigeria, 20 additional Anas duck mtDNA D-Loop sequences were harvested from Genbank, representing different regions in Europe, Asia, North America, North Africa and Australasia, and incorporated into the construction of the evolutionary phylogenetic trees and network diagrams. The genbank accession numbers of all downloaded sequences were included in the identity of such sequences.

RESULTS AND DISCUSSION

Results for the evolutionary phylogenetic tree analysis are shown on figures 2 and 3. The results show three main haplogroups (European, Nigerian and Asian), an indication of their genetic distinctiveness and adaptation to their various regional environments. This is further evident by the wide divergence from the root of the tree and high bootstrap values (99%) separating the European clade from the Asian. However, the Nigerian ducks can clearly be seen clustering distinctively with the European ducks to form a clade separate from their Asian counterparts. This may be a strong indication of the genetic affinity of the Nigerian ducks and those of the European extraction. Also, the Nigerian samples can be said to be of very close genetic distance as they closely cluster together with very low to zero bootstrap values. This in turn is suggestive of a European ancestry in contrast to an Asian one.

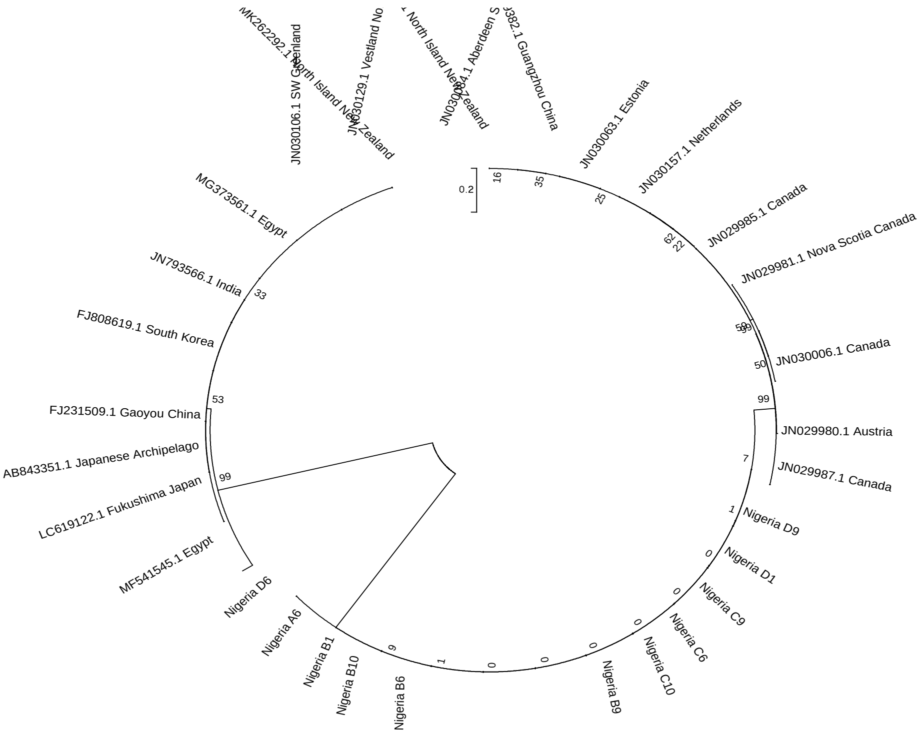

Figure 2: Phylogenetic tree showing the circular evolutionary relationship of Nigerian Anas ducks with those from world duck native regions. The evolutionary history was inferred using the Neighbor-Joining method. The optimal tree with the sum of branch length = 1.96849767 is shown. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Maximum Composite Likelihood method and are in the units of the number of base substitutions per site. The figures represent the Genbank accession numbers of the sequences.

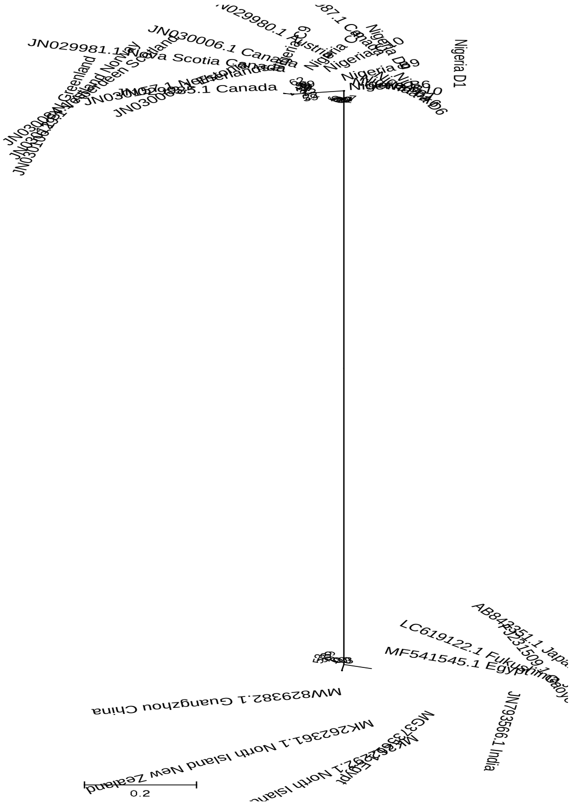

Figure 3: Phylogenetic tree showing the radial evolutionary relationship of Nigerian anas ducks with ducks from major global native regions

The findings of the phylogenetic trees are further supported by the results of the evolutionary network analysis (Figure 4). The results show a total of fifteen haplotypes for the combined Nigeria and global sequences, with a haplotype diversity (Hd) of 0.8559, indicative of strong genetic diversity among the sampled global duck populations, occasioned by phylogeographic adaptations. However, the Nigerian ducks all fell into one haplotype, a further indication of their low genetic diversity. Like the phylogenetic tree, the network matrix shows a high genetic distance and distinction between the European and Asian haplotypes as shown by the many mutation points and median vectors separating the two regions. The European ducks namely, Austria, Estonia, Western Europe (Aberdeen, Scotland; Vestland, Norway), Greenland, Netherlands, form a cluster with North American ducks (Canada), on one side of the network. On the extreme end ducks from Asian (Guangzhou, China; Japanese Archipelago; North Island, New Zealand; South Korea, India, Egypt), Fukushima, Japan; Egypt and China, form a distinct cluster. This may be a strong indication of divergence in evolutionary ancestry. The matrix shows the Nigerian ducks much more closely networked with the European ducks, an indication of a European evolutionary descent. Specifically, the network shows the Nigerian haplotype diverging directly from the western European haplotype (*WEURO*), being separated by only four median vectors despite the wide geographic distance. It is interesting that the *WEURO* haplotype constitute of British (Aberdeen, Scotland) and Norwegian sequences. Nigeria having being a former British colony, It is therefore reasonably possible that the Nigerian Anas mallard ducks were most likely introduced into the country from Britain during the colonial, slavery or early contact periods. In the absence of land linkage between Britain and Nigeria, it is only logical that such introductions were done aboard colonial and trade ships following the North-South trans-Atlantic maritime route connecting Europe and West Africa. This route of introduction may well apply to much of the rest of West and generally sub-Saharan Africa, especially regions bothering or proximate to the western coast from North to South (or Dakar to Capetown) (Figure 1). This generalization may not apply on the Eastern coast as it is open to the Pacific and Indian Oceans and all its consequent trade and cultural influences (Mwacharo et al. 2011, Fuller et al. 2011, Herrera et al, 2017). The network also shows the rest of the European ducks, along with their Canadian counterparts forming a radial or star-like distribution around around the *WEURO* haplotype, this may be a pointer to the British isle being a subdivergent center for the dispersal of the Anas to at least some part of western Europe and North America. The matrix in addition reveals that Egypt despite its land connection and relatively closer geographic distance to west Africa compared to Europe, has its ducks with very little genetic semblance with those of Nigeria, as seen by its distance and very high number of mutation points from the Nigerian haplotype. Despite its location on the African continent, all the Egyptian haplotypes form a cluster with the Asian haplotypes. This may not be unconnected with the fact that as a center for ancient civilization, Egypt would have been open up much earlier to trade and cultural influences of the near and far East Asia (Fuller and Boivin 2009), including South East Asia thought to be the evolutionary centre of origin of the wild duck. Both phylogenetic and Network results therefore may have casted strong doubts on the notion of Egypt being a gateway for the introduction of the Anas duck into Nigeria from Asia following trans-Saharan routes.

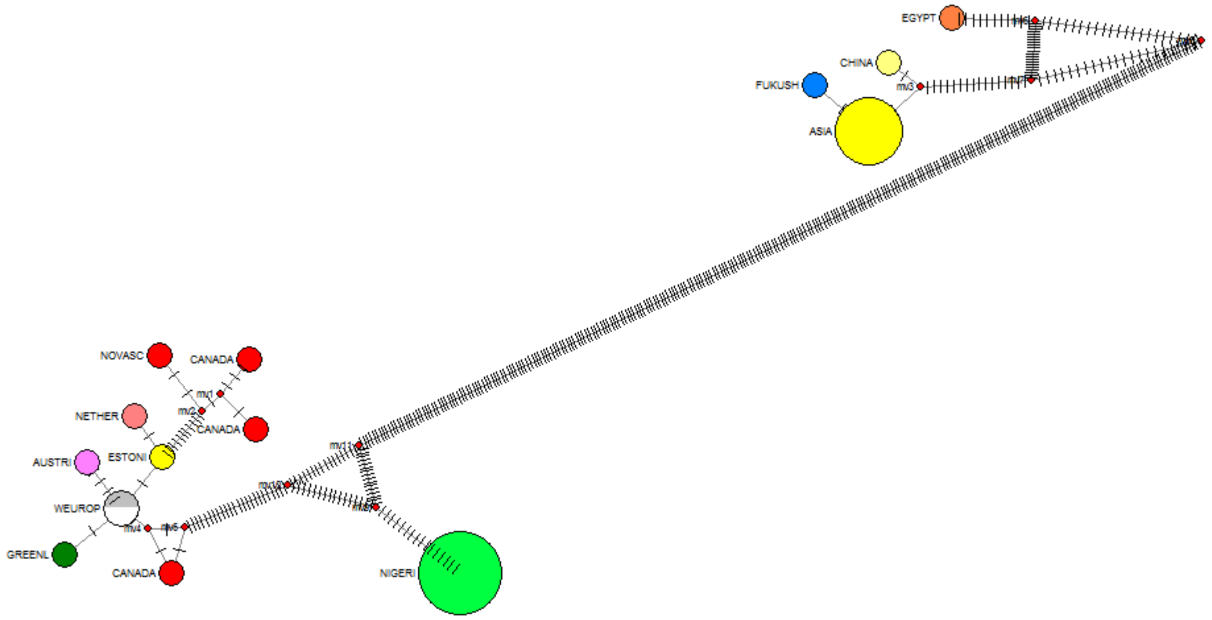

Figure 4: Median joining phylogenetic network showing the evolutionary relationship of Nigerian anas ducks with ducks from major global native regions, based on 603bp segment of polymorphic sites of the mtDNA D-loop of 40 individuals.

The different populations used with their genbank accession numbers in brackets are distinguished by use of colour codes (Green = Nigeria, orange = Egypt (MF541545.1), gray = Norway(JN030129.1), white = Britain (JN030084.1), pink = Austria (JN029980.1), light red = Netherlands (JN030157.1), Deep red = Canada (JN029981.1, JN029985.1, JN029987.1, JN030006.1Dark green =

Greenland (JN030106.1), Medium yellow = Estonia (JN030063.1) , light yellow = Gaoyou, China(FJ231509.1) , Blue = Fukushima, Japan(LC619122.1), Deep Yellow = Asia (AB843351.1_Japanese Archipelago, FJ808619.1_South_Korea, JN793566.1_India, MG373561.1_Egypt , MK262292.1_North Island, New Zealand, MK262361.1_North Island, New Zealand, and MW829382.1_Guangzhou_China) . Area of each circle is proportional to the frequency of the corresponding haplotype. The red dots between the haplotype nodes refer to the positions of median vectors, while the strokes represent the mutation points.

CONCLUSION

The findings from this study suggest that the Nigerian locally adapted Anas mallard ducks (*Anas plathyrynchos*) are evolutionary maternal descendants of western European mallard ducks (particularly the British ducks), which were most probably introduced into the country following trans-Atlantic maritime routes, as opposed to a trans-Saharan introduction from Asia via Egypt.

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