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LETTER

Evaluating the relationships between the legal and illegal international wildlife trades

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Abstract

The international legal trade in wildlife can provide economic and other benefits, but when unsustainable can be a driver of population declines. This impact is magnified by the additional burden of illegal trade, yet how it covaries with legal trade remains little explored. We combined law-enforcement time-series of seizures of wildlife goods imported into the United States (US) and the European Union (EU) with data on reported legal trade to evaluate the evidence for any relationships. Our analysis examined 28 US and 20 EU products derived from CITES-listed species with high volume and frequency of both reported trade and seizures. On average, seizures added 28% and 9% to US and EU reported legal trade levels respectively, and in several cases exceeded legal imports. We detected a significant but weak overall positive relationship between seizure volumes and reported trade into the US over time, but not into the EU. These results highlight the importance of maintaining long-term records of border seizures and enforcement effort, and accounting for illegal trade where possible in non-detriment findings. Our findings suggest a complex and nuanced temporal association between the illegal and legal wildlife trades.

KEYWORDS

CITES, EU-TWIX, LEMIS, seizures, sustainable trade, wildlife crime, wildlife trade

1 | INTRODUCTION

The international trade in wildlife is a long-standing activity (Jenkins & Broad, 1994) with the potential for economic and other benefits. However, recognizing that unsustainable trade can negatively impact source populations, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) entered into force in 1975 as a global policy mechanism to ensure sustainability. Over 35,000 species are listed in CITES, in one of three Appendices with

differing trade implications. The collation of CITES permits into the CITES Trade Database has enabled an overview of the legal wildlife trade at global (Harfoot et al., 2018) and regional (Outhwaite & Brown, 2018; Sinovas et al., 2016, 2017) scales, as well as specific studies on individual taxa (Wu, 2016).

Knowledge of the illegal wildlife trade remains much more limited due to its covert nature. Distinct markets for the trafficking of specific wildlife products have been identified (UNODC, 2016), and aspects of illegal trade examined (Beastall, Bouhuys, & Ezekiel, 2016). However, broader relationships between the legal and illegal wildlife trades remain ill-defined. Analyses of seizures across multiple taxa are limited but include individual case studies (UNODC, 2016), taxa and products seized at US and EU ports of entry (Olsen et al., 2019; Petrossian, Pires, & van Uhm, 2016; van Uhm, Pires, Sosnowski, & Petrossian, 2019), a summary of twelve years of seizure records (Rosen & Smith, 2010), and two reviews of illegal wildlife trade into the EU (Mundy-Taylor, 2013; van Uhm, 2016). Comparisons of legal trade to seizures also remain rare, but include analyses of reptiles from Indonesia (Lyons & Natusch, 2011; Nijman & Shepherd, 2010) and an overview of Southeast Asian wildlife trade (Nijman, 2010). Notably, none of these studies explore the nature and significance of the temporal relationship—positive, negative, or uncorrelated—between seizure rates and legal trade flows.

Here we analyze seizures of CITES-listed taxon-products by law-enforcement agencies in the United States and European Union and evaluate their association with reported legal trade volumes. A "taxon-product" represents a taxon (typically species) and product(s) that are traded equivalently in a destination market (for example, leather goods from *Caiman crocodilus* and subspecies). As trends in seizures may reflect variation in enforcement as well as illegal trade (Underwood, Burn, & Milliken, 2013), we included covariates representing enforcement effort. We focused on taxon-products with high volumes and frequencies of reported trade and seizures. Seizure volumes represent an "on-the-ground" measure of contraband goods interceptions. The majority of seizures, at least at the US border, are for imports (Petrossian et al., 2016), so we focus on these rather than exports.

Our study had three main objectives. First, we compare relative volumes of legal trade and seizures for products entering the US and the EU. This provides a "minimum estimate" of illegal trade and how it compares to the legal trade in these jurisdictions. Second, we test for statistically significant associations over time, whether positive or negative, between legal trade and seizure volumes. Third, we assess the utility of these data to inform species conservation and policy responses.

2 | METHODS

2.1 | Data sources and extraction

Importer-reported wildlife trade data from three sources were combined for this analysis: the CITES Trade Database (trade.cites.org) for the reported legal trade, the Law Enforcement Management Information System (LEMIS) for US seizures, and the EU Trade in Wildlife Information Exchange (EU-TWIX) database for EU seizures. While LEMIS constitutes a separate database, most data are also reported to the CITES Trade Database, which here we used directly. Seizures primarily reflect interdictions at international borders.

Legal trade volumes of CITES-listed taxa were extracted from importer-reported records in the CITES Trade Database for the United States and EU from 1975 to 2014. Source code "I" ("confiscated or seized") records were excluded to ensure only trade reported as legal remained. The final year (2014) was selected to ensure high record completeness across all databases. We analyzed records from all sources of trade and for all purposes, aggregated across exporting countries. To ensure consistency with EU-TWIX, EU records were filtered to exclude those involving trade between Member States (i.e., analysis was of trade entering the EU from outside its borders).

US seizure volumes were records where the importing Party was the United States and the source code "I," representing seizure records from LEMIS. Data were extracted for the same period as the reported trade, though with LEMIS becoming operational in 1983 most time-series began later. For EU seizures we analyzed from 2005 to 2014, the longest period with relatively complete seizure information in the EU-TWIX database at the time of analysis. Data were standardized to CITES standard nomenclature.

Records were aggregated to unique taxon (species or subspecies), product and unit combinations ("taxon-products") to yield comparable time-series of reported legal trade and seizure volumes. As our focus was on testing for consistency of relationships, we analyzed taxon-products which were frequently interdicted, had legal trade across multiple years, and for which trade and seizure volumes were both relatively high; see Appendix S1 for full details.

We removed products for which the number or amount of wildlife could not be ascertained (medicines, powder, waxes, and derivatives). Most plants were traded as medicines or other derivatives, and/or only identified to family level, hence were omitted from the analysis. Species transferred between CITES Appendices during the analysis period were excluded, to prevent confounding effects. Split-listed taxa (populations on both Appendix I and II) and subspecies on a different Appendix to their parent were similarly excluded; thus some iconic species such as African elephant (*Loxodonta africana*)

were not included. One exception was caviar (from *Acipenseriformes*), which was retained given the product importance and interchangeability.

Following this processes, we were left with 28 time-series for the US and 20 for the EU. Whilst our stringent criteria meant that some high-profile or focal CITES-listed taxa were not retained, they ensured that the time-series we analyzed represented taxon-products identified to species level with relatively high volumes (totals) and frequencies (years of data) of both trade and seizures that were equivalent between databases.

2.2 | Modeling approach for relating reported trade to law enforcement seizures

We used hierarchical Bayesian modeling to assess the relationship between seizures and reported legal trade volumes, with a unique slope parameter for each taxon-product. We considered a slope parameter (representing the change in illegal seizures with legal trade) as statistically significant if its 95% posterior probability interval did not contain zero. A significant positive slope implied that as legal trade increased seizures volumes also increased. If the slope estimate was significantly negative, it implied the opposite (a decrease in seizure volumes when legal trade increased). Finally, if the slope estimate was not significantly different from zero, there was no evidence for a relationship; this was our null expectation. We compared these slope values across taxon-products, destination markets, CITES Appendices, and taxonomic groups.

To account for variation in enforcement effort, we included the total number of seizures across all taxon-products in each year in the US or the EU as a covariate. While seizures of specific individual taxon-products may fluctuate, the total number of seizures is more likely to reflect enforcement effort than total illegal volume. Thus, we assume that this proxy reflects on the ground enforcement effort reasonably well. We checked this assumption in the United States through comparing results to an alternative (but shorter) proxy of the total number of containers inspected each year. We also accounted for differences between EU Member States in seizure reporting rates to CITES with an additional covariate (Table S2).

All models were fitted in a Bayesian modeling framework using a Hamiltonian Monte Carlo approach (Stan Development Team, 2015). See Appendix S1 for full details.

3 | RESULTS

Figure 1 shows example time-series for importer-reported legal trade and law-enforcement seizure volumes. Full time-series are displayed in Figures S1 and S2.

3.1 | Relationship between seizure volumes and reported legal trade volumes

The ratios of total reported legal trade to seizure volumes are shown in Figure 2 (the United States) and Figure 3 (the European Union). There was wide variability across taxon-products, from seizures adding almost no additional volume, to being equivalent to or even exceeding legally traded items. In the US, the mean ratio of seizures to reported trade was 0.28 (i.e., seizures added, on average, around 28% to the volume of reported legal trade). CITES Appendix I listed species generally had higher ratios, potentially because legal trade is permitted only in exceptional circumstances (e.g., for scientific purposes). In the EU, the mean ratio was around 0.09 (i.e., seizures added almost 10% to reported trade). However, for some EU taxon-products it was substantially higher: for instance, seizures of Appendix II listed *Tridacna maxima* shells were close to the total reported legal trade volume (Figure 3).

3.2 | Association between trends in legal trade and seizure volumes over time

The meta-analytic median indicated a significant and positive relationship between reported legal trade and seizure volumes across all taxon-products in the United States (Figure 4). Furthermore, 5 of 28 (18%) individual taxon-products showed a significant positive relationship. In the EU, none of the 20 taxon-product combinations nor the meta-analytic median showed a significant relationship (Figure 5). The variance accounted for was in general fairly low (Figures S1 and S2) in both destination markets. There were no significant differences in meta-analytic posterior slope estimates between taxonomic groups, product types, and CITES Appendices.

Using an alternative proxy for enforcement effort in the United States to test robustness (Figure S3) gave broadly similar patterns, though while the meta-analytic median was still positive it was non-significant, and individual time-series showed differences. This may be due to shorter time-series for the alternative effort proxy, as shortening the original effort time-series to the same time-period also resulted in a non-significant outcome (Figure S4).

4 | DISCUSSION

4.1 | Relationship between seizure volumes and reported legal trade volumes

Seizures represent an absolute lower bound on the level of illegal trade activity. Even so, the relative volume of seizures to reported legal trade was substantial (0.28 for the United States and 0.09 for the EU). Differences between US and EU

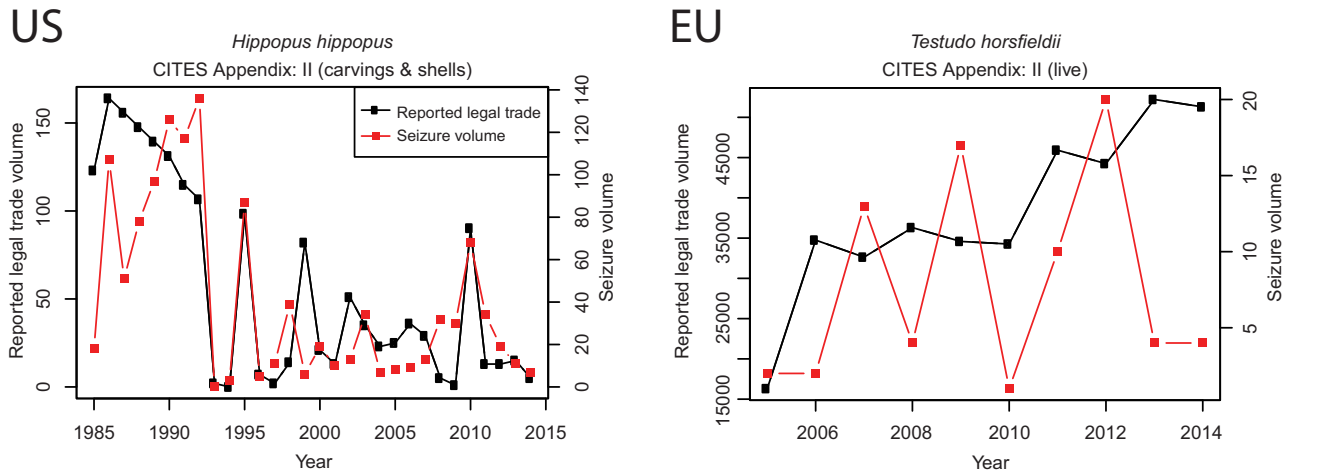

FIGURE 1 Example time-series plots for US and EU reported legal trade and law-enforcement seizure volumes of CITES-listed wildlife products. Black squares and lines represent reported trade volumes, and red squares and lines seizure volumes. Data have been processed using a robust statistics approach as described in the Methods. CITES data are importer-reported and include trade from all sources except source "I" (confiscated or seized). For full time-series and model fits see Figures S1 and S2

destination markets may be due to longer US time-series, differences in taxon-products analyzed, or variation in enforcement targeting and effort.

Our analysis highlights taxa for which the relative volume of seized products was very high, and in some cases higher than the legally reported trade (Figures 2 and 3). Export of Appendix I and II taxa requires a "non-detriment finding" (NDF) to ensure that trade is sustainable and not detrimental to species survival in the wild. Scientific Authorities should "consider the volume of legal and illegal trade" as part of their NDF (CITES Resolution Conf. 16.7 Rev. CoP17). Assessing relative volumes of legal trade and seizures can help prioritize species where illegal trade may constitute a significant proportion of overall volume. However, unless deriving from a single population, it may be challenging to translate from seizures (potentially from multiple populations/countries) to the harvest of individual populations. Furthermore, different specimen parts can enter the illegal trade as separate products (such as meat, claws, skulls/trophies), so it is not as straightforward as simply summing seized specimens to assess impact on wild populations.

4.2 | Association between trends in legal trade and seizure volumes over time

The analysis of relationships between reported legal and seized wildlife goods suggests a complex and nuanced picture (Figures 4 and 5). The US data showed an overall significant positive relationship, as did almost 20% of individual taxon-products. There were no significant positive associations for the EU, and no significant negative associations in either market. We note that EU time-series (10 years) were short compared to US time-series (up to ~30 years), and therefore less able to detect long-term trends.

However, in general it appears that there may be a weakly positive relationship (though not necessarily causality) between reported legal trade and seizures for the United States, but with high variability among taxon-products. This could be due to multiple factors. An increase in legal trade for a specific taxon-product could lead to greater awareness among authorities, and increased enforcement effort or ability to identify illegal specimens. Administrative errors resulting in seizures may also increase as legal volume increases. Some taxon-products are traded as personal items and due to lack of awareness may have been transported without necessary paperwork. Increased legal trade may also lead to increased illegal trade if demand cannot be met (conversely, increased legal trade could provide an adequate supply, reducing the need for illegally sourced products). Finally, there may be noncasual but correlated factors; for example, more direct flights between the United States and source countries over a multidecadal span may have increased the potential for trade.

4.3 | Policy, management, and conservation implications

The policy and wildlife management/conservation implications of this study are at least threefold. First, the volume of additional trade that seizures represent over and above reported trade (Figures 2 and 3) implies that these data, notwithstanding the scaling difficulties outlined above, should be considered when estimating impacts of trade and deciding permissible trade levels (see also Lyons & Natusch, 2011; Nijman, 2010; Nijman & Shepherd, 2010). We identified specific taxa for which seizures imply a much greater

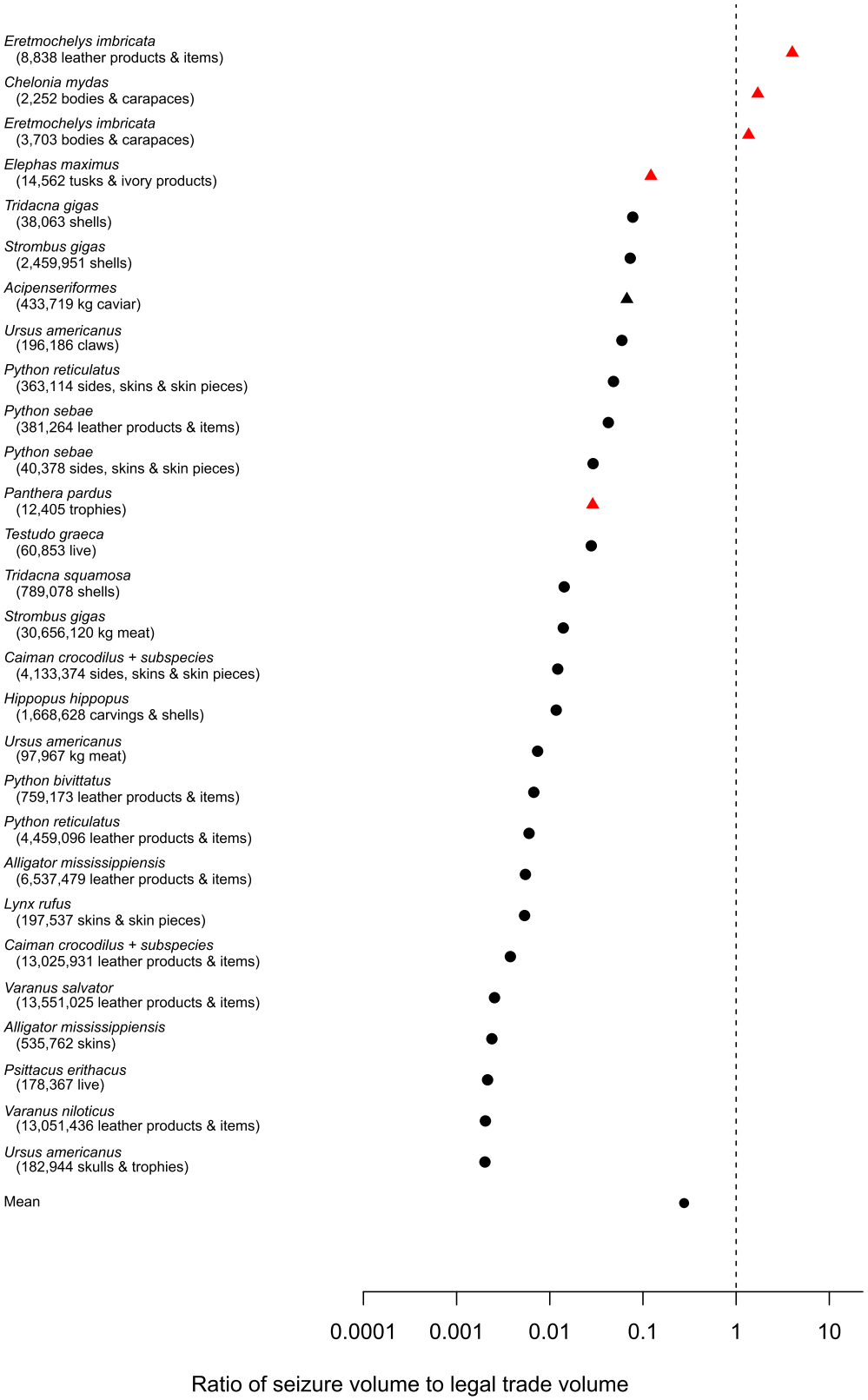

FIGURE 2 Relative ratios of seizures to importer-reported legal CITES trade (from all sources) for the United States, summed over the period of analysis (typically 1980s to 2014). Symbols indicate the ratio of seizure volumes to reported trade volumes (in terms of numbers or kilograms of products).Vertical dotted line indicates a 1:1 ratio at which the number or weight of seized goods would be equivalent to the total reported legal trade during this period. Red triangles indicate CITES Appendix I taxa; black circles indicate Appendix II taxa. Numbers in brackets indicate the summed number/weight of both reported and seized goods for each taxon-product. Note that Acipenseriformes includes one Appendix I and two Appendix II species. Taxon-products ordered by relative ratio, from largest (top) to smallest (bottom)

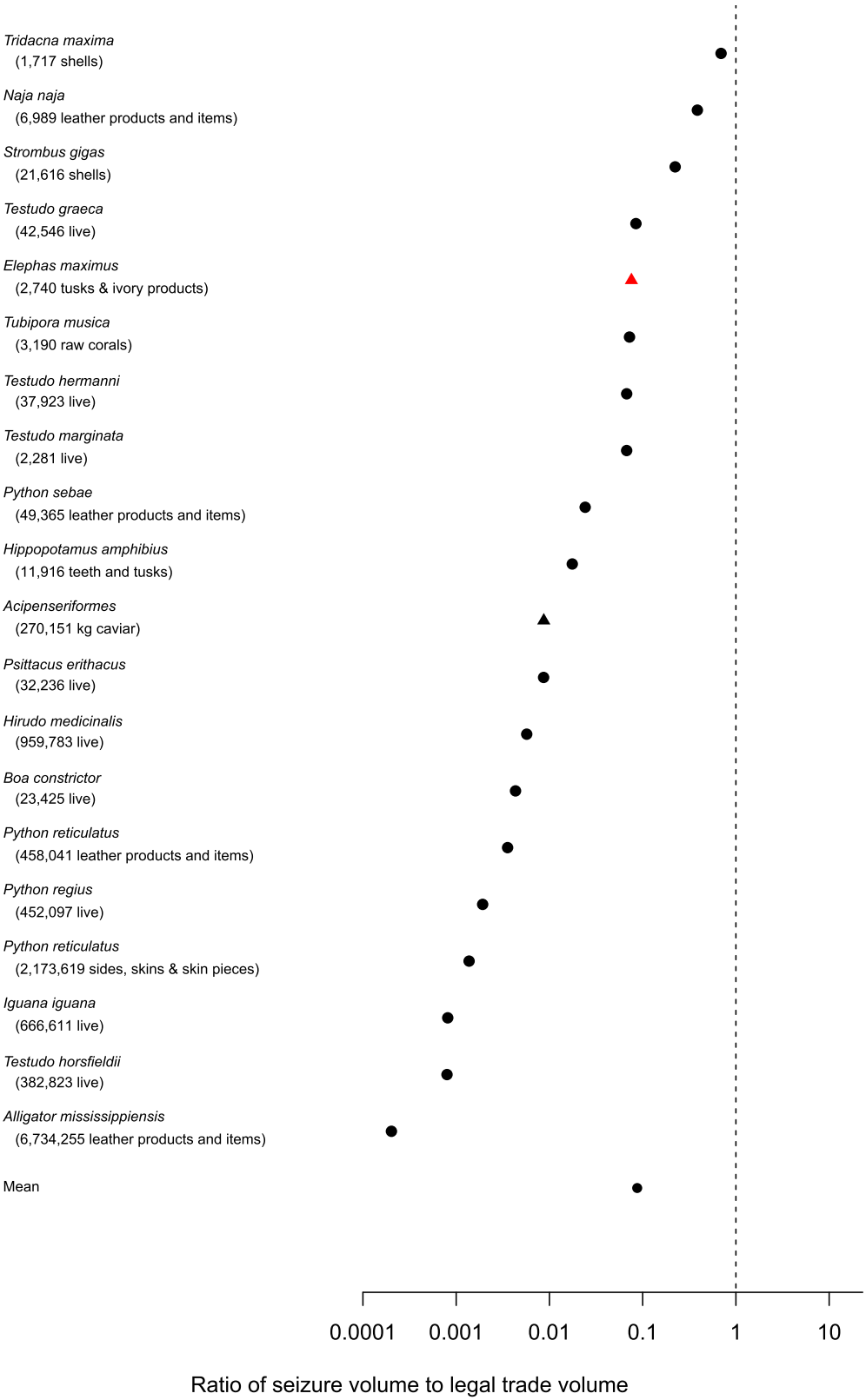

FIGURE 3 Relative ratios of seizures to importer-reported legal CITES trade (from all sources) for the EU, summed over the period of analysis (2005 to 2014). Symbols indicate the ratio of seizure volumes to reported trade volumes (in terms of numbers or kilograms of products). Vertical dotted line indicates a 1:1 ratio at which the number or weight of seized goods would be equivalent to the total reported legal trade during this period. Red triangles indicate CITES Appendix I taxa; black circles indicate Appendix II taxa. Numbers in brackets indicate the summed number/weight of both reported and seized goods for each taxon-product. Note that Acipenseriformes (black triangle) includes one Appendix I and two Appendix II species. Taxon-products ordered by relative ratio, from largest (top) to smallest (bottom)

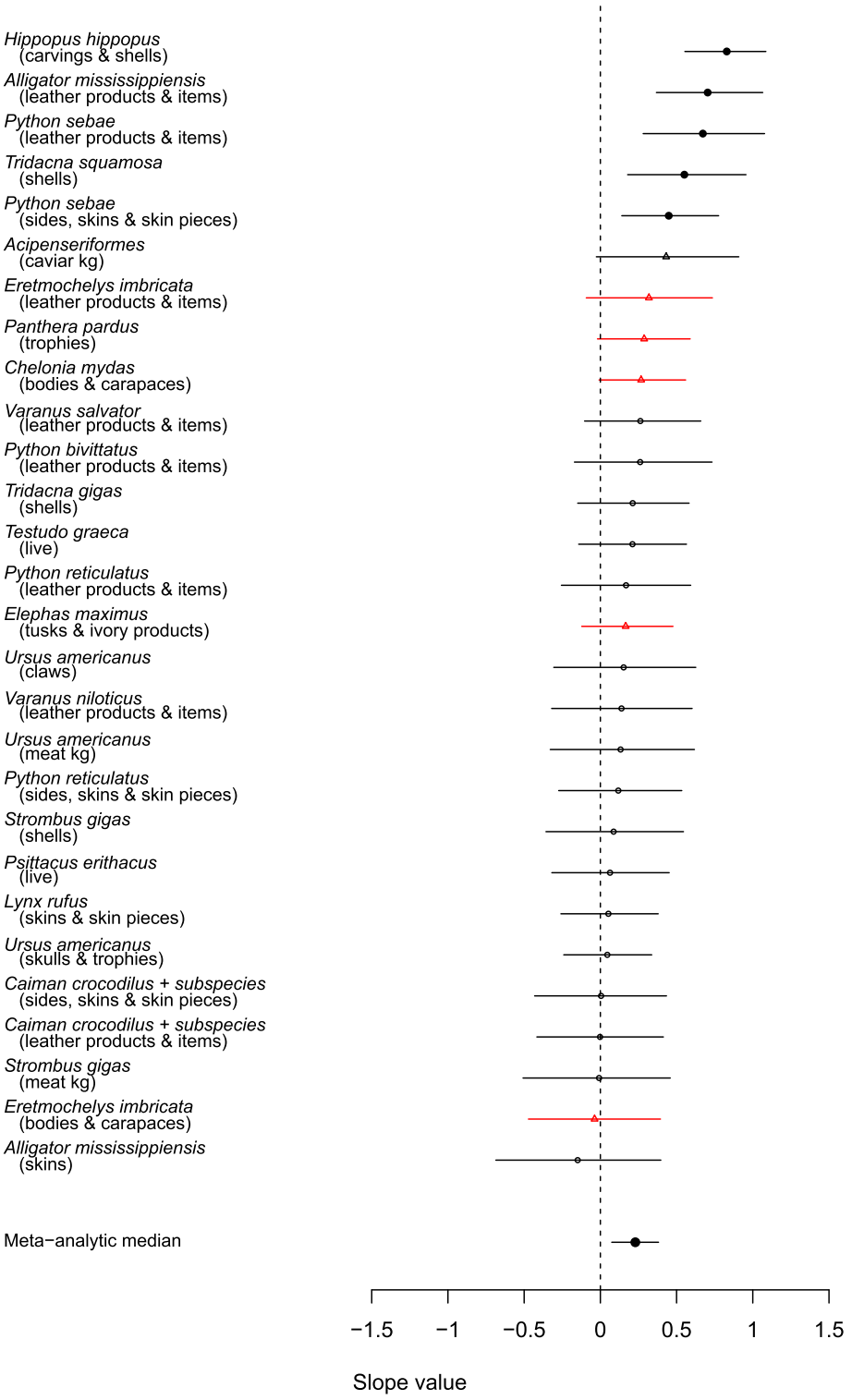

FIGURE 4 Strength of the temporal relationship between importer-reported legal trade volumes and seizure volumes for taxon-products entering the United States (time-series typically spanning early 1980s to 2014). A positive slope value indicates a positive relationship between reported trade and seizure volumes, while a negative value indicates an inverse relationship. Symbols indicate posterior Bayesian median model estimates, while lines indicate 95% credible intervals. Values represent slope parameters from a hierarchical Bayesian regression model that uses reported trade as a predictor of seizure volume (with units of increase in seizures per unit change in legal trade). The meta-analytic median represents the overall hierarchical slope parameter value. Red triangles indicate CITES Appendix I species; all other species CITES Appendix II during the analysis period. Note that Acipenseriformes (black triangle) includes one Appendix I and two Appendix II species. Taxa ordered by effect size

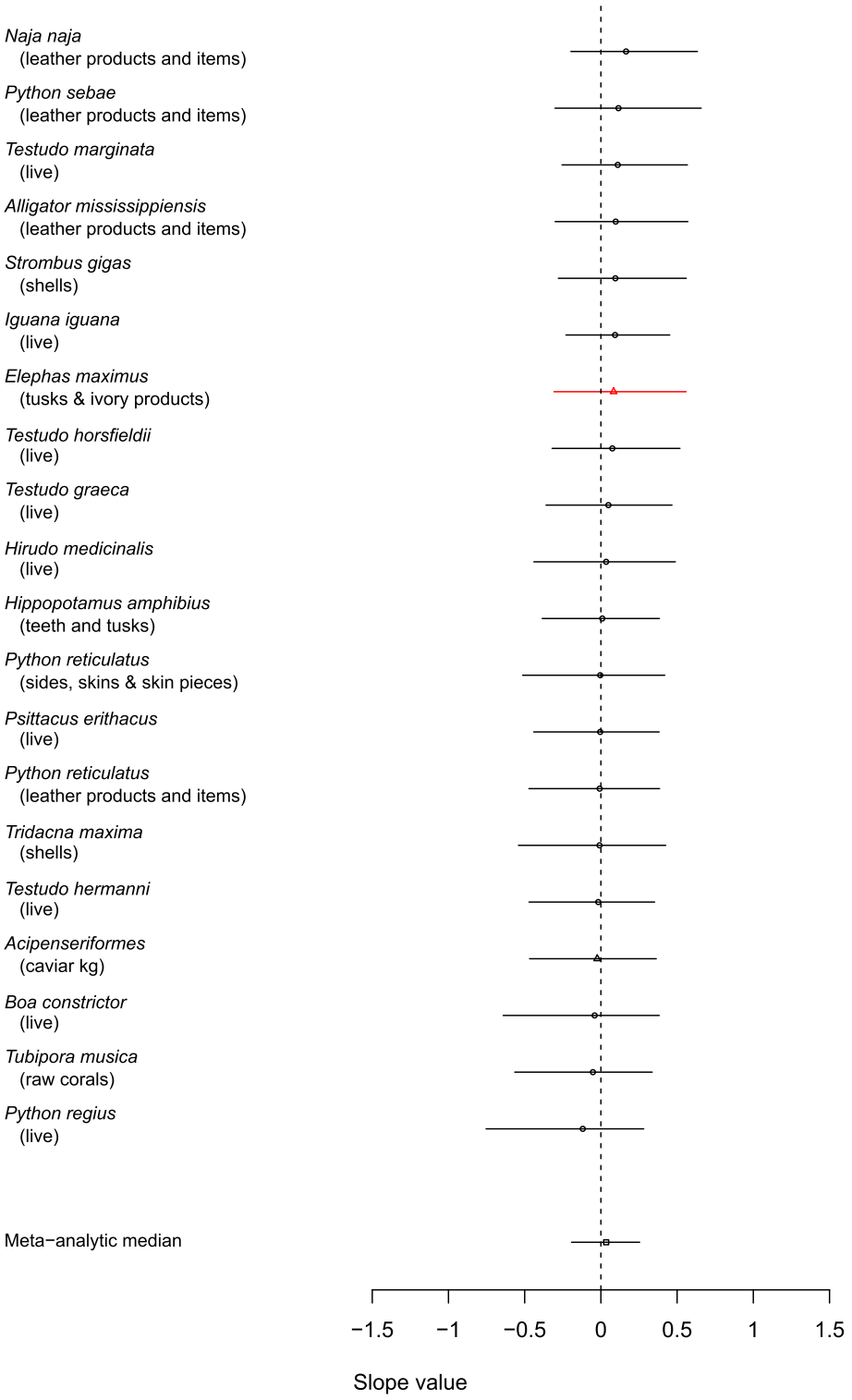

FIGURE 5 Strength of the temporal relationship between the importer-reported legal trade volumes and seizure volumes for taxon-products entering the European Union (2005 to 2014). A positive slope value indicates a positive relationship between reported trade and seizure volumes, while a negative value indicates an inverse relationship. Symbols indicate posterior Bayesian median model estimates, while lines indicate 95% credible intervals. Values represent slope parameters from a hierarchical Bayesian regression model that uses reported trade as a predictor of seizure volume (with units of increase in seizures per unit change in legal trade). The meta-analytic median represents the overall hierarchical slope parameter value. Red triangles indicate CITES Appendix I species; all other species CITES Appendix II during the analysis period. Note that Acipenseriformes (black triangle) includes one Appendix I and two Appendix II species. Taxa ordered by effect size

trade volume than apparent from legal trade alone, suggesting impacts may be underestimated. Ensuring that timely information on seizures is communicated to source countries may assist in the determination of NDFs and impact assessments (Nijman, 2010). Furthermore, trends in the ratios of reported legal trade to seizure volumes provide a "lower bound" on the proportion of traded wildlife that is illicit, and could potentially provide indicators for the UN Sustainable Development Goals (SDG Indicator 15.7.1) and the CBD post-2020 biodiversity framework (CBD, 2020).

Second, there were specific taxon-products for which significant positive relationships between reported legal trade volumes and seizure volumes were detected (Figure 4), and an overall significant but weakly positive relationship across all taxon-products in the United States. Analysis of additional variables that may influence outcomes (e.g., countries involved in trade, value and detectability of commodities) may help unpick the processes leading to observed relationships. Careful analysis of specific taxon-products (e.g., UNODC, 2016) are helpful, though only meta-analyses can detect broader trends. Further exploration of additional taxa and importing countries would also be warranted.

Third, collecting and centralizing data on seizures, enforcement effort, reported legal trade, and reporting effort is essential for understanding relationships between the legal and illegal wildlife trades. Since 2017, CITES Parties have been urged to report on illegal trade (Rev. CoP17), which may add additional understanding. Identifying and centralizing effective enforcement effort proxies, maintaining and extending current time-series, and locating seizure data for more target markets will also provide a more complete picture of the global wildlife trade.

4.4 | Assumptions and caveats

The existence of a statistical association between reported legal trade and seizure volumes is not necessarily indicative of a causal relationship between the legal and illegal wildlife trades. Variation in seizures of specific taxon-products can be due to many factors (including unmeasured), though we have adjusted for biases in enforcement and reporting effort.

In addition, an evolving policy and interdiction environment can impact enforcement effort and targeting. For example, EU import restrictions for birds since 2005 could have caused a change in dynamics (though our EU analysis only began in 2005). The EU also has import restrictions for specific species-country combinations. For example, imports of wild *Testudo horsfieldi* from Tajikistan were suspended from 2005 to 2008. However, we examined trends over time across all exporters and minimized the impacts of policy decisions and changes in listing status by only analyzing taxon-products which remained in the same CITES Appendix and EU Annex.

We also note that our analysis only extends to taxon-products with relatively high seizure and reported trade volumes, and identification to species level. Patterns and relationships may vary for other taxa, products, or destination markets. The criteria used to retain records meant that data demands were high.

Finally, criminologists have long recognized the challenges of using official crime statistics to estimate the "dark figure" of unrecorded crimes, as well as the social construction and definitional contingency of such statistics (Coleman & Moynihan, 1996). The true relationship between observed and unobserved wildlife crime will always remain somewhat obscured. Triangulating the complex and dynamic nature of the relationship using multiple data sources and analyses will lead to a more thorough understanding of underlying patterns.

5 | CONCLUSIONS

Our analysis of trade into the United States and the European Union identified taxon-products for which seizures represented a substantial, and in some cases a majority, of trade volume. This highlights the importance of accounting for known illegal trade (i.e., seizures), where feasible, as a "lower bound" on overall trade volume when making non-detriment findings.

In the United States, there was a significant positive overall relationship between legal trade and seizure volumes over time, though highly variable among taxon products. We did not detect a general pattern in the EU. Our findings suggest that for some markets and taxon-products there may be a weakly positive association, though it remains complex and merits further evaluation. We have also identified the critical importance of standardized long-term monitoring data, including on enforcement effort, to enable assessments of legal and illegal wildlife flows around the globe.

Our analysis reinforces the complexities of the relationship between the legal and illegal wildlife trades and provides a starting point to further explore the nuances of specific taxa, products, enforcement environments, and destination markets. Illegal wildlife trade is a global challenge that can have profoundly deleterious consequences but remains enormously difficult to quantify. Long-term datasets and analyses on border seizures of wildlife products and their relationship to reported trade may help to shed light on the scale, trends, and threat of this largely covert activity.

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DATA ACCESSIBILITY STATEMENT

All aggregated time-series and code for their analysis are available at https://github.com/derekt.

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REFERENCES

Beastall, C. A., Bouhuys, J., & Ezekiel, A. (2016). *Apes in demand: For zoo and wildlife attractions in Peninsular Malaysia and Thailand*. Selangor, Malaysia: Petaling Jaya.

CBD. (2020). *CBD/WG2020/2/3/Add.1*. Montreal, Canada.

Coleman, C., & Moynihan, J. (1996). *Understanding crime data: Haunted by the dark figure*. Buckingham, UK: Open University Press.

Harfoot, M., Glaser, S. A. M., Tittensor, D. P., Britten, G. L., Malsch, K., & Burgess, N. D. (2018). Unveiling the dynamics of the global trade in wildlife. *Biological Conservation.*

Jenkins, M., & Broad, S. (1994). *International trade in reptile skins: A review and analysis of the main consumer markets, 1983–1991*. TRAFFIC International, Cambridge, UK.

Lyons, J. A., & Natusch, D. J. D. (2011). Wildlife laundering through breeding farms: Illegal harvest, population declines and a means of regulating the trade of green pythons (Morelia viridis) from Indonesia. *Biological Conservation*, *144*, 3073–3081.

Mundy-Taylor, V. (2013). *Illegal wildlife trade and the European Union: An analysis of EU-TWIX seizure data for the period 2007–2011*.

Nijman, V. (2010). An overview of international wildlife trade from Southeast Asia. *Biodiversity and Conservation. 19*, 1101–1114.

Nijman, V., & Shepherd, C. R. (2010). *Wildlife trade from ASEAN to the EU: Issues with trade in captive-bred reptiles from Indonesia*. Cambridge, UK.

Olsen, M. T. B., Geldmann, J., Harfoot, M., Tittensor, D. P., Price, B., Sinovas, P., … Burgess, N. D. (2019). Thirty-six years of legal and illegal wildlife trade entering the USA. *Oryx*, 1–10. https://doi.org/10.1017/S0030605319000541

Outhwaite, W., & Brown, L. (2018). *Eastward bound: Analysis of CITES-listed flora and fauna exports from Africa to East and Southeast Asia 2006 to 2015*. TRAFFIC International, Cambridge, UK.

Petrossian, G. A., Pires, S. F., & van Uhm, D. P. (2016). An overview of seized illegal wildlife entering the United States. *Global Crime*, *17*, 181–201.

Rosen, G. E., & Smith, K. F. (2010). Summarizing the evidence on the International Trade in Illegal Wildlife. *Ecohealth*, *7*, 24–32.

Sinovas, P., Price, B., King, E., Davis, F., Hinsley, A., & Pavitt, A. (2016). *Southern Africa's wildlife trade: An analysis of CITES trade in SADC countries. Technical report prepared for the South African National Biodiversity Institute (SANBI)*. Cambridge.

Sinovas, P., Price, B., King, E., Hinsley, A., & Pavitt, A. (2017). *Wildlife trade in the Amazon countries: An analysis of trade in CITES listed species*. Cambridge, UK.

Stan Development Team. (2015). Stan: A C++ library for probability and sampling, version 2.10.0.

van Uhm, D. P. (2016). Illegal wildlife trade to the EU and harms to the world. In T. Spapens, R. White, & W. Huisman (Eds.), *Environmental crime in transnational context: Global issues in green enforcement and criminology* (pp. 43–66). London, UK: Routledge.

van Uhm, D. P., Pires, S. F., Sosnowski, M., & Petrossian, G. (2019). A comparison of seizures of illegal wildlife between the US and the EU: Implications for prevention. In M. J. Lynch & S. F. Pires (Eds.), *Quantitative studies in green and conservation criminology: The measurement of environmental harm and crime* (pp. 127–145). London: Routledge.

Underwood, F. M., Burn, R. W., & Milliken, T. (2013). Dissecting the illegal ivory trade: An analysis of ivory seizures data. *PLoS One*, *8*(10), e76539.

UNODC. (2016). *World wildlife crime report: Trafficking in protected species*. Vienna, Austria.

Wu, J. (2016). *Shark fin and Mobulid Ray sill plate trade in mainland China, Hong Kong, and Taiwan*. Cambridge, UK.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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