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What is the reliability of visually based animal trade census outcomes? A case study involving the market monitoring of the Sumatran Laughingthrush *Garrulax bicolor*

TOMÁŠ BUŠINA[1*], MAREK KOUBA[1] and NURSAHARA PASARIBU[2]

[1] *Department of Ethology and Companion Animal Science, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, Prague 6, 16500, Czech Republic.*
[2] *Department of Biology, Faculty of Mathematics and Natural Sciences, University of North Sumatra, Jalan Dr. T. Mansur No. 9, Medan, 20155, Sumatera Utara, Indonesia.*

* *Author for correspondence; email: tomas.businao@gmail.com*

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Summary

A considerable variety of Indonesian avifauna is forced into the domestic and international pet trade, where the majority of individuals are caught in the wild. To monitor the volume and development of the trade and to evaluate the threat status of the traded species, bird market surveys are usually performed. The most commonly used monitoring technique is the "Direct Counting Method – DCM", i.e. the counting of openly displayed individuals offered for sale. In this study, we evaluate the reliability of the outputs that DCM delivers by conducting regular long-term bird censuses at two of the main animal markets in Medan (Sumatra, Indonesia) involving 10 major local vendors specialising in the Sumatran Laughingthrush (*Garrulax bicolor*; SL), our target species. Both markets were visited from March to December 2015 with three different survey intervals (one, two and four visits per month). In total, according to DCM, we recorded up to 461 SL individuals offered for sale. However, a comparison of the monthly logs recorded directly by the vendors during the same period revealed that DCM only uncovered a negligible proportion of the total trade. Specifically, we detected only 4.6%, 8.1% and 16.1% of the traded SL individuals in relation to the set survey intervals. While the numbers of recorded SL individuals according to DCM and the three survey intervals were significantly interrelated, none of them correlated with the real numbers of traded birds provided by the vendors. Our results suggest that census-based market data are underestimated, and represent an unknown proportion of true trade volumes, regardless of the intensity of visits. In order to obtain reliable data and prevent the underestimation of the volume of trade, we recommend of undisclosed monitoring of markets and the engagement of trusted individuals with a past personal interest in this field or, if possible, the vendors themselves.

Keywords: monitoring, overexploitation, species threats, trade estimation, wildlife trade

Introduction

Caged bird trade involving birds predominantly caught in the wild is a well-established and widespread business in South-East Asia (Nijman 2010, Edmunds *et al.* 2011, Krishnasamy and Stoner 2016) and is the main reason for population declines across a wide range of species (Collar 2015, Lee *et al.* 2016, Eaton *et al.* 2017, Harris *et al.* 2017, Symes *et al.* 2018). Despite the fact that a considerable proportion of this trade is illegal, it flourishes because of the historical tradition of keeping birds in these countries (Jepson and Ladle 2005, Fijen 2015) and due to its enormous profitability (Rosen and Smith 2010, Wilson-Wilde 2010). At present, researchers and conservationists are putting continuous pressure on the Indonesian government to deal with the problem because Indonesia is considered one of the main hubs for the trade in wild birds, supplying both domestic and international trade (TRAFFIC 2015, Beastall *et al.* 2016, Bušina *et al.* 2018b, Rentschlar *et al.* 2018).

In the last few decades, the large-scale, poorly controlled and commercially motivated collection of wild birds across the whole of the Indonesian archipelago has resulted in several local species, particularly songbirds (Passeriformes), being pushed to the brink of extinction, e.g. Straw-headed Bulbul *Pycnonotus zeylanicus* (Bergin *et al.* 2018), Rufous-fronted Laughingthrush *Garrulax rufifrons* (Collar and van Balen 2013), Black-winged Myna *Acridotheres melanopterus* (Shepherd *et al.* 2016b), Javan Green Magpie *Cissa thalassina* (Nijman *et al.* 2017). Many other species find themselves in a similar predicament and are currently experiencing huge population declines (Eaton *et al.* 2015, Harris *et al.* 2015, 2017). This songbird crisis resulted in the establishment of the Asian Songbird Trade Specialist Group within the IUCN Species Survival Commission. The main goal of this group is to prevent the extinction of any bird species from the areas concerned and to reverse their population decline (Lee *et al.* 2016, Shepherd and Cassey 2017). The urgent need to undertake immediate conservation action gained such traction at international level that the songbird crisis became the main topic of the latest campaign launched by EAZA (European Association of Zoos and Aquaria) for the years 2017–2019 called Silent Forest (EAZA 2017).

The lack of a systematic, long-term monitoring scheme for the population size and distribution of most forest-dependent bird species in Indonesia (Sodhi *et al.* 2004, Collen *et al.* 2008) means that the only accessible data for the assessment of their population and threat status is generated through market monitoring studies and/or seizure reports. These provide only basic information about the frequency of occurrence of particular bird species at the markets and are usually supplemented by random observations from the field, interviews with bird-trappers and/or vendors and expert opinion (Shepherd *et al.* 2004, Eaton *et al.* 2015, Harris *et al.* 2015, Shepherd *et al.* 2016a, Nijman and Nekaris 2017, Rentschlar *et al.* 2018). Undoubtedly, these datasets provide some insight into the population dynamics in the wild. However, the credibility of such datasets generated through market monitoring surveys is questionable because vendors might be aware of the illegality of their activities and very little is known about how much they actually reveal about the volume and scope of the trade.

Within this context, as long as the vast majority of wildlife trade is illegal, it can be assumed that the results of such market monitoring surveys represent just the "tip of the iceberg" in terms of the true numbers of traded and seized animals. As a result, inventory studies (e.g. Gastañaga *et al.* 2011, Shepherd 2011, Chng *et al.* 2015, 2018, Eaton *et al.* 2015, Shepherd *et al.* 2016a, Nijman *et al.* 2017) and studies that apply statistical modelling techniques (e.g. Barber-Meyer 2010, Daut *et al.* 2015, Harris *et al.* 2017, Nijman and Nekaris 2017, Nijman *et al.* 2018) may similarly be biased because of the incompleteness of the input data. This error is a direct consequence of the applied data collection method, i.e. the direct counting of only openly displayed individuals offered for sale (the so-called Direct Counting Method; DCM). Importantly, the DCM itself does not claim to measure the entirety of the trade, it only measures what is openly available for sale. It follows that DCM is considering only a small but unknown proportion of the trade which cannot reveal or represent the full extent of trade. However, a tendency to generalise DCM data can be seen in some studies (e.g. Gastañaga *et al.* 2011, Shepherd 2011, Chng *et al.* 2015, Shepherd *et al.* 2016a, Nijman and Nekaris 2017).

The effect of the application of DCM is an inevitable trade-off between the numbers of birds recorded and the frequency of market visits. Frequent surveys increase the risk of unsold, permanently displayed birds being repeatedly counted, whereas infrequent market visits can lead to the underestimation of bird turnover. Furthermore, the DCM also excludes those birds not directly on display and those that perish due to the poor conditions they are kept in. Last but not least, DCM may include individuals that were possibly sold among the vendors themselves, and therefore potentially counted twice. It is these arguments that have led several authors to conduct bird market surveys using different timetables based on their own experience and/or estimated turnovers suggested by interviewed vendors. These timetables vary from one-off visits (Shepherd 2007, Chng *et al.* 2015, 2016, 2018, Shepherd *et al.* 2016a, Nijman *et al.* 2017), through monthly visits (Shepherd 2011), to irregularly repeated surveys (Daut *et al.* 2015, Nijman and Nekaris 2017, Nijman *et al.* 2018, Rentschlar *et al.* 2018) and generate heterogeneous information.

This study aims to demonstrate how deceptive the outcomes of bird market monitoring surveys based on DCM can be. This results from the fact that an unknown portion of the trade is taken into consideration using DCM (no matter whether consciously or unconsciously), that inevitably results in misinterpretation of the total trade extent. To determine the weaknesses of the method, surveys were conducted according to three different schedules and compared with data simultaneously collected by vendors, which is indicative of real market turnover (Bušina *et al.* 2018b). The research was conducted at two markets in Medan, the largest city on Sumatra, where our research group was already well established and was conducting long-term research into the Sumatran Laughingthrush *Garrulax bicolor*, which became the model species for this market monitoring study.

Methods

Study species and legislation

The Sumatran Laughingthrush (hereinafter SL) is a medium-sized passerine endemic to Sumatra which occupies pristine old-growth mountain forests (BirdLife International 2016). In fact, very little is known about its ecology (Collar and Robson 2007, Eaton *et al.* 2016) and few observations have been made in the wild (Brickle 2009, Bušina and Kouba 2017, Bušina *et al.* 2017, 2018a Harris *et al.* 2017). However, its strong, exceptionally melodious song display makes it one of the most popular and sought-after songbirds, thereby exposing it to enormous trapping pressure, resulting in drastic population decline in the wild (Shepherd *et al.* 2016a, Harris *et al.* 2017, Bušina *et al.* 2018b). Until recently, according to Indonesian nature conservation legislation (Attachment to Government Directive No. 7/1999 of the Republic of Indonesia), the SL was not listed as a protected species, as a result of which, the scope and volume of trapping was regulated by a harvest quota system which is determined annually (for more information see Shepherd 2011, Chng *et al.* 2015, 2018). However, under pressure from ornithologists and wildlife conservationists, the Indonesian authorities revised the list of nationally protected species, which now includes the SL and hundreds of other local species (Gekkon 2018). Nevertheless, despite the legal protection the SL commands and the harvest quota (KSDA 2015) being set at zero, it remains illegally traded on the open markets across the islands of Sumatra and Java (Shepherd *et al.* 2016a, Bušina *et al.* 2018b, Chng *et al.* 2018), and is openly advertised for sale through social media (Iqbal 2015).

Study area and data collection

Bird market monitoring was conducted in Medan, the capital of North Sumatra province. Two markets were surveyed, namely Jalan Bintang, which is actually located at Jalan Dr. FL. Tobing (3° 35′24.8″N, 98°41′17.6″E), and Jalan Putri Merak Jingga (3°36′02.3″N, 98°40′24.6″E). These markets have a long history in wildlife trade which is reflected in the fact that most related studies on Sumatra have been conducted here (e.g. Nash 1993, Shepherd *et al.* 2004, Shepherd 2011,

Table 1. The total number of Sumatran Laughingthrushes recorded at the two main bird markets in Medan, Indonesia, during March to December 2015 according to the applied monitoring methods. In total, 10 vendors were surveyed using both the Direct Counting Method (DCM) of openly displayed individuals (Method I) and the collection of vendors' turnovers (Method II).

Survey method/schedule	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean ± SD	Total
Method I												
Monthly interval (A)	11	8	8	10	11	13	7	18	17	17	12 ± 4.1	**120**
Fortnightly interval (B)	24	12	16	17	18	22	14	24	30	36	21 ± 7.5	**213**
Weekly interval (C)	54	36	50	40	43	46	29	47	55	61	46 ± 9.6	**461**
Method II												
Vendors' records	801	660	669	599	151	134	170	299	302	220	401 ± 253.5	**4005**

Harris *et al.* 2015). Market monitoring took place for 10 months in the period between March and December 2015 using two different methods (Method I and II, see below). In total, 10 vendors (six based in Jalan Bintang, four in Jalan Putri Merak Jingga) running permanent stores trading in wildlife were monitored. In order to avoid the suspicions of the vendors being aroused, only local students from a collaborating university were employed to conduct the scheduled market visits and censuses, thereby refraining from direct interaction with the vendors. Like previous studies in which DCM was applied (e.g. Chng *et al.* 2015, Shepherd *et al.* 2016a, Nijman and Nekaris 2017, Nijman *et al.* 2017, Rentschlar *et al.* 2018) only SLs openly displayed for sale (Method I) were recorded. Market visits were conducted weekly to enable the evaluation of the effectiveness of revealing the volume of bird trade over different periods of time, namely per month (A), fortnight (B) and week (C). In order to compare the census data collected through DCM, parallel market monitoring was also carried out (Bušina *et al.* 2018b). Using a hired mediator, an ex-middleman familiar with the local wildlife network, who kept our identity secret, we were able to encourage the same 10 vendors to collect and provide us with their own monthly SL sales records for the same time period (Method II). The vendors' data, anonymously written down by themselves after each transaction, were collected by the hired mediator at the end of each month and were re-entered into our own standardised record sheets for further statistical analysis. The datasheets contained fundamental information, including the date, number and origin of the SL individuals bought by the vendors from trappers and/or local middlemen, as well as market mortality for every single month, as recorded by the vendors themselves (Bušina *et al.* 2018b).

Analysis of market survey data

The numbers of observed openly displayed individuals (DCM - Method I) from both monitored markets (Jalan Bintang and Jalan Putri Merak Jingga) were added up for each of the set survey intervals and further analysed as one single market dataset representing the main trend in SL trade in Medan. The total number of actually traded individuals recorded by the vendors themselves (Method II) was obtained in the same way (Table 1). To compare and identify the differences between the employed monitoring methods (I and II), including all three survey intervals (A–C), a one-way ANOVA test was applied, followed by Tukey's HSD post-hoc test. To determine whether the numbers of observed birds recorded by DCM (A–C) correlate with one another, and with the real trade data provided by the vendors themselves, the Pearson correlation test was used.

Results

The total numbers of SL individuals recorded at both markets according to the set survey intervals during the study period are presented in Table 1. The total monthly numbers of SL individuals offered for sale according to DCM (Method I) increased linearly with the intensity of the survey

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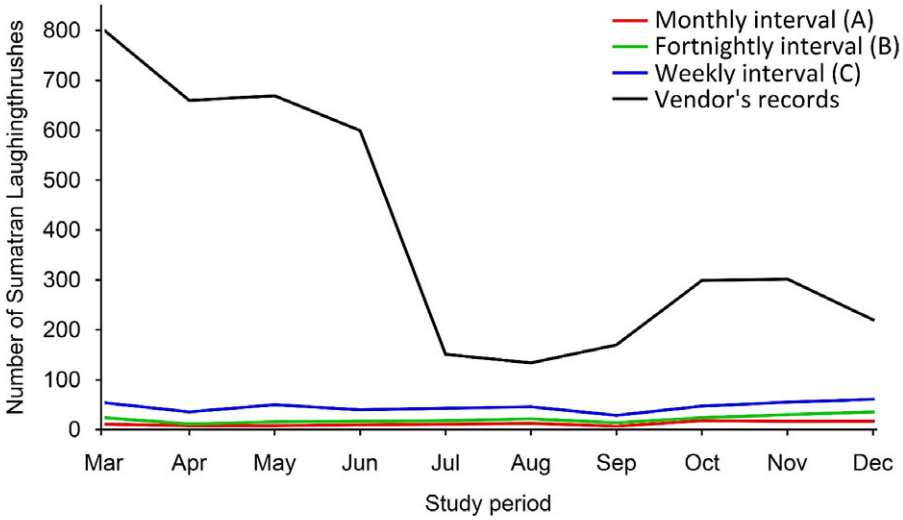

Figure 1. Comparison of Sumatran Laughingthrush (SL) trade volumes in Medan during the period March–December 2015 according to Direct Counting Method (DCM) for the set survey intervals (A–C) and according to the real numbers of traded SL individuals provided by vendors. The market turnovers indicated by DCM show that the outcomes provided by this visually based monitoring method are incomplete (show max. 16.8% of total turnover) and insensitive to changes in market supply.

interval (A–C; Table 1) and revealed only 4.6% (A), 8.1% (B) and 16.8% (C) of the actual trade recorded by the vendors themselves (Method II).

The numbers of SLs observed using DCM (Method I, survey intervals A–C) varied only slightly (see Figure 1), whereby a Pearson test revealed a significant inter-correlation: A–B (R = 0.87, P = 0.001), A–C (R = 0.69, P = 0.027), B–C (R = 0.86, P = 0.001) (see Figure 2). Conversely, the numbers of traded SLs recorded by the vendors (Method II) varied markedly (see Figure 1) and did not correlate with the numbers of SLs observed using DCM (Method I, survey intervals A–C): survey A (R = -0.406, P = 0.245); survey B (R = - 0.297, P = 0.404); and survey C (R = 0.067, P = 0.854) (see Figure 2).

A variance analysis revealed that the numbers of actually traded and openly displayed birds were significantly different (one-way ANOVA, $F_{3,36} = 21.848$, df = 9, $P = 0.001$). Multiple comparisons of the applied monitoring methods using Tukey's HSD post-hoc test showed significant differences between the number of SLs recorded by the vendors – monthly turnover records (Method II) - and the DCM censuses (Method I, survey intervals A–C), specifically: ($P = 0.001$, $\alpha = 0.05$). Within the group of DCMs (survey intervals A–C) no differences were found: A–B ($P = 0.998$), A–C ($P = 0.931$), B–C ($P = 0.972$).

Discussion

Animal market monitoring is a frequently used conservation tool for quantifying the threat which wildlife trade undoubtedly poses to a variety of species worldwide, and which subsequently contributes to the implementation of different conservation measures (Wingard and Zahler 2006, Engler and Parry-Jones 2007, Herrera and Hennessey 2007, Alacs and Georges 2008, Zhang *et al.* 2008, Rosen and Smith 2010, Gastañaga *et al.* 2011). However, this assumes that the data used

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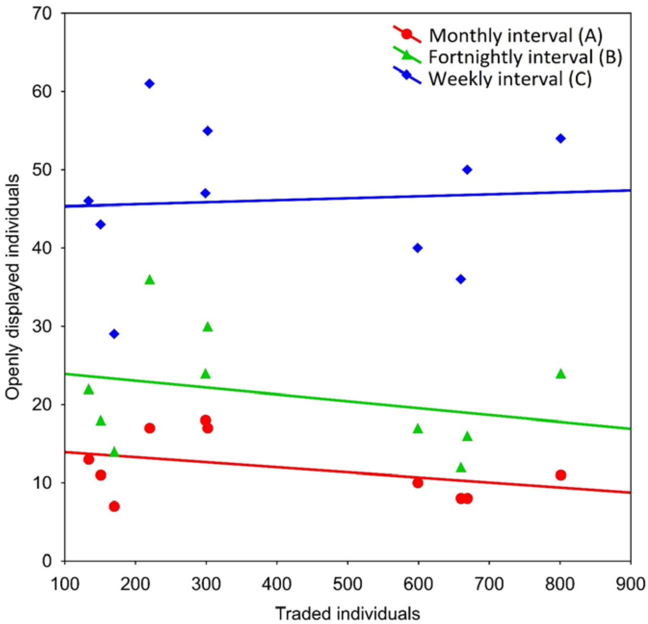

Figure 2. Pearson correlation regression lines based on summarised monthly data for March–December 2015 collected in Medan, North Sumatra, Indonesia. Each line represents a different predetermined survey interval (A–C) for DCM and shows the relationship between the numbers of observed and actually traded SL individuals recorded by vendors.

as the basis for decision making with regards to conservation measures are unbiased as much as possible. If this were not the case, and decisions on conservation policy were based on biased monitoring data, it may have serious consequences for the target species. It is therefore imperative to have reliable input datasets. This study is, as far as we are aware, the first to evaluate the reliability of the conventionally used DCM. A comparison of the market records acquired through the two different monitoring methods (Method I and II, see above) employed in this study revealed inadequacies in DCM and highlights the need to re-evaluate our perception of the volume and scope of wildlife trade.

Although this study primarily focuses on the quantification of the volume of SL trade in Medan, it is also presented as a model for demonstrating the potential weaknesses of DCM, which is often used to estimate the volume of trade in wildlife. Despite the method's shortcomings, the lower labour demands, easy application, repeatability, discreetness, etc. still make DCM one of the preferred trade investigation methods for most taxa (Shepherd *et al.* 2004, Flores-Palacios and Valencia-Diaz 2007, Natusch and Lyons 2012, Phelps and Webb 2015, Morgan 2016). This preference is also strengthened by the fact that the success of other trade monitoring methods, such as road blockades or stall raids, places greater demands on the quality of the intelligence information gathered and the accuracy of its delivery. Furthermore, the presence of conservation agencies and/or law enforcement officers is essential in these cases (Lee *et al.* 2005, Hernawan 2015, Krishnasamy *et al.* 2016, TRAFFIC 2018).

This study has shown that the basic trade chain model, "trapper – middleman – seller – end buyer", is not linear and straightforward as might be expected and leakage of SLs from the trade chain occurs at many points. In fact, not all individuals are meant to be displayed for direct sale. Firstly, some SL are often resold among seller themselves. Secondly, some of them are meant for transport to other markets across Indonesia (Chng *et al.* 2015, 2016, 2018) and some become part of international wildlife trafficking (Bušina *et al.* 2018b). Finally, many of them die at various stages of the entire trade chain. Hence, the reliability of trade estimates derived from visually-based monitoring (DCM) is disputable, and caution is therefore pertinent when drawing conclusions about trade volumes, as acknowledged by, for example, Shepherd *et al.* (2004) or Chng *et al.* (2018).

In order to maximise the likelihood of recording the largest possible number of traded individuals and to minimise the risk of repeated counting of unsold individuals displayed over a long period of time, several authors have resorted to making market visits at set time intervals according to their own knowledge and experience of the dynamics of the local trade and/or vendor interviews (Shepherd 2006, Gastañaga *et al.* 2011, Regueira and Bernard 2012, Nijman and Nekaris 2017, Nijman *et al.* 2018). However, the results of the research presented in this study show that the number of visits, respectively the length of time between visits, has very little impact on the determination of the scope of the actual trade in wildlife. Furthermore, the linear increase in the number of observed SL as a result of intensified market visits implies that vendors keep approximately the same number of openly displayed individuals at all times, regardless of the actual number of birds they have sold or could have in stock (see Table 1). Within this context, we can only speculate about the reasons why only negligible proportions of SLs were actually displayed for sale. It could be either the result of the restricted space vendors available have for display cages, the illegality of the trade itself, or because these individuals were meant for different part/s of the whole trade chain (see above).

There was also no relationship between the numbers of openly displayed individuals and actually traded individuals, regardless of the frequency of the market visits. The inability of DCM to reflect trade fluctuations is clearly evident from the comparison of the recorded monthly turnovers (see Figure 1). While data from the vendors showed dynamic changes in the market, with a marked slump in trade volume in the period July–September and a moderate recovery thereafter, the visually-based survey data via DCM remained practically constant, indicating relatively stable turnover. This seeming constancy clearly suggests that with increasing real volume of trade the underestimation caused by the DCM will increase still more as well, in particular when only one or two visits per month are performed, as was the case in this study (Figure 2). In other words, the more SL will actually be traded, the fewer individuals will be recorded by DCM in total. On the contrary, it could also be argued that none of the displayed individuals was sold, whereby DCM would then provide an overestimation of the outcomes because of the repeated counting of the same individuals.

Regarding the DCM's low ability to detect market changes, similar constancy in the market availability of certain species suffering from population decline (e.g. Green Magpie *Cissa chinensis*, Straw-headed Bulbul, Magpie Robin *Copsychus saularis musicus*), as is the case for SL, was also found in a wide-ranging long-term animal market monitoring study employing DCM presented by Shepherd *et al.* (2004). It would therefore appear that DCM is unable to provide clear evidence about the volume, scope and dynamics of the actual trade in wildlife. It is therefore important to stress that the availability of birds in markets is driven by many factors, e.g. the type of vendor and the character of its store, the season, current trends, customer preferences, the time of day a survey is conducted, etc. (Burivalova *et al.* 2017, Krishna *et al.* 2019, Marshall *et al.* 2019). As a result, and as this study has shown, precise outcomes delivered by DCM cannot therefore be expected.

Nonetheless, despite the limitations of DCM, the delivered results still have a certain conservation value. Changes in market availability directly observable by sight may be indicative of either the severe exploitation of a particular species, resulting in a decrease in supply, as is currently the case, for example, of the laughingthrushes or exactly the opposite, by drawing the attention of conservationists to those species that are becoming more popular and sought-after, thereby resulting in an increase in their market presence, as is the case for owls due to the popularity brought by Harry Potter movie (Nijman and Nekaris 2017). The complexity of wildlife trade networks and the great variety of traded animals hamper attempts to perform comprehensive, in-depth quantification of the market volumes and trends. However, in order to be able to understand the dynamics of the trade in wildlife and to take appropriate action towards effective protection, it is essential to measure accurately the actual number of individuals traded. It is clear that if the data sets for this study were only gathered by DCM, the results, suggestions and conclusions drawn would be fundamentally different and misleading. As shown, the comparison of the data collected by DCM with the real turnover from vendors found that the trade in SL is larger than it was initially thought to be, and therefore, poses an even greater threat than could ever have been imagined. In spite of the fact that we focused in this study on one species (SL) only (and it is important to note that there are certainly differences between species involved in wildlife trade), it is very worrying to think that this situation also applies to many other species worldwide.

Objectively, quantifying animal markets through vendors' book records collected via undercover "agents" might be challenging. Mainly because of the market size, range of traded species and last but not least the need for a mutually trustworthy person to cooperate with vendors and carry out monitoring. The applicability of this method on a wider scale and its potential weaknesses will only become apparent in the future. However, the above-mentioned difficulties should not be a reason not to try to obtain such data, as they are and will be in future even more essential in order to protect and save many different species.

Finally, our study revealed the serious limitations in the commonly used DCM, regardless of the set survey intervals, and put forward as far as we know a new investigative approach for delivering accurate trade data. Moreover, considering increasing persecution of illegal wildlife trade and wildlife conservation policy enforcement, it is presumed that trade in wildlife will become even more under-the-counter activity, and thus, the DCM may become an even less useful tool. Therefore, we encourage researchers and conservationists dealing with the illegal trade in wildlife to adopt and implement our approach in the future.

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