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What is the reality of wildlife trade volume? CITES Trade Database limitations

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ABSTRACT

Five selected forms (claws, skins, skulls, teeth, and trophies) of American black bear (*Ursus americanus*) were used to demonstrate how variable the volume of total international trade can be based on different approaches. Records from the comparative tabulations of the CITES Trade Database were presented in three ways: (1) identical data from both the exporter and the importer (4%), (2) traded volume reported by the exporter and importer differed (21%), and (3) traded volume reported either by exporter or importer only (75%). Six types of calculations were used to assess the total trade volume of selected American black bear forms. Proportional deviances of alternatively calculated traded volumes from their respective maxima significantly differed between individual calculations. However, these deviances were consistent between forms. The average difference between maximum and minimum calculated traded volume was 63 ± 23%. The most striking difference was found in trophies, where this difference represented 108,269 trophies in absolute terms. Specific changes to improve the usability of the CITES Trade Database are recommended and include the following: (1) combining the permit number with export and import reports to allow unmistakable identification of the entire trade flow, (2) unambiguous specification of the method of calculating volumes of both gross and net trade tabulations in the database guide, (3) better specification and avoidance of possible confusion of terms (forms), and (4) prohibition of automatically assigning value to empty fields.

1. Introduction

International trade in wildlife represents a serious threat to biodiversity conservation (Bush et al., 2014; Sutherland et al., 2009). It has often reduced abundance of traded species, and in extreme cases, entire populations can be extirpated (Eaton et al., 2015; Flecks et al., 2012; Jepson, 2015). Furthermore, trade can also promote the introduction of alien species (Collins et al., 2013; García-De-Lomas and Vilà, 2015). As a result, the resilience or resistance of the biotic community can be reduced (Cardinale et al., 2012), and thus, the functions of the whole ecosystem are threatened (Challender et al., 2015).

Wildlife trade involves live animals and plants as well as a plethora of their products, including ivory, horns, scales, timber, meat and other derivatives. Wildlife trade is considered the fourth largest global illegal trade after narcotics, humans and counterfeit products (WWF and Dalberg, 2012). Walley (2013) estimated the legal trade of wildlife is worth USD $323 billion annually; however, it is difficult to accurately assess the scale of the global wildlife trade (Oldfield, 2014). To monitor the amount of international trade in wildlife, the CITES Trade Database was developed and is maintained by UNEP-WCMC on behalf of the CITES Secretariat (https://trade.cites.org/). The CITES Trade Database (2015) currently holds more than 15 million records of trade of live animals and plants and their by-products and over 34,000 scientific names of taxa. The database is very frequently used to illustrate the volume of wildlife trade and can serve as an argument for conservation actions (e.g., Auliya et al., 2016; D'Cruze and Macdonald, 2016; Harris et al., 2015; Luiselli et al., 2016).

However, the serious problem is that it provides incomplete data, which can be interpreted unambiguously, and even the user manual confirms this (CITES 2013, p. 9). To monitor the trade in CITES regulated species, parties are required to submit annual reports summarizing import and export records. For each specimen traded, all of the following data should be reported: taxonomy, CITES Appendix (I, II, and III), year of shipment, exporting and importing country, and exported and imported quantities as well as the country of origin of the specimen. Additionally, information on the purpose of the transaction (e.g., scientific, education, or medical), the source of the specimen (e.g., wild, captivity, or confiscated/seized), a description of the traded form (referred to as specimen "term", e.g., skins, tusks, or wallet) and the unit of measurement associated with the quantity (e.g., grams, pairs, or

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cans) should also be documented (CITES, 2013). In fact, only a minority of the data entries fulfil all these requirements.

The aim of this paper was to demonstrate the shortcomings of the CITES Trade Database, especially in terms of how many different ways the data from CITES Trade Database can be approached considering the incompleteness of the database entries. Moreover, we calculated how variable the volume of total trade can be based on different algorithms for the example of American black bear (*Ursus americanus*).

The black bear is listed in Appendix II under Ursidae spp. Appendix II lists species that are not now threatened by extinction but that may become so if trade is not strictly regulated and monitored. Commercial trade in Appendix II species is allowed only if exporter issues permit reporting that the trade will not be detrimental to the survival of the species in the wild. Importing permits are also required for Appendix II species.

American black bear is native to Canada, USA and Mexico and is considered Least Concern according in the IUCN Red List. Throughout most of its range, this species is currently not threatened (Garshelis, 2009; Garshelis et al., 2016). The global population is estimated at more than twice that of all other species of bears combined. Notwithstanding, a few small, isolated populations of American black bears may be threatened with extirpation due to small population size, effects of fluctuating food resources, or direct human-caused mortality (Howe et al., 2007; Larkin et al., 2004). The trade in products from black bear parts is not yet widely addressed in North America. However, use and demand for bear parts is increasing in Asian communities, in Canada and the USA. As Asian bear populations decline and wild bear bile and other bear parts become more difficult to obtain, sources of bear parts outside Asia will be developed by traders and others willing to make significant profits (Servheen, 1999; Williamson, 2002).

2. Methods

International trade data were obtained from the CITES Trade Database for American black bear for the period 2000–2013 (http://trade.cites.org/en/cites_trade/; downloaded December 2015). For our needs, we focused our attention on the legal trade of the five most traded forms of American black bear – claws, skins, skulls, teeth and trophies. Trade in all of these forms is reported in two units within the CITES Trade Database: specimens and sets for claws and teeth or kilograms and specimens for skins, skulls and trophies. The records where only the volume was reported in specimens were used. Trade data were compiled using both gross/net trade tabulations (GTT/NTT) and comparative tabulations (CT). GTT/NTT provides data either of gross exports, gross imports, net exports or net imports (CITES, 2013), while CT contains additional information on the purpose of the transaction and source of the specimen. In the CT, the data are presented in three ways. Traded quantity was summed when all the data from both the exporter/re-exporter and importer were identical (Type 1 data). Type 2 data represented the records in which traded volume reported by exporter and importer differed. The last variant consisted of traded volume reported either by exporter or importer only (Type 3 data).

Six types of calculations were used to assess the total trade of selected American black bear forms. The first four methods of calculations (Table 1) are based on the sum of data type 1 and the following values:

I) **higher** values of the data of type 2 + **all values** reported either by exporter or importer of the type 3 data (i.e., maximum possible trade volume),
II) **lower** values of the data of type 2 + **all values** reported either by exporter or importer of the type 3 data,
III) values reported by the **exporter** only for all data types,
IV) values reported by the **importer** only for all data types.

Gross trade volume (G) and net trade volume (N) were obtained from GTT and NTT, respectively. However, it is not possible to use these tabulations with respect to source and purpose, as these data are lacking there. Proportional differences between maximum (calculation I) and alternatively calculated traded volumes were counted for each form. Kruskal-Wallis test was used for comparison of these differences (Statistica 12, StatSoft, Inc.).

Table 1
Calculation algorithms: different use of data types.

Data type/Calculation		I	II	III	IV
1	E = I	E = I			
2	E > I	E	I	E	I
	E < I	I	E	E	I
3	only E	E	E	E	–
	only I	I	I	–	I

Note: E: traded volume reported by exporter, I: traded volume reported by importer.

3. Results

3.1. Data characteristics and accuracy

The entire dataset for the international trade in American black bear contained 5968 records for the period 2000–2013. Almost 68% (4055 records) of this dataset related to the five selected forms. In total, 118 countries (plus 10 records with an unknown country) were reported as exporters and/or importers of the five selected American black bear forms. Of these countries, 47 countries (40%; plus, one report with an unknown origin) were both an exporting and importing country, 10 (8%) were an exporter only, and 61 (52%) countries only imported bear forms. The majority of American black bear trades took place between Canada as an exporter and United States as an importing country. These two countries participated in 96% of the records.

From the three types of data that report the traded volume identified here, the identical trade volumes reported by both the exporter and importer (Type 1 data) occurred only in 158 records (i.e., 4%). For the particular forms, the complete data share varied from almost 2% in skulls to 9% in teeth (Table 2).

The quantity reported by the importer or exporter was the most prevalent missing data occurring in three-quarters of the records (i.e., 3035 records; Table 3). Four percent of the records (i.e., 172 records) missed data in one of the following categories: importer, exporter, origin, purpose, source and various combinations thereof. From these categories, the most frequent types of missing data were records with missing purpose or origin, with each of them accounting approximately 1% of all trade records (Table 3).

Approximately one-fifth of the records of the whole dataset (21%) corresponded to Type 2 data, with the higher traded volume reported by the exporter approximately twice as often as by the importer (591 and 271 records, respectively). However, some differences were found

Table 2
Percentage of data types for the selected forms for years 2000–2013.

Data type/Form		Claws	Skins	Skulls	Teeth	Trophies
(n)		(272)	(1493)	(953)	(212)	(1125)
1	E = I	5	4	2	9	5
2	E > I	20	21	16	17	4
	E < I	5	4	6	9	11
	Total	25	25	22	26	15
3	only E	45	58	62	46	30
	only I	25	14	15	20	50
	Total	70	72	77	66	80

Note: E: traded volume reported by exporter, I: traded volume reported by importer.

Table 3
Absolute and relative occurrences of each type of missing data from the five selected forms (n = 4055).

Category with missing data	Number of records	
	Absolute	Relative (%)
Quantity: importer	2015	49.69
Quantity: exporter	1020	25.15
Purpose	55	1.36
Origin ("XX")	47	1.16
Importer	38	0.94
Exporter	17	0.42
Source	7	0.17
Importer + Origin	3	0.07
Importer + Purpose	3	0.07
Origin ("XX") + Purpose	2	0.05

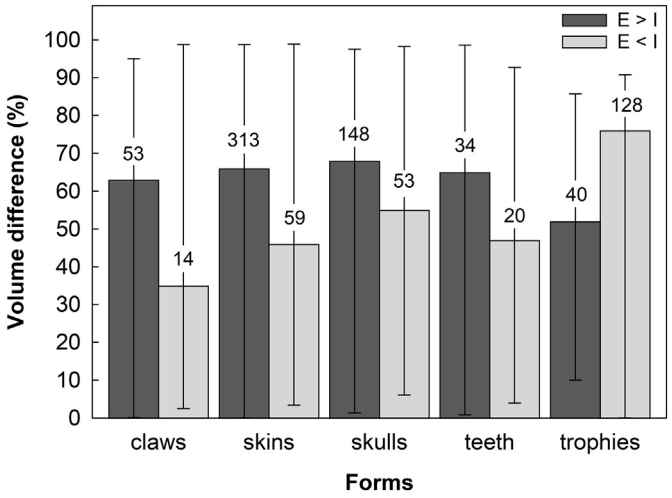

Fig. 1. Mean difference between the traded volume reported by exporter (E) and importer (I) in the Type 2 data. Error bars represent the minimum and the maximum. Numbers of the records are above the columns.

between the particular forms. Higher traded volumes reported by exporters than importers were found more frequently in all forms except the trophies. For trophies, the importers reported higher traded volume, almost three times more often than the exporters (Table 2).

For Type 2 data, the average difference in the traded volume between the exporter and importer was 63 ± 26% (± S.D.) for the records where the exporter reported higher volume than the importer and 52 ± 26% (± S.D.) for the reverse situation. In trophies, the importers reported approximately three-quarters more traded volume than that reported by the exporters in the Type 2 data (E < I) (Fig. 1).

Type 3 data dominated (75%) the records for the international trade in American black bear during the study period. Specifically, half of the whole dataset contained records where only the exporters entered the amount of the traded CITES specimens. Almost one-quarter of the records of the trade volume was declared by the importer only. In these cases, records missing the importing country data prevailed in the same four forms as in Type 2 data (Table 2).

3.2. Traded volumes

The maximum traded volume calculated using calculation I represents the basic level (100%) for the comparisons (Fig. 2). Overall, the most traded forms were claws, followed by teeth, trophies, skins and skulls. The trade between USA and Canada accounted for 90% of the trade for claws, 69% for skins, 71% for skulls, 94% for teeth and 92% for trophies of the total international trade.

Proportional deviances of alternatively calculated traded volumes from their respective maxima significantly differed between individual calculations irrespective of forms ($H(4, N = 25) = 12.126$; $p = 0.016$; Fig. 3a). However, these deviances were consistent between forms ($H(4, N = 25) = 1.241$; $p = 0.871$; Fig. 3b). Overall, the traded volumes most similar to the maximum volume of trades were those reported in the GTT (95% of maximum traded volume for all forms). In contrast, the lowest average traded volume was found when calculation II (lower traded volume in Type 2 data) was used (Fig. 3a). The variability of both G and N traded volumes was the lowest, while the highest variability was achieved using calculations III and IV (Fig. 3a).

The difference between the maximum and minimum calculated traded volume for individual forms was 63 ± 23% (± S.D.) on average. The mean difference between the maximum and all alternatively calculated traded volumes was 26 ± 5% (± S.D.) where the highest difference was found in trophies (33 ± 45% (± S.D.)) and the lowest in skins (23 ± 30% (± S.D.)). The most striking difference was found in trophies, where the minimum traded volume represented only 3% of the maximum, i.e., the difference of 108,269 trophies in the absolute terms (Fig. 2).

4. Discussion

The CITES Trade Database offers data on international trade of plant and animal species that have been protected by the CITES Convention since 1975. To provide a reliable background for sound conservation decisions, there is a logical and strong demand for the highest accuracy of the reported data. In this respect, it is surprising that the database guide admits inaccuracies (CITES 2013, p. 9). Indeed, the database is far from being impeccable. As the database does not specify any recommended algorithm for calculating traded volume (CITES Trade Database team was asked for [11/29/2017], but no response was received), we used and compared several feasible approaches to compute the traded volume of the American black bear using excerpted data originating from the CITES Trade Database. Our results not only critically analyse the CITES Trade Database but also show for the first time how different volumes of trade can be obtained using various feasible approaches of their evaluation.

Several authors (Bennett, 2015; Blundell and Mascia, 2005; Rowley et al., 2016), who used the CITES Trade Database, did not specify how they quantified the traded volume. Low representation of complete data in the CITES Trade Database is more of a rule than an exception. Surprisingly, only a small number of papers have admitted discrepancies in the available trade data (Challender et al., 2015; Foster et al., 2016; Luiselli et al., 2016), and when the discrepancies were noted, they were considered insignificant (Luiselli et al., 2016). Alternatively, authors may have been aware of errors in the database but only reported the results of one of the possible approaches (Andersson and Gibson, 2018; Bruckner, 2001; Carpenter et al., 2004; Nijman and Shepherd, 2010; Pernetta, 2009; Russo, 2015; Vall-llosera and Cassey, 2017).

Only 4% (158 records) of the records fulfilled the requirements of a complete trade record with the same trade volumes reported by both importer and exporter (Type 1 data). These records were the only records that could be evaluated conclusively. The frequency of the occurrences of these records was very similar to 6% of complete data reported by Foster et al. (2016) for trade in seahorses and 7.3% reported by Russo (2015) for 90,204 records of 50 exporting African countries from the same source. However, Russo (2015) omitted the data that had missing exported quantity. If the author used these records, then the share of complete data would be even smaller. After additional data processing (merging records missing export quantity with records missing import quantity and removing records lacking export quantity), Russo (2015) increased the proportion of unambiguous records to 10.2%. In our case, data merging only led to the exclusion of ambiguities in 0.3% of records. In contrast to a relatively small percent of complete records in respect to volume (Type 1 data), other categories of records (i.e., purpose, origin and importer country)

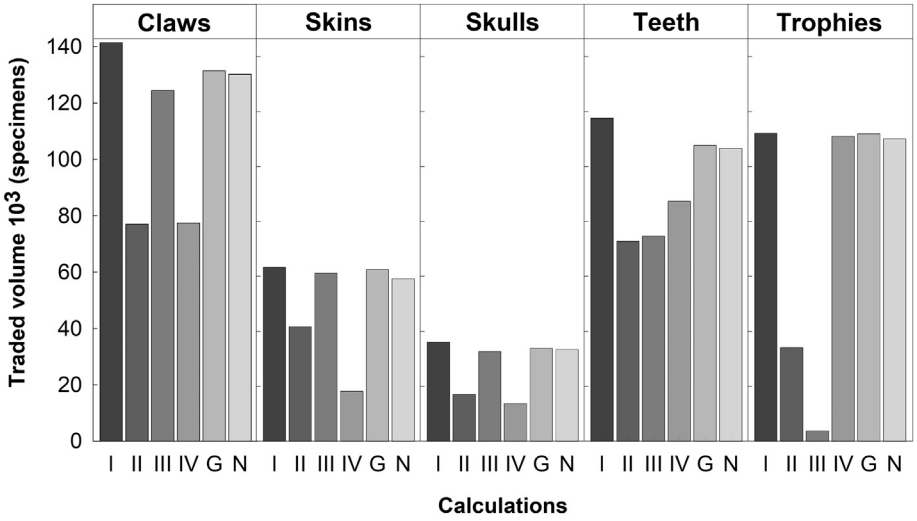

Fig. 2. Absolute traded volume (thousands of specimens) of selected traded forms using various calculations.

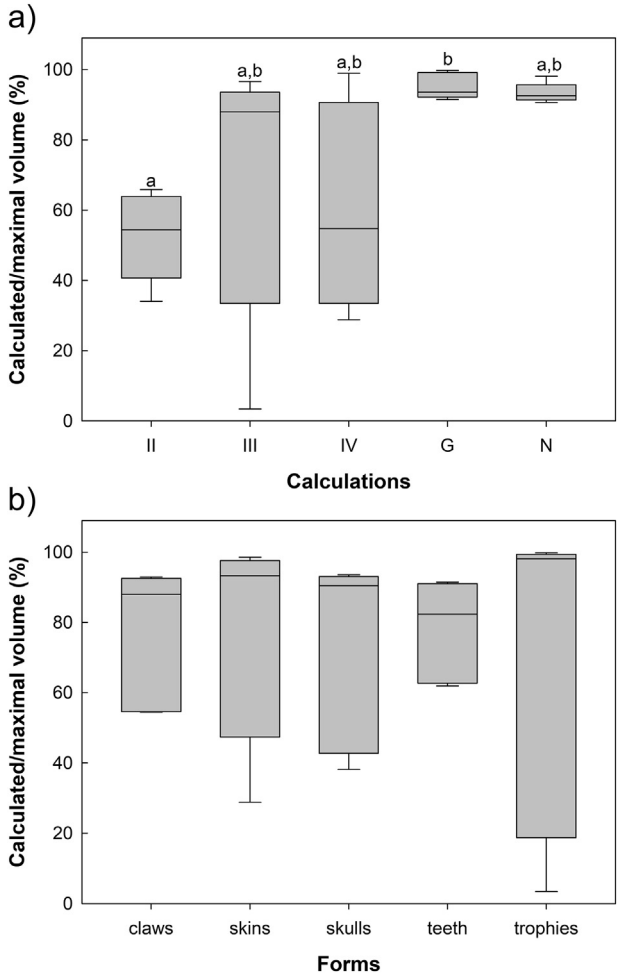

Fig. 3. a - Percentage of traded volume using various calculations, b - Percentage of traded volume for each form (100%: maximum traded volume – calculation I). Line: median, box: quartiles and range: min–max.

were almost 99% completed or were even complete (i.e., exporter and source). This result is once again in agreement with Russo (2015), where the categories of purpose and origin, as well as source, were left blank in a similar portion of records as in our dataset.

Different traded volumes reported by the exporter and importer (Type 2 data) represented 21% of records of the whole dataset. A similar occurrence (22%) of this difference between the exporter and importer volumes was found by Russo (2015). In such cases, where the exporter declared a higher volume than the importer, the reason for this volume discrepancy could be that the exporter reported volume according to the permit but the importer according to the actual state (Andersson and Gibson, 2018). However, part of this subset was formed by records (approximately 7%) in which the imported quantity was higher than the quantity reported by the exporter. In trophies, these records (I > E) occurred even more often than the records with E > I. Importantly, the differences between the traded volumes reported by the exporter and the importer were not negligible (63% and 52% for E > I and I > E, respectively). This difference was even 75% (I > E) of the traded volume in trophies. The form “trophy” in the database guide is specified ambiguously, and in the case of bear, it may include skull, skin, claws and teeth (CITES, 2017). A possible explanation is that the importers ascribe some particular forms as the trophy rather than to more explicit forms (claws, skins, skulls and tooth). Large differences between the exporter and the importer data could also be caused by the system of making records from individual trade reports. For example, missing or not specified units are automatically assigned as a specimen (CITES, 2013). Omitting units in the data can quickly change the record, for example, 100 kg of teeth to 100 teeth. Such a trade appears in two different records in the CITES Trade Database and subsequently is considered twice. A prohibition of automatic unit assignment does not prevent the occurrence of blank fields, but it does not allow the undesirable addition of false data.

Records containing only the exported or the imported quantity (Type 3 data) prevailed (75%). Possible sources of trade volume discrepancies could be related to the use of nonstandard measurement units; reporting different taxonomic levels, forms, sources or purposes; late submissions or complete absence of annual reports; or a delivery of the shipment in the year following the one of the permit authorization. The most dominant type of missing category (50%) was the quantity reported by the importer (here also called Type 3 data: only E). Similarly, Russo (2015) reported that this category of missing data prevailed (63%) in the records of international trade with Appendix I and Appendix II species exported out of Africa between 2003 and 2012. Andersson and Gibson (2018) also found that the importer or exporter failed to report trade volume of hippo teeth “in many cases” but did not specify the proportion of such reports. The omission of these data may be due to the fact that (1) some of these records are actually export permits for trades with countries where import permits are not issued or at least not required (Green and Hendry, 1999), (2) records reported by

the importer have one or more discrepancies in other categories and thus do not match export permit, (3) the import quantity was not submitted to the database by the importing country, and (4) the trade was not realized at all. In our dataset, the traded volume reported by the exporter was missing in 25% of the records (here also called Type 3 data: only I). These records should be considered as realized trades, where the importer permits (different traded volume or other categories of records) mismatched the exporter permits.

A large number of errors and deficiencies in the records are reflected in the significant differences in the calculated trade volumes. For individual forms the American black bear, traded volumes differed significantly when determined using different calculations. On the other hand, the difference among the calculations was the same for all five considered forms. Thus, we can assume that the error in reporting the data in the CITES Trade Database is systematic and is not more pronounced for one form than for the others. However, in some cases, the difference between the maximum and minimum calculated volume can be very distinctive. When we used the exporter data only for American black bear trophies, we determined only 3% of the possible maximum volume. This striking difference is a result of the data error rate, as 80% of the trophy trade records missed either export (50%) or import (30%) data (Table 3).

Some authors are aware of the inaccuracies in the database and try to avoid this fact by selecting only a subset of data (usually without justification). The disparity in the use of the database is obvious as exemplified by two recent papers evaluating amphibian trade, where Auliya et al. (2016) used only the data reported by the importers, and Sinovas et al. (2017) used exporter data only. The reported export and import amounts of legal wildlife trade in the CITES Trade Database are dramatically mismatched. This approach should be treated cautiously in the situation when the data with missing importer or exporter traded volume dominate the dataset, which was also the case of our dataset (75% of records). We highly recommend reporting trade volumes according to both exporter and importer data. When we used only the export data (calculation III) or only the import data (calculation IV), the calculations led to very different results. The average traded volume calculated according to importer data reached only about half the maximum traded volume, and the median value for calculation from export data only was 88% of its maximum value.

Equally important as various trade volumes is that the higher value is not consistently acquired by the import or the export data for all five forms. We found a higher overall volume reported by the exporter for three of the five forms, and for the two remaining forms, it was the opposite, with the average difference between volumes from calculations III and IV being 55 ± 31% (± S.D.). The difference in trophies was the most significant, as the importer declared a 29-times higher traded volume than the exporter. Andersson and Gibson (2018) and Bennett (2015) also found a substantial difference between the export and import data for the hippo (*Hippopotamus amphibius*) teeth and blue monitor (*Varanus macraei*), respectively. For the blue monitor, ten of 22 countries with recorded trade did not report any imports of the species (Bennett, 2015). Most of the authors used only the export or import data. The import data users supported their approach by an alleged fact that the export data represent the CITES export permits rather than actual exported volume (Andersson and Gibson, 2018; Bruckner, 2001; Carpenter et al., 2004). According to the opposite opinion, importers often did not report the data, and this approach lead to an underestimation of the actual state (Bennett, 2015; Luiselli et al., 2016). Considering the settings, purpose and function of the CITES Trade Database, the traded volume reported by the importer should refine the traded volume provided by the exporter permit. Regardless, this method of calculation using only the export or the import data without prior, careful consideration of the input data seems unreliable from our point of view, and it is not possible to responsibly recommend either method as more appropriate. We are aware of some level of oversimplification in our approach to calculating the sums of the traded volumes, as the same error cannot be expected for all reports. Specifically, our equation I expresses the maximum possible quantity traded, which most likely overestimates the real state of the issue. However, automatically calculated GT and NT volumes were the most similar to their respective maxima. It is important to note that these output types also tend to overestimate the trade volume (CITES, 2013).

The worrying uncertainty of the CITES data is compromising, especially because the CITES Trade Database guide (CITES, 2013) does not offer any precise guidance on how to calculate trade volume. This scenario is a very undesirable condition despite the fact that all CITES parties are obligated to report trade in Appendix-listed species accurately. Although the CITES data are often used as a background for conservation actions of animal and plant species and the regulation of their trade (e.g., Auliya et al., 2016; D'Cruze and MacDonald, 2016; Harris et al., 2015; Luiselli et al., 2016), the pervasive discrepancies described in this study can lead conservationists and enforcement personnel to reluctantly make ultimate conclusions about wildlife trade trends. Not knowing the true extent of the wildlife trade, we can be facing a much greater threat to biodiversity than is now generally recognized. Given the potentially widespread discrepancies indicated by our analysis, further use of the CITES Trade Database for these purposes should be conditional on the explicit indication of the method of calculating the quantity traded, e.g., Vall-llosera and Cassey (2017). At the same time, it would be highly appropriate to substantially remove the common sources of discrepancies in the wildlife trade recordings by CITES Secretariat authority.

At this time, we recommend following actions to improve usability of the CITES Trade Database: (1) combine the permit number with the export and import report to allow unmistakable identification of the entire trade flow, (2) unambiguously specify the method of calculating volumes of both GTT and NTT in the database guide, (3) better specify and avoid possible confusion of terms (forms), and (4) prohibit the automatic value assignment of empty fields.

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