



Scaly trade: Analyses of the media reports of pangolin (Pholidota) scale interceptions within and out of Africa

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ABSTRACT

Despite the international trade ban (CITES, Appendix I), African pangolin trade and shipping within and out of Africa persist. *Phataginus tricuspis* and *Smutsia gigantea* are now classified as Endangered, and *Phataginus tetradactyla* and *Smutsia temminckii* as Vulnerable on the IUCN Red List. To date, the comprehensive trade data of African pangolin scales is still lacking. Here we analyzed pangolin interception data linked to Africa from social media, pangolin organizations, and online news media between 2016 and 2024. We report 130 seizure incidents accounting for 287,272 kg of African pangolin scales involving 15 African and seven Asian countries. Overall, Nigeria and the Democratic Republic of Congo are major exporters, while China, Vietnam, and Singapore are the major importers of African pangolin scales. Domestic interceptions were highest in Nigeria, Cameroon, and Uganda, signifying that they may be transit countries. While there was a negative correlation between the number of seizures and years, and the quantity of scales seized and years, 2019 reported a sharp increase in quantity of scales (97,877 kg; 34 % of the data). Furthermore, both metrics declined after 2019, with interceptions increasingly confined to African countries. This could reflect lack of resources, low capacity for identifying pangolin scales, change in routes of trafficking over time, underground trade, law enforcement and customs corruption. Our study contributes to the growing body of data on the African pangolin trade by focusing on trade routes, seizures, and importer and exporter countries, which are essential for effective conservation management.

1. Introduction

Pangolins (Family Manidae) consist of eight recognized species restricted to two continents; four species are endemic to Asia, while the remaining four are found exclusively in Africa (Gaudin et al., 2009; Malimbo et al., 2020). Recent studies revealed a possibility of a ninth species (*Manis* sp.) which falls into the Asian group based on mitochondrial gene fragments, morphometrics, and whole genome data from confiscated scales in Hong Kong (Gu et al., 2023; Hu et al., 2020; Zhang et al., 2015). Currently, pangolins are the world's

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most trafficked wild mammals, with estimations of more than one million individuals traded globally since 2000 (Emogor et al., 2021; Heinrich, 2017; Ingram et al., 2018; Omifolaji et al., 2020). Although habitat loss, degradation, and fragmentation are known as significant threats to pangolin populations in situ (Ingram et al., 2018; Pietersen et al., 2019b; F. Zhang et al., 2022), illegal poaching and trafficking have been reported as major global concerns (Heinrich et al., 2016; Malimbo et al., 2020; Nixon et al., 2019; Pietersen et al., 2019a).

The demand for pangolins has been rising as their meat, skins, and scales are used for traditional medicine both in Africa and Asia (Boakye et al., 2015; Ingram et al., 2022; Malimbo et al., 2020; Nguyen et al., 2021; Nijman, 2023; UNODC, 2016). The increase in the demand for pangolin parts (Ingram et al., 2019a; Svensson et al., 2013) in Asia has led to severe population declines in Asian pangolin species. To meet the demand in Asia, pressure has shifted toward African pangolin species belonging to two genera (*Phataginus* and *Smutsia*): *P. tetradactyla*, *P. tricuspis*, *S. gigantea*, and *S. temminckii* (Challender and Hywood, 2012; Emogor et al., 2021; Heinrich et al., 2016; Ingram et al., 2019a, 2018). Consequently, the international trade of all four African species has been banned as of 2017, following their inclusion on Appendix I of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Their conservation status has also been uplifted to Endangered (*P. tricuspis* and *S. gigantea*) and Vulnerable (*P. tetradactyla* and *S. temminckii*) on the IUCN Red List of Threatened Species (Ingram et al., 2019b; Nixon et al., 2019; Pietersen et al., 2019a, 2019b).

Despite the trade prohibition and other protective measures, traffickers operating in countries in East, Central, and West Africa are trafficking pangolin scales within and out of the continent, particularly to Asian countries (Challender et al., 2015; Emogor et al., 2021; Heinrich et al., 2016; Heinrich, 2017; Ingram et al., 2019a; Omifolaji et al., 2020). Reported incidents indicate that Nigeria, the Democratic Republic of Congo (DRC), and Cameroon were the main countries exporting pangolin scales from Africa to Asia (Ingram et al., 2019a; Xu et al., 2016). A comprehensive study undertaken on pangolin trade between 2010 and 2021 also reported Nigeria as a key transit hub, receiving major shipments from other African countries such as Cameroon and Gabon, destined for Asian markets (Emogor et al., 2021). Our study analyzed social media and organizational seizure incidents from 2016 to 2024 to assess whether these sources can reveal major pangolin trafficking routes and ongoing interceptions. Our study contributes to the body of comprehensive trade data to aid conservation management initiatives.

2. Methods and materials

2.1. Data collection

We collected intracontinental and intercontinental confiscation data of African pangolin scales for the period between 01 January 2016 and 31 December 2024 (Supplementary Table 1). We primarily sourced data from various social media platforms including Facebook, Twitter, and Instagram using keywords “African pangolin trafficking”, “pangolin scales”, and “pangolin scale trade”. When posts contained limited information, further investigations were done by following embedded Google links to full articles. Most source pages did not provide information on the exact species identification and full details on whether suspects were arrested and their case proceedings. We obtained additional data from leaders or members of active organizations dedicated to countering poaching and wildlife trafficking in Central and West Africa. These included LAGA (The Last Great Ape Organisation), Wildlife Law Enforcement’s press releases and its associated organization, EAGLE (Eco-Activists for Governance and Law Enforcement), and Conserv Congo. We categorized confiscations as intra-African (between African countries) and intercontinental (Africa to Asia). Furthermore, we classified countries involved as import countries (where scales were intercepted from another country), export (countries where scales were shipped from), and transit (countries where scales were intercepted en route). For incidents where only the country of seizure was reported, and no additional information on the trade route was available, we treated the seizure as domestic (i.e., we considered the country of seizure as the destination).

The scope of the study was confined to the confiscation of pangolin scales from the four African pangolin species, with the database exclusively including shipments ≥ 15 kg. For each confiscation, we collected the following information: (a) date of confiscation, (b) export country, (c) import country, (d) transit country, and (e) agencies involved in confiscation (Table S1). It is important to note that the dataset may not comprehensively represent all intracontinental and intercontinental confiscations due to reporting biases. Although our dataset is limited to reports from organisations and online social media pages, most of our data entries overlapped with other published African trade studies (e.g., Emogor et al., 2021; Ingram et al., 2019a; Omifolaji et al., 2020; Tinsman et al., 2023).

2.2. Data analyses

We conducted all statistical analyses in R v. 4.4.1 (R Core Team, 2024). We treated each seizure incident as one unit of analysis regardless of the quantity of pangolin scales involved. We assessed the correlation between the volume of scales (kg) seized and the number of seizures using Pearson’s correlation method and a simple linear regression model (lm). Similar assessments were done for the number of seizures and quantity of scales over time using lm. We accepted statistical significance at $P < 0.05$ for all tests, and models were visualized using *ggplot2* package (Wickham, 2016). We constructed trade flow maps using *ggplot2* and *sf* (Pebsma, 2018) packages to visualize intracontinental and intercontinental trade routes. Trade maps were further updated on PowerPoint Microsoft software.

3. Results

3.1. Intracontinental and intercontinental confiscation of African pangolin scales between 2016 and 2024

A total of 130 seizure incidents (287,272 kg) were identified through social media posts and Google news between 2016 and 2024 (Fig. 1a, b). Overall, there is a significant positive correlation between the number of seizures and the quantity of scales intercepted (Pearson's $r = 0.66$, $t = 2.30$, $p = 0.05$), indicating a significant increase in quantity as seizure incidents increase (Supplementary Fig. 1a). On the other hand, a negative correlation between quantity and year (Pearson's $r = -0.42$, $t = -1.21$, $p = 0.02$) and between seizures and years (Pearson's $r = -0.72$, $t = -2.75$, $p = 0.25$) was observed. These values were indicative of a general decline in both the quantity of scales seized and the number of seizures over the years (Supplementary Fig. 1b,c). Of the total seizure incidents, 85 (65 %) were intracontinental while 45 (35 %) were intercontinental. However, intercontinental seizures accounted for high volume of scales (Fig. 1b). The average annual seizures differed significantly between the two categories: intracontinental (mean = 9.4) and intercontinental (mean = 5; $p < 0.05$). Both categories declined in 2020, with intercontinental seizures dropping to just one incident in 2020 and 2022 (Fig. 1a). Notably, intercontinental seizures ceased entirely from 2023 to 2024, with all seizures during this period shifting to intracontinental incidents. Intercontinental scale quantities dominated from 2016 to 2019, peaking in 2019 at 90,760 kg but sharply declined to 10,701 kg in 2020 and subsequently dwindling to zero by 2023–2024 (Fig. 1b). In contrast, the quantity of scales from intracontinental category were lower but consistent and reaching their peak in 2024 (Fig. 1b).

3.2. Intracontinental seizure incidents and volume of scales confiscated between 2016 and 2024

Of the 85 intracontinental seizures recorded, 85 % were domestic, accounting for 77,038 kg of scales. Only 15 % (20,921 kg) of seized scales were exported and imported between countries (Supplementary Fig. 2a–c). Significant incidents include a 2017 seizure where Uganda exported 6 000 kg of scales to Tanzania, and seizures in 2021 involving unknown origins and Nigeria exporting scales to Nigeria and the DRC, respectively (Fig. 2a,b). Apart from being an exporter, Uganda also acted as both a transit and importer of scales from the DRC (Fig. 2c). Kenya served as a transit point for scales from Guinea and the DRC (destined for Asian countries), and also imported scales from Cameroon (Fig. 2c). On a domestic level, Nigeria recorded the highest volume of scales, followed by Cameroon, and Uganda, while Togo reported the lowest with 37 kg of scales seized (Fig. 2d).

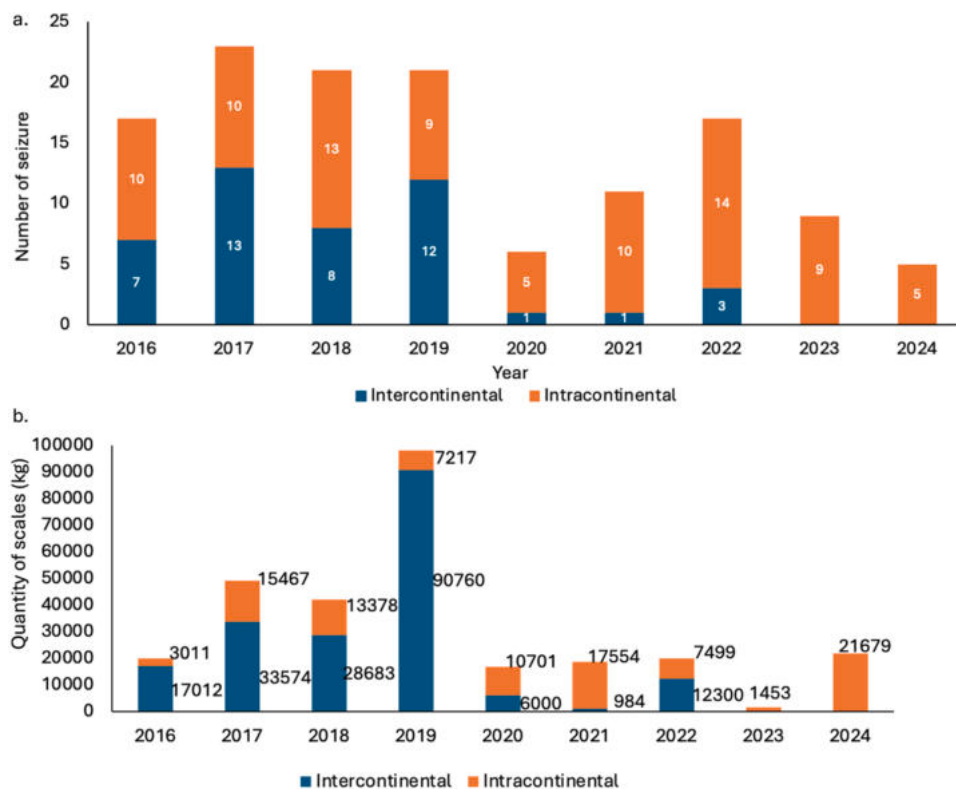


Fig. 1. a. Number of seizure incidents, and b. quantity of African pangolin scales intercepted intercontinentally and intercontinentally between 2016 and 2024.

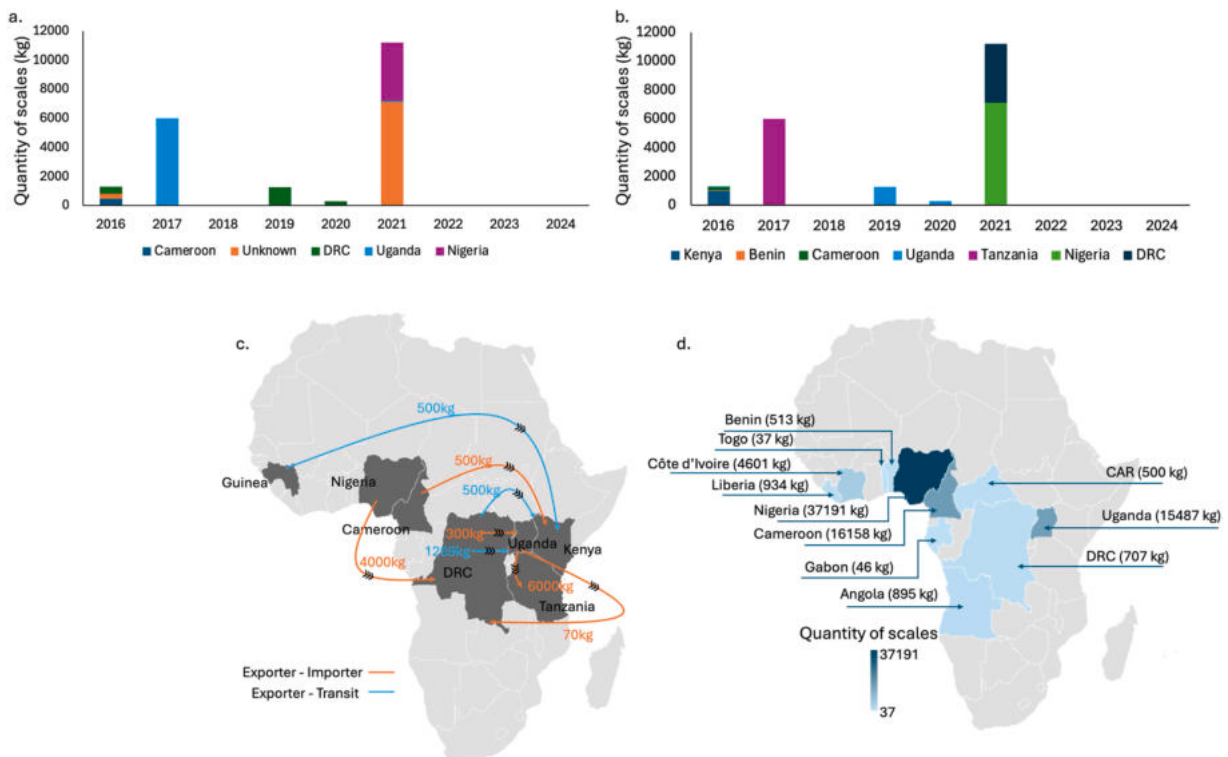


Fig. 2. Quantity of African pangolin scales a–c. exported and imported between African countries, and d. intercepted within each country.

3.3. Major intercontinental exporters and importers of pangolin scales

Only four African countries were identified as major exporters of scales intercontinentally, with Nigeria as the main exporter, followed by the DRC (Fig. 3a). China was the largest importer with 86,348 kg of scales, followed by Singapore (37,824 kg), and Vietnam (30,723 kg) (Fig. 3b). Notably, the quantity of both exports and imports peaked in 2019 before rapidly declining. Nigeria remained the sole exporter after 2019, and Vietnam became the primary importer of scales during this period (Fig. 3b). Scales exported from Nigeria during 2016 and 2024 were seized in China, Nepal, Vietnam, Singapore, and Malaysia (as importer and transit) (Fig. 3c). Ghana exported to China and Malaysia, while the DRC exported to Singapore, Malaysia, Vietnam, China, Turkey (transit), and Thailand (as importer and transit) (Fig. 3c).

4. Discussion

Due to the demand for pangolin scales in Asian markets, African pangolins are increasingly at risk of being trafficked to Asia (Tinsman et al., 2023). Given the trafficking risk of pangolins, the analysis of trade and seizure records is crucial for conservation efforts. Relying on media and pangolin organization reports, our records do not capture the full scope of intracontinental and intercontinental illegal seizure incidents or the quantities intercepted over the nine years. However, they do reveal trafficking patterns and hotspots that might otherwise go unnoticed. Understanding trade route dynamics is essential for developing targeted interventions to safeguard pangolin populations.

4.1. Intracontinental and intercontinental seizure of African pangolin scales over the period of nine years

Our study analyzed a total of 130 seizure incidents, totaling 287,272 kg of pangolin scales intercepted intra- and intercontinentally. While most seizures occurred in Africa, the largest volumes of scales were seized in intercontinental shipments. Compared to previous reports that used news reports, press releases, and agencies as their data source (e.g., WA BICC, 2020), some of the seizures in our data aligned with those previously documented in pangolin trade studies (Emogor et al., 2021; Ingram et al., 2019a; Omifolaji et al., 2020; Tinsman et al., 2023). Contrasting incidents were those that included shipments < 15 kg and other news reports not covered by our data source. However, our data also captured additional incidents not included in earlier reports and extends the available data, providing a more up-to-date perspective on pangolin scale trafficking trends. Notably, there were also overlaps in incidents between our data reports and reports from previous studies done in Africa (Emogor et al., 2021; Ingram et al., 2019a; Omifolaji et al., 2020; Tinsman et al., 2023; Yeo et al., 2024), supporting the authenticity and reliability of social media news and organization reports in

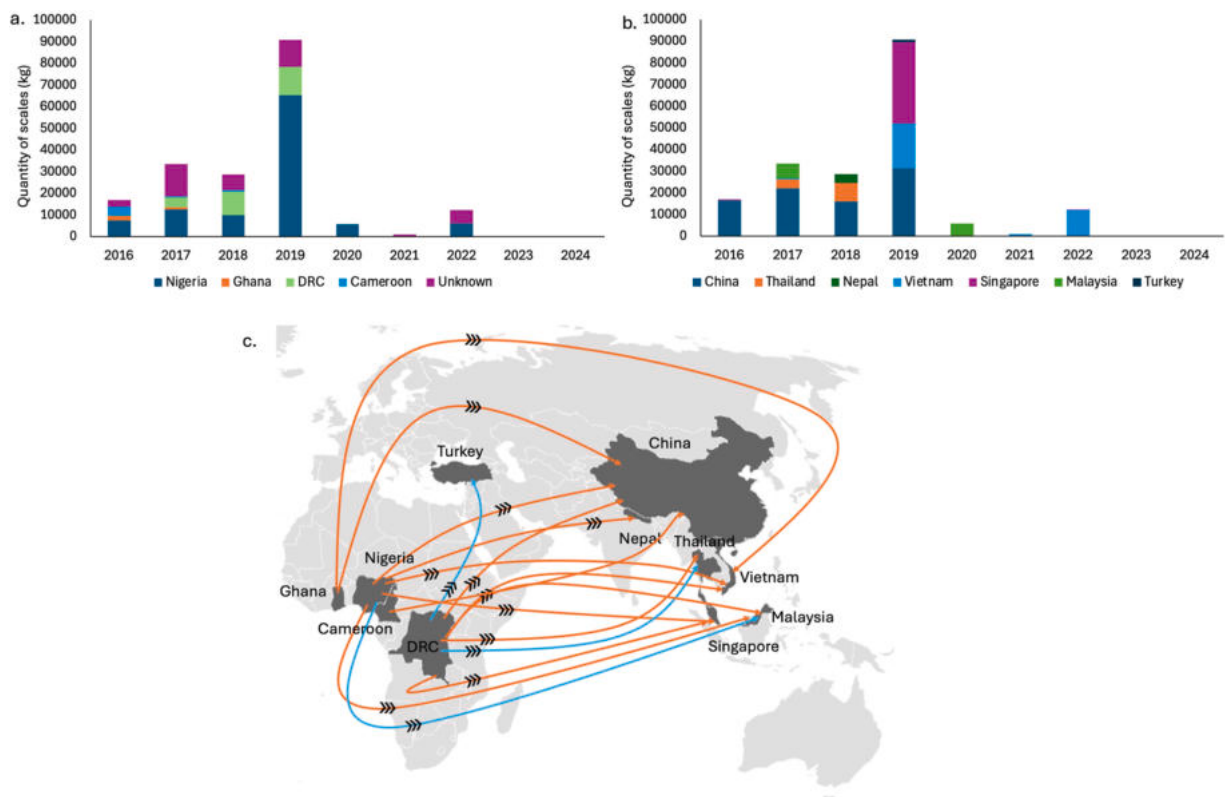


Fig. 3. Quantity of scales a. exported from African countries, b. imported into Asian countries, and c. the flow of intercontinental trafficking. Blue lines indicate export to transit countries, orange lines indicate export to import countries.

characterizing trade seizure trends. The media news data approach has been reported to provide valuable insights in characterizing the illegal trade of pangolins (Harrington et al., 2018; Omifolaji et al., 2022; Tinsman et al., 2023).

4.2. A negative correlation between seizure incidents, quantity of pangolin intercepted, and years reported

Our data indicate a general decline in both seizure incidents and the quantity of scales seized over the years, with the exception of 2019 which showed a sharp increase in both metrics. Albeit other differences in the quantity of scales, Omifolaji et al. (2020) reported a similar trend in seizure incidents and quantity of scales linked to Nigeria between 2018 and 2019. Similarly, Emogor et al. (2021) also found an increase in the number of pangolin seizures linked to Nigeria during the same period. The slight contrast in the trend may be expected given that our data went further than 2019. For example, when analyzing data from the same period as other studies, particularly Omifolaji et al. (2020), we observed a similar trend where the number of pangolin seizure incidents increased over the years (data not shown).

The incidents and quantity of scales intercepted dropped post 2019, in alignment with previous findings (Emogor et al., 2021; Tinsman et al., 2023). The post-2019 decrease may represent fewer reported cases from law enforcement agencies or officials due to lack of effort or resources such as a standardized and formalized database for pangolin seizures or other wildlife crime. Changes in trafficking routes over time may also lead to a drop in seizure incidents not reported, where crime networks have changed ports for moving scales. Increased corruption (EIA, 2020) may also result in the clearance of contraband, leading to many incidents not recorded as customs may turn a blind eye to concealing shipments. In other cases, customs may have low capacity for identifying pangolin scales, and there is also low technology for detecting wildlife products. Furthermore, the drop post-2019 may reflect awareness of pangolins' potential link to COVID-19, leading to more strict traveling bans and reduced demand. Similar trends have been observed in other wildlife trafficking cases such as ivory (EIA, 2022). This is because they are mostly seized in the same shipment, showing high convergence. Despite the overall decrease, countries such as Nigeria and Vietnam continued with illegal trafficking activities which may suggest onward operation of wildlife crime networks due to limited international cooperation between Africa and Asia (EIA, 2022).

4.3. Major exporters and importers of African pangolin scales between 2016 and 2024

Our study identified Nigeria as a major exporter of African pangolin scales to Asia, consistent with previous studies (Ingram et al.,

2019a; Omifolaji et al., 2020). However, genomic analyses by Tinsman et al. (2023) revealed that only 4.2 % of the scales reportedly from Nigeria originated there, indicating its role as a major transit rather than a primary source. This corroborates with findings that Nigeria has facilitated the movement of scales from other African countries to Asia since 2017 (Emogor et al., 2021; Omifolaji et al., 2020). The discrepancies between our dataset and genomic work may indicate misclassifications of Nigeria's role in the pangolin scale supply chain. Similar misclassifications may extend to other countries, leading to under- or overrepresenting roles of countries in the supply chain. Nigeria's prominence in the illegal pangolin trade may be attributed to its well-developed international travel infrastructure (Emogor et al., 2021; Ingram et al., 2019a) and established illicit trade routes for other species such as parrots (Psittacidae) and ivory (Elephantidae). Other incidents in our data have also identified transnational wildlife trafficking networks operating in Nigeria. Furthermore, Nigerian intermediaries collect scales from across African countries for Chinese buyers at Lagos airport, a known hotspot for illegal wildlife trafficking (Omifolaji et al., 2020).

The primary importers identified were China, Vietnam, and Singapore, aligning with earlier reports that 92 % of live pangolins seized between 2007 and 2015 were destined for China and Vietnam (UNODC, 2016). However, instead of being an origin, Singapore was recorded as a consistent transit for scales bound for Vietnam in most incidents, which may suggest organized crime behind illegal wildlife trade coming through this country. Similarly, other studies identified China and Vietnam as major destinations for African pangolin scales (Ingram et al., 2019a; Omifolaji et al., 2020). These results may be attributed to the demand for pangolin-based medicines, food, and a link to increased affluence (Nijman et al., 2016) in these countries, suggesting a need for targeted conservation efforts in these areas. Our findings also highlight intracontinental movement of scales, signifying stockpiling before intercontinental trafficking or supply to local markets. For example, in 2016, authorities intercepted 1000 kg of scales in Guinea and the DRC imported from Kenya, and en route to Laos and Thailand. Similarly, large-scale domestic seizures in our study may indicate onward transit activities that may be bound for other African or Asian countries, although available data lack destination details for other incidents. For example, intelligence linked a key Liberian suspect to a pangolin scales trafficking network in Nigeria, while another domestic incident involved the arrest of six Chinese suspects operating in Nigeria, suggesting possibilities of trafficking to Asia. Due to the missing information on other exporters "Unknown", some African countries that may be involved may not be mentioned at all in this study. Similar case could potentially apply for Asian countries as some, or all could be characterized as transit countries rather than final destination.

5. Conclusion and recommendations

This study analyzed social media reports of African pangolin scales intercepted between 2016 and 2024. We reported a decrease in interceptions post-2019 which may be linked to lack of law enforcement effort or resources, low capacity for identifying pangolin scales, change in routes of trafficking over time, and customs corruption. We acknowledge that during data collection, some incidents may have been missed due to factors such as language barriers in media reports or incidents that went undetected or unreported (Challender and Hywood, 2012; Ingram et al., 2018). Furthermore, there are limitations inherent in utilizing media-based and online datasets, which may have influenced our findings. A significant challenge lies in the frequent lack of details regarding the source, transit, or destinations of reported seizures. Some records report only one stage of the supply chain (i.e., source, transit, or destination), without contextual trade route information. Our dataset identifies Nigeria as a source country while Tinsman et al. (2023) characterized it as a transit, highlighting the potential for misclassification of which stage of the supply chain Nigeria is attributed. Such discrepancies may lead to the risk of underrepresenting, overrepresenting, or mischaracterizing the actual role of each country in the supply chain. Thus, the results only reflect the interception incidents that were found, and the actual number of scales intercepted is likely to be far greater. Similarly, the role of each country in the supply chain may be less or more. Although several seizures in our study reported arrests of traffickers, including key suspects connected to crime networks, further investigations that may lead to arrests of other members or detection of illicit shipments are lacking. Our results confirm that the demand for scales in Asia has created an illegal trade in African pangolins. While media-based data may complement law enforcement reports, integrating these two data could enhance monitoring efforts, providing a more comprehensive image of pangolin scale trafficking. We recommend a multidisciplinary study which includes (a) ongoing data mining of African pangolin trade seizures, (b) international collaboration to disrupt wildlife crimes, and (c) applying ecological and genetic tools for tracking the population status of African pangolins, and for precisely identifying the origins of intercepted scales.

CRedit authorship contribution statement

Catherine Maria Dzerefos: Methodology, Writing – review & editing. **Zwannda Nethavhani:** Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Raymond Jansen:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – review & editing.

Ethics

This study used publicly available secondary data from social media, Google news and organization reports. To ensure ethical compliance, no personally identified information was collected. Therefore, ethical approval was not required.

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Supporting information

Supplementary data can be found on a separate file ([Supplementary materials](#) file)

Conflict of Interest

The authors declare that they have no conflict of interest.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.gecco.2025.e03669](https://doi.org/10.1016/j.gecco.2025.e03669).

Data availability

Data will be made available on request.

References

- Boakye, M.K., Pietersen, D.W., Kotzé, A., Dalton, D.L., Jansen, R., 2015. Knowledge and uses of African pangolins as a source of traditional medicine in Ghana. *PLoS One* 10, 0117199. <https://doi.org/10.1371/journal.pone.0117199>.
- Challender, D.W.S., Harrop, S.R., MacMillan, D.C., 2015. Understanding markets to conserve trade-threatened species in CITES. *Biol. Conserv* 187, 249–259. <https://doi.org/10.1016/j.biocon.2015.04.015>.
- Challender, D.W.S., Hywood, L., 2012. African pangolins under increased pressure from poaching and intercontinental trade. *Traff. Bull.* vol. 24, pp. 53–5. (<https://bit.ly/3q9ZaD4>).
- EIA, 2020. Out of Africa: How West and Central Africa have become the epicentre of ivory and pangolin scale trafficking to Asia. (<https://reports.eia-international.org/out-of-africa/#:~:text=Large%20scale%20transportation%20of%20ivory%20and%20pangolin%20scales&text=Traffickers%20use%20buses%20or%20trucks,be%20smuggled%20into%20China%20overland>).
- EIA, 2022. Two Sides of the Same Coin: Tackling transnational wildlife trafficking between West and Central Africa and South-East Asia. (<https://eia-international.org/report/two-sides-of-the-same-coin-tackling-transnational-wildlife-trafficking-between-west-and-central-africa-and-south-east-asia/>).
- Emogor, C.A., Ingram, D.J., Coad, L., Worthington, T.A., Dunn, A., Imong, I., Balmford, A., 2021. The scale of Nigeria's involvement in the trans-national illegal pangolin trade: temporal and spatial patterns and the effectiveness of wildlife trade regulations. *Biol. Conserv.* 264, 109365. <https://doi.org/10.1016/j.biocon.2021.109365>.
- Gaudin, T.J., Emry, R.J., Wible, J.R., 2009. The phylogeny of living and extinct pangolins (mammalia, pholidota) and associated taxa: a morphology based analysis. *J. Mamm. Evol.* 16, 235–305. <https://doi.org/10.1007/s10914-009-9119-9>.
- Gu, T.T., Wu, H., Yang, F., Gaubert, P., Heighton, S.P., Fu, Y., Liu, K., Luo, S.J., Zhang, H.R., Hu, J.Y., Yu, L., 2023. Genomic analysis reveals a cryptic pangolin species. *Proc. Natl. Acad. Sci. USA* 120, 2304096120. <https://doi.org/10.1073/pnas.2304096120>.
- Harrington, L.A., D'Cruze, N., Macdonald, D.W., 2018. Rise to fame: events, media activity and public interest in pangolins and pangolin trade, 2005–2016. *Nat. Conserv.* 30, 107–133. <https://doi.org/10.3897/natureconservation.30.28651>.
- Heinrich, Sarah, 2017. The global trafficking of pangolins: a comprehensive summary of seizures and trafficking routes from 2010–2015. *Traffic*.
- Heinrich, S., Wittmann, T.A., Prowse, T.A.A., Ross, J.V., Delean, S., Shepherd, C.R., Cassey, P., 2016. Where did all the pangolins go? International CITES trade in pangolin species. *Glob. Ecol. Conserv.* 8, 241–253. <https://doi.org/10.1016/j.gecco.2016.09.007>.
- Hu, J., Roos, C., Lv, X., Kuang, W., Yu, L., 2020. Molecular genetics supports a potential fifth Asian Pangolin species (Mammalia, Pholidota, *Manis*). *Zool. Sci.* 37, 538–543. <https://doi.org/10.2108/zs200084>.
- Ingram, D.J., Coad, L., Abernethy, K.A., Maisels, F., Stokes, E.J., Bobo, K.S., Breuer, T., Gandiwa, E., Ghiurghi, A., Greengrass, E., Holmern, T., Kamgaing, T.O.W., Ndong Obiang, A.M., Poulsen, J.R., Schleicher, J., Nielsen, M.R., Solly, H., Vath, C.L., Waltert, M., Whitham, C.E.L., Wilkie, D.S., Scharlemann, J.P.W., 2018. Assessing Africa-wide Pangolin exploitation by scaling local data. *Conserv. Lett.* 11, e12389. <https://doi.org/10.1111/conl.12389>.
- Ingram, D.J., Cronin, D.T., Challender, D.W.S., Venditti, D.M., Gonder, M.K., 2019a. Characterising trafficking and trade of pangolins in the Gulf of Guinea. *Glob. Ecol. Conserv.* 17, 00576. <https://doi.org/10.1016/j.gecco.2019.e00576>.
- Ingram, D.J., Edwards, I.B., Kedzierska Manzon, A., 2022. Of meat and ritual: consumptive and religious uses of pangolins in Mali. *Afr. J. Ecol.* 60, 184–192. <https://doi.org/10.1111/aje.12945>.

- Ingram, D.J., Shirley, M.H., Pietersen, D., Godwill Ichu, I., Sodeinde, O., Moumbolou, C., Hoffmann, M., Gudehus, M., Challender, D., 2019b. *Phataginus tetradactyla*, Black-bellied Pangolin. The IUCN Red List of threatened species™. (<https://doi.org/10.2305/IUCN.UK.2019>).
- Malimbo, D.K., Nyumu, J.K., Vitekere, K., Mapoli, J., Visando, B., Mbumba, J., Tungaluna, G.C., Tarla, F., Hua, Y., 2020. Exploitation of Pangolins (Pholidota, Mammalia) by communities living in and around the Tayna Nature Reserve (RNT) North Kivu, Democratic Republic of Congo (DRC). *J. Geosci. Environ. Prot.* 08, 1–17. <https://doi.org/10.4236/gep.2020.84001>.
- Nguyen, L.B., Fossung, E.E., Affana Nkoa, C., Humle, T., 2021. Understanding consumer demand for bushmeat in urban centers of Cameroon with a focus on pangolin species. *Conserv. Sci. Pract.* 3, e419. <https://doi.org/10.1111/csp2.419>.
- Nijman, V., 2023. Effect of CITES Appendix I listing on illegal pangolin trade as gauged from seizure reports in Indonesia. *Eur. J. Wildl. Res.* 69, 105. <https://doi.org/10.1007/s10344-023-01736-5>.
- Nijman, V., Zhang, M.X., Shepherd, C.R., 2016. Pangolin trade in the Mong La wildlife market and the role of Myanmar in the smuggling of pangolins into China. *Glob. Ecol. Conserv.* 5, 118–126. <https://doi.org/10.1016/j.gecco.2015.12.003>.
- Nixon, S., Pietersen, D., Challender, D., Hoffmann, M., Godwill Ichu, I., Bruce, T., Ingram, D.J., Matthews, N., Shirley, M.H., 2019. *Smutsia gigantea*, Giant Ground Pangolin. The IUCN Red List of threatened species. (<https://doi.org/10.2305/IUCN.UK.2019>).
- Omifolaji, J.K., Hughes, A.C., Ibrahim, A.S., Zhou, J., Zhang, S., Ikyaagba, E.T., Luan, X., 2022. Dissecting the illegal pangolin trade in China: An insight from seizures data reports. *Nat. Conserv.* 46, 17–38. <https://doi.org/10.3897/natureconservation.45.57962>.
- Omifolaji, J.K., Ikyaagba, E.T., Jimoh, S.O., Ibrahim, A.S., Ahmad, S., Luan, X., 2020. The emergence of Nigeria as a staging ground in the illegal pangolin exportation to South East Asia. *Forensic Sci. Int.: Rep.* 2, 100138. <https://doi.org/10.1016/j.fsir.2020.100138>.
- Pebesma, E., 2018. Simple features for R: standardized support for spatial vector data. *R J.* 10, 439–446. <https://doi.org/10.32614/RJ-2018-009>.
- Pietersen, D., Jansen, R., Connolly, E., 2019a. *Smutsia temminckii*, Temminck's Pangolin. The IUCN Red List of threatened species™. (<https://doi.org/10.2305/IUCN.UK.2019>).
- Pietersen, D., Moumbolou, C., Ingram, D.J., Soewu, D., Jansen, R., Sodeinde, O., Keboy Mov Linkey Iflankoy, C., Challender, D., Shirley, M.H., 2019b. *Phataginus tricuspidis*, White-bellied Pangolin. The IUCN Red List of threatened species™. (<https://doi.org/10.2305/IUCN.UK.2019>).
- R Core Team, 2024. R: A Language and Environment for Statistical Computing. Vienna, Austria. (<https://www.R-project.org/>).
- Svensson, M., Bersacola, E., Bearder, S., 2013. Pangolins in Angolan bushmeat markets. *IUCN SSC Pangolin Specialist Group*. (<http://www.pangolinsg.org/news>).
- Tinsman, J.C., Gruppi, C., Bossu, C.M., Prigge, T.L., Harrigan, R.J., Zaunbrecher, V., Koepfli, K.P., LeBreton, M., Njabo, K., Wenda, C., Xing, S., Abernethy, K., Ades, G., Akeredolu, E., Andrew, I.B., Barrett, T.A., Bernáthová, I., Bolfíková, B., Diffo, J.L., Fopa, G.D., Ebong, L.E., Godwill, I., Pambo, A.F.K., Labuschagne, K., Mbekem, J.N., Momboua, B.R., Mousset Moumbolou, C.L., Ntie, S., Rose-Jeffreys, E., Simo, F.T., Sundar, K., Swiacká, M., Takuo, J.M., Talla, V.N.K., Tamoufe, U., Dingle, C., Ruegg, K., Bonebrake, T.C., Smith, T.B., 2023. Genomic analyses reveal poaching hotspots and illegal trade in pangolins from Africa to Asia. *Science* 382, 1282–1287. <https://doi.org/10.1126/science.adi5066>.
- UNODC, 2016. World Wildlife Crime Report Trafficking in Protected Species. Vienna, Austria.
- WA BICC, 2020. Scoping study for pangolin conservation in West Africa. (https://pdf.usaid.gov/pdf_docs/PA00X9WW.pdf).
- Wickham, H., 2016. *Elegant Graphics for Data Analysis*. Springer-Verlag, New York. (<https://ggplot2.tidyverse.org>).
- Xu, L., Guan, J., Lau, W., Xiao, Y., 2016. An overview of Pangolin trade in China. *TRAFFIC Briefing Paper*. (<https://www.traffic.org/site/assets/files/10569/pangolin-trade-in-china.pdf>).
- Yeo, D., Chan, A.H.J., Hiong, K.C., Ong, J., Ng, J.Y., Lim, J.M., Zhang, W., Lim, S.R., Fernandez, C.J., Wong, A.M.S., Lee, B.P.Y.H., Khoo, M.D.Y., Cheng, T.X.W., Lim, B.T.M., Yeo, H.H.T., Tan, M.M.Q., Sng, W.B.G., Adam, S.S., Ang, W.F., How, C.B., Xie, R., Wasser, S.K., Finch, K.N., Loo, A.H.B., Yap, H.H., Leong, C.C., Er, K. B.H., 2024. Uncovering the magnitude of African pangolin poaching with extensive nanopore DNA genotyping of seized scales. *Conserv. Biol.* 38, 14162. <https://doi.org/10.1111/cobi.14162>.
- Zhang, H., Miller, M.P., Yang, F., Chan, H.K., Gaubert, P., Ades, G., Fischer, G.A., 2015. Molecular tracing of confiscated pangolin scales for conservation and illegal trade monitoring in Southeast Asia. *Glob. Ecol. Conserv.* 4, 414–422. <https://doi.org/10.1016/j.gecco.2015.08.002>.
- Zhang, F., Wu, S., Cen, P., 2022. The past, present and future of the pangolin in Mainland China. *Glob. Ecol. Conserv.* 33, 01995. <https://doi.org/10.1016/j.gecco.2021.e01995>.