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## LETTER

## Recent Pangolin Seizures in China Reveal Priority Areas for Intervention

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### Keywords

China; market; pangolins; social network analysis; traditional Chinese medicine; trafficking; wildlife trade .

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### Abstract

All pangolin species globally are now listed under Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) due to escalating demand for their meat and scales, often for use in traditional medicine. While China has introduced pangolin trade restrictions, the country continues to represent the largest market and destination for pangolin products. We summarize pangolin seizure data reported in public media from 2008 to 2016, incorporating often neglected small seizures reported in Chinese. During that period, the equivalent of 65,849 pangolin individuals (23,109 individuals and 21,377 kg of scales) was recorded in 206 seizures in China. Using social network analysis, Guangzhou, Fangchenggang, and Kunming were identified as key nodes of the illegal pangolin market. Our work highlights the scale and scope of pangolin trade in China, applies novel methods for analyzing trade patterns, and offers guidance for future law enforcement and policy interventions for combatting wildlife trade internationally.

### Introduction

Illegal wildlife trade is estimated to be among the most lucrative illicit businesses in the world (Nellemann *et al.* 2016). Wildlife trafficking represents a significant threat to world biodiversity (Sodhi *et al.* 2004). Regulation of this trade is critical for the conservation of many species, as is enforcement of regulations to restrict trade and reduction of demand for illegal wildlife, among other important interventions (Schneider 2008; Oldfield 2014).

Pangolins have been particularly hard-hit by trafficking in recent years (Liu & Weng 2014). China is the largest market for pangolins globally with an estimated demand for as many as 200,000 individual pangolins per year (Wu & Ma 2007; Challender *et al.* 2015; Nijman *et al.* 2016). Escalating demand for pangolin meat and scales in traditional Chinese medicine (TCM) has been a significant factor in the recent recategorization in the IUCN Red List status of all eight pangolin species, two of which are now critically endangered and two endangered (Challender *et al.* 2014). All four Asian species are actively traded in the region (Challender *et al.* 2015; Zhang *et al.* 2015), and since 2008 evidence for African species being traded

in Asia has additionally highlighted the internationalization and growing complexity of the pangolin market (Challender & Hywood 2012; Zhang *et al.* 2015).

Accordingly, interventions imposed within China can exert significant influence in reducing pangolin trade and remains a key conservation priority. Existing studies from global databases often focus on national scales, which provide limited practical application for law enforcement (Challender *et al.* 2015). On the other hand, local studies lack a broader perspective without specific source or destination data, which can also constrain conservation efforts (Nijman *et al.* 2016). A comprehensive approach linking local trade to global patterns of pangolin species is needed to identify targeted policy and enforcement efforts.

Social network analysis, a tool recently been applied in criminology including the illegal wildlife trade (Patel *et al.* 2015; Hinsley *et al.* 2016), could potentially meet these demands. Digital media reports of wildlife seizures represent a useful source of data on illegal markets despite imperfections and incompleteness (Hansen *et al.* 2012). Seizure data are collected with inherent biases in that not all trades are seized and not all seizures are reported.

Nonetheless, market analyses using seizure data reveal important patterns in wildlife trade when these limitations are adequately acknowledged (Stoner & Pervushina 2013; Underwood *et al.* 2013; Challender *et al.* 2015).

We summarized recent pangolin seizure data reported in public media from China between 2008 and 2016, including often neglected small seizure incidents reported in Chinese. We used social network analysis to quantify trade patterns and identify key cities within China where law enforcement and other interventions can more effectively limit pangolin trade. We also analyzed the network with respect to source countries in order to quantify how local patterns (within China) correspond to global trends in the illegal pangolin market.

## Methods

We conducted a comprehensive search in Google using key Chinese words meaning “pangolin” and “seized” (i.e., “穿山甲,” “查获,” “截获,” “走私,” “没收”) from the years 2008 to March 2016. Searches were done for each year until no further results pages appeared. For each seizure incident covered in public media (e.g., news reports, press releases, etc.), we recorded the year of the seizure, the quantity or weight of pangolins/pangolin products, the trade source and destination (in China or abroad if provided), and the form of transportation used. As most reports documented how many individuals were found, we standardized scale quantity into individuals using an estimate of 0.5 kg of scales per individual. This ratio varies by species and by water content, but ranges from 0.36 to 0.57 kg (Yang *et al.* 2010; Zhou *et al.* 2012). Unfortunately, in most cases, media reports do not identify the species of pangolin seized and so analyses at the species level were not possible. Seizures reported in units of boxes were not included in our analysis. We also checked online court verdicts of prosecutions for quantity estimates (<http://wenshu.court.gov.cn>, in Chinese, since 2013) by searching key words “location,” “year,” and “pangolin” in Chinese for each seizure. For replicated reports within our database, we selected the earliest date as the most valid. Although we attempted to include all seizure information online for the study period, our seizure data are likely biased given uncertainty in law enforcement intensity and media coverage rate through the years. In this case, interpretation of the results should be treated with some caution; for example, the seizures recorded here will represent an underestimate of the true extent of the illegal pangolin trade.

Beyond quantifying seizures, we conducted analyses with seizures that had both source and destination information within China. In the analysis of the market network, we considered three indices: betweenness

centrality, degree centrality, and fragmentation (Patel *et al.* 2015). Betweenness quantifies the shortest pathways through a city from source to destination. The higher a city’s betweenness value, the more important it is in the trade flow and the more control it has over the downstream or upstream trajectory of trade flow. Two betweenness values were calculated; Borgatti’s target betweenness and Borgatti’s source betweenness, which vary by placing greater influence on the first and last intermediating vertices, respectively (Butts 2010). Degree is a direct measurement of a city’s importance in receiving and giving. It can be further separated by examining “in-degree” and “outdegree,” respectively, both weighted by the number of trade flow through connections. Fragmentation is traced back to “Borgatti’s key player problem” (Borgatti 2006) that sets out to find the cities that most affect the intactness of the network; either cities that could reach out to other cities most efficiently—reciprocal distance (positive), or that most seriously fragment the trade network—fragmentation index (negative). These three basic metrics have been used in wildlife trade previously (Patel *et al.* 2015) as well as in other fields such as epidemiology (Ortiz-Pelaez *et al.* 2006).

We further validated the robustness of our results by bootstrapping the trade links 1,000 times with replacement (Lusseau *et al.* 2008). We used bootstrapping with replacement to increase the independence of the resampling process and produce conservative results (Duval *et al.* 2010). For fragmentation, we restricted our analyses with undirected flow between cities (i.e., trade could happen from both cities A to B and from cities B to A) and without weight (i.e., the amount of trade is not considered) (Patel *et al.* 2015). In addition, no bootstrapping was executed for reciprocal distances. Betweenness and degree centrality were calculated in R (R Core Development Team 2014) with the package “sna” (Butts 2010) with direction considered. Key players were identified through the software Keyplayer1.45 (Borgatti 2014) assuming that trade was possible in both directions.

Circos ([www.circos.ca](http://www.circos.ca)) was used to visualize pangolin trade networks in a circular layout to improve flow readability. Circular graphs were produced for two network regimes: source country with imported cities and cities within China. In each regime, both trade flow (incident number) between cities and the scale of trade (pangolin equivalent numbers/amounts) were visualized based on seizure data.

## Results

From January 2008 to March 2016, 21,377 kg of scales and 23,109 individual pangolins were recorded in a total of 206 seizure reports, equivalent to 65,849 individuals

in sum. Of these seizures, 148 (representing 88% of the total seizure individual equivalents) had source and destination information used in the network analyses. In addition to these data on scale weights and individual numbers, another six boxes of scales of unspecified volumes were also reported in media reports, which are not included in further analyses. The illegal trade recorded here is far greater than trade volumes reported in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Trade Database (<http://trade.cites.org/>), in which 7,291 kg of scales and 117 individuals were imported to China between 2008 and 2015. Detailed information for seizures can be found in Figure S1 and Supporting Information S1.

The network graph of the illegal pangolin market in China highlights important locations of trade (Figure 1). When considering seizure incident number, Fangchenggang (Guangxi), Dehong (Yunnan), and Shenzhen (Guangdong), border cities with Vietnam, Myanmar, and Hong Kong, respectively, were the largest import cities (Figure 1a). As for pangolin individual equivalents seized, Fangchenggang still ranked as the highest, with Hong Kong second, and Jiangmen third (Figure 1b). Similarly, circular graphs of domestic trade showed that when considering seizure incident numbers, Fangchenggang was the largest supply city within China as a consequence of its large import quantities; Kunming (Yunnan) and Guangzhou (Guangdong) were key connection points, with both playing an important role in import and transport of pangolins to other cities in China (Figure 1c). With respect to total pangolin numbers, the highest number of individuals passed through Guangzhou, while Kunming and Beihai (Guangxi) were important connection cities, and Fangchenggang and Dehong were the largest supply cities for other cities in China (Figure 1d). We also found that transportation mode for which seizures took place varied across cities, e.g., private vehicles represent the majority of seizures only in Fangchenggang (Figure 2).

Degree centrality highlighted Fangchenggang as the top indegree (importer) and among the top five outdegree (exporter) cities in both seizure incident numbers and amounts (Table 1) and Vietnam was the top outdegree country in both seizure incident numbers and amounts. Bootstrapping, however, identified the top indegree city as Kunming instead of Fangchenggang in both seizure quantity and incident numbers (Tables S2 and S3).

Betweenness centrality showed that for all indices, Guangzhou had the highest betweenness value (highest influence on pangolin transfer), followed by Changsha and Kunming (Table 2). Bootstrapping results, however, supported Kunming as the top city for all betweenness indices (Tables S2 and S3).

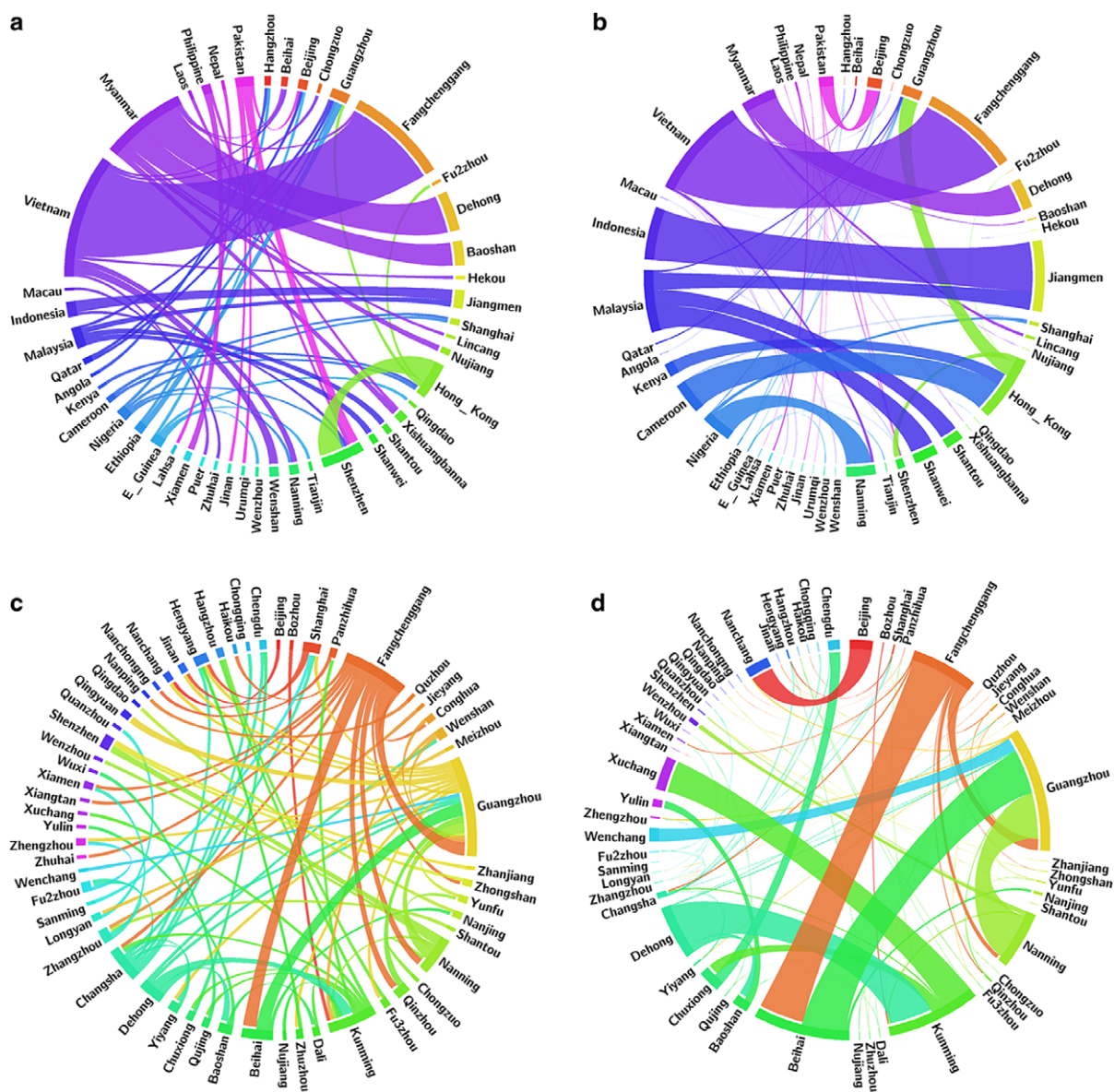
The fragmentation index showed that elimination of trade in six cities could reduce the total trade volume by almost 90% in both seizure amount and incident numbers (Table 3). Kunming had the highest fragmentation rank (Table 3). For reciprocal distance, six cities were found to account for 94% of the incident numbers network and Guangzhou alone could account for 47%. However, the seizure amount network only built up to 19% of the full network with the top five important cities (Table 4). Bootstrapping for fragmentation identified Guangzhou as the most important city (i.e., key player that could best fragment the network) in the seizure amount network (Table S4).

## Discussion

Our study on pangolin seizures in China over the past several years provides potentially important insights into leverage points to disrupt the international illegal pangolin market. Guangzhou, Kunming, and Fangchenggang were identified as key target cities in terms of trade flow (degree centrality), trade control (betweenness centrality), and market intactness (fragmentation). The results suggest that interventions in these cities could have a disproportionately strong impact on the entire illegal pangolin trade network. We also identified Vietnam as the largest volume source country for illegal pangolins seized in China. Additionally, several other countries in Southeast Asia (Malaysia, Myanmar) and Africa (Nigeria, Cameroon, and Kenya) represent key sources, supporting earlier work on the subject (Liu & Weng 2014; Challender *et al.* 2015; Zhang *et al.* 2015; Nijman *et al.* 2016). However, countries (sources) and cities other than those identified by this study may also be important; if large trade volumes exist in other cities that have escaped law enforcement, these cities would not likely be identified by our seizure-dependent analysis. Our identification of source countries also only represents the location from which pangolins were shipped into China and not necessarily where the animals were actually hunted.

Of the key cities, Guangzhou tops almost all indices in our analysis. Pangolin consumption has become a status symbol as both scarcity and demand have increased, and Guangzhou has the highest reported rate of wildlife consumption in China (Zhang & Yin 2014). Connected to the South China Sea by the Pearl River and situated within a hub of highways and railways crossing southern China, Guangzhou's transit accessibility can complicate enforcement. Kunming is another important trade nexus where pangolins are efficiently imported from Myanmar and Vietnam. The recent recognition of Myanmar as an important route for wildlife trafficking into China accords with the pattern we observed (Nijman *et al.* 2016).

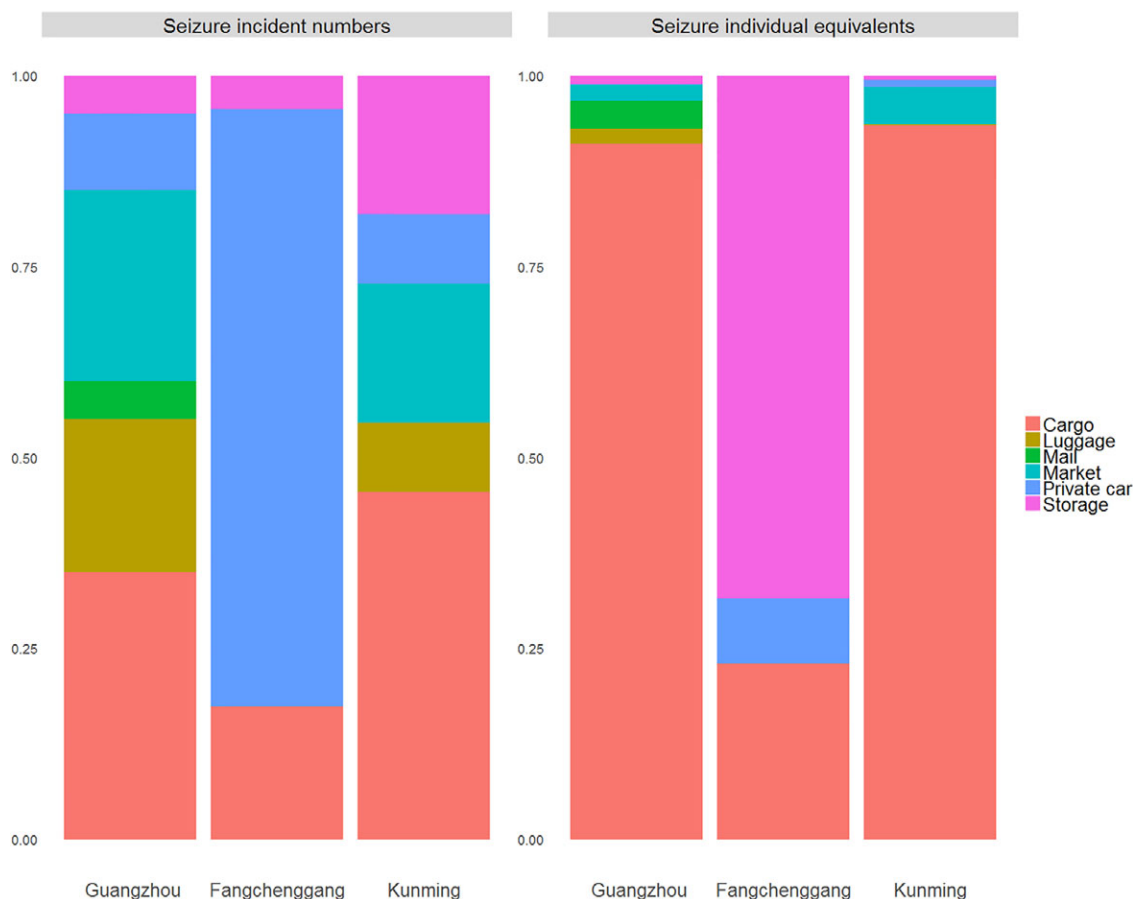




**Figure 1** Circular graph of pangolin trade network between cities and countries in seizure incident number (a, c) and total amount (pangolin individual equivalents) (b, d), including international (a, b) and domestic trade (c, d). Width of the connection band represents size. A gap between the connection band and a different colored ring bar indicates import, otherwise the band represents export.

Similarly, Fangchenggang marks another major entry point for pangolins transported from Vietnam to China, consistent with Vietnam’s increasing role in illegal wildlife trade (Ngoc & Wyatt 2013). Under China’s recent “one belt, one road” policy (Kennedy & Parker 2015), infrastructure projects are well underway in these relatively isolated southwestern cities (Fangchenggang and Kunming). As transportation conditions improve significantly, the potential impact of these trading routes needs to be closely monitored (Nijman et al. 2016).

Effective enforcement is essential in upholding laws and policies regulating wildlife trade (Oldfield 2014). Our results could aid Chinese law enforcement parties in the disruption of pangolin trade routes with intensified inspection of vehicles and cargo (Figure 2) in identified key cities. This would require significant cooperation and coordination between China’s dispersed law enforcement parties: customs in screening cargo, urban administrative police in inspecting of markets, traffic police in checking private cars, People’s Armed Police, and forestry



**Figure 2** Locations of pangolin seizures in three key cities; Guangzhou, Kunming, and Fangchenggang in amount (pangolin individual equivalents) and seizure incident number by percentage. Cargo represents pangolins found with other bulk shipments or goods; luggage represents personal luggage; mail is a delivered mail package; market represents restaurants, TCM market or food market; private car represents personal small sedan-like car; storage represents seizures found in a warehouse by accident or confession of relevant or associated crime.

police in monitoring borders and remote areas (Zhang *et al.* 2008). China has also recently established its newly revised “Wild Animal Protection Law” that will commence January 2017, with changes, for the first time stating that consumption of wildlife parts is illegal with a fine 2–10 times the approximate value of illegal seizures and jail sentences for serious cases (Xinhuanet 2016). The recent decision to list all eight pangolin species under

Appendix I of CITES, and the resulting ban of international trade in all eight species will additionally compel greater national-level enforcement and public outreach. These positive policy developments are promising, but pending implementation their effectiveness remains to be seen.

While the market network described here could be key in identifying locations for increased enforcement to

**Table 1** Degree centrality (flow of trade) ranks of countries and cities for the seizure amount (pangolin individual equivalents) and incident number networks

Rank	Indegree (amount)	Outdegree (amount)	Indegree (incident number)	Outdegree (incident number)
1	Fangchenggang	Vietnam	Fangchenggang	Vietnam
2	Guangzhou	Indonesia	Guangzhou	Myanmar
3	Jiangmen	Malaysia	Shenzhen	Fangchenggang
4	Hong Kong	Fangchenggang	Dehong	Guangzhou, Hong Kong
5	Nanning	Myanmar	Baoshan	Nanning

**Table 2** Betweenness centrality (number of shared routes through a city, weighed by source and destination) of countries and cities for the seizure amount (pangolin individual equivalents) and incident number networks

Rank	Betweenness (amount)	Borgatti's source betweenness (amount)	Borgatti's destination betweenness (amount)	Betweenness (incident number)	Borgatti's source (incident number)	Borgatti's destination (incident number)
1	Guangzhou	Guangzhou	Guangzhou	Guangzhou	Guangzhou	Guangzhou
2	Kunming	Changsha	Kunming	Kunming	Changsha	Kunming
3	Changsha	Kunming	Nanning	Changsha	Kunming	Nanning
4	Nanning	Nanning	Changsha	Nanning	Nanning	Fangchenggang
5	Yiyang	Fuzhou	Hong Kong	Yiyang	Fangchenggang	Changsha

**Table 3** Key players identified based on fragmentation index (which cities would most negatively affect the network intactness if removed) for networks of seizure amount (pangolin individual equivalents) and incident number

Cities (amount)	Fragmentation index (amount)	Cities (incident number)	Fragmentation index (incident number)
Kunming	0.348	Kunming	0.309
Kunming, Dehong	0.504	Kunming, Guangzhou	0.44
Kunming, Guangzhou, Vietnam	0.665	Kunming, Guangzhou, Fangchenggang	0.56
Kunming, Guangzhou, Vietnam, Shenzhen	0.74	Kunming, Guangzhou, Fangchenggang, Shenzhen	0.663
Kunming, Guangzhou, Fangchenggang, Shenzhen, Shanghai	0.835	Kunming, Guangzhou, Fangchenggang, Shenzhen, Shanghai	0.835
Kunming, Guangzhou, Fangchenggang, Shenzhen, Shanghai, Vietnam	0.906	Kunming, Guangzhou, Fangchenggang, Shenzhen, Shanghai, Equatorial Guinea	0.888

**Table 4** Key players identified based on the reciprocal distance index (cities that could most positively affect network intactness) for networks of seizure amount (pangolin individual equivalents) and incident number

Cities (amount)	Reciprocal distance index (amount)	Cities (incident number)	Reciprocal distance index (incident number)
Guangzhou	5.3%	Guangzhou	47.0%
Kunming, Guangzhou	9.3%	Kunming, Guangzhou	56.2%
Kunming, Guangzhou, Fangchenggang	12.40%	Kunming, Guangzhou, Fangchenggang	63.4%
Kunming, Guangzhou, Fangchenggang, Zhangzhou	14.8%	Kunming, Guangzhou, Fangchenggang, Vietnam	67.5%
Kunming, Guangzhou, Fangchenggang, Zhangzhou, Urmqi	17.2%	Kunming, Guangzhou, Fangchenggang, Vietnam, Equatorial Guinea	71.9%
Kunming, Guangzhou, Fangchenggang, Zhangzhou, Urmqi, Xishuangbanna	19.3%	Kunming, Guangzhou, Fangchenggang, Vietnam, Shanghai, Shenzhen	94.3%

help curb pangolin trade (Phelps *et al.* 2014), pangolin conservation will also require additional interventions beyond seizures and penalties. Social marketing and public education, demand reduction, and conservation awareness programs will all be crucial components of a successful and integrated conservation program in China, and in other pangolin range states (Zhang *et al.* 2008; Challender & MacMillan 2014; Zhou *et al.* 2015). One priority should be the spread of information about pangolins and the environmental consequences of their use in TCM to the general public to change attitudes regarding

pangolin exploitation (Liu & Weng 2014) and emphasize that no reliable clinical efficacy of scales has been reported. Despite challenges and variation in the efficacy of outreach campaigns, successful attempts to reduce shark fin consumption in China through conservation campaigns (led by government agencies as well as local and international conservation organizations) in recent years offer a positive example for such initiatives (Eriksson & Clarke 2015).

Development of an interactive online database of detailed seizure times and locations could also be

established and has been highlighted as a research priority in the pangolin IUCN SSC conservation action plan (Challender *et al.* 2014). Establishing country-wide comprehensive platforms comparable to ETIS (Elephant Trade Information System) (Underwood *et al.* 2013) and encouraging greater reporting of trading and consumption through Chinese social media (e.g., Weibo and Wechat) could also produce finer-scale data for future analyses of market trends and additional targeted interventions. Nongovernmental organizations within China could also supplement seizure data through market surveys to determine demand and consumption dynamics.

Several additional research priorities remain which could aid pangolin conservation efforts in China and abroad. A major gap in our own study was a lack of species information in most seizure reports. To address this, further development of genetic forensics offers a promising way forward in identification of species (and possibly geographic origins) for pangolin seizures (Zhang *et al.* 2015). Finally, the consequences of trade regulations and laws (e.g., CITES) must be fully understood and implemented within complex market dynamics—for example, price trends should be closely monitored and considered to determine the impact of changes in trade regulation (Challender *et al.* 2015; Harris *et al.* 2016).

The results presented here likely have implications that go beyond pangolins. China is a major importer of an immense variety of wildlife, particularly from Southeast Asia, but details of trade markets within the country are limited (Nijman 2010). TCM, in particular, has driven the demand and consequent population declines experienced by several iconic species including rhinoceroses and tigers (Graham-Rowe 2011). Particularly worrying are recent and massive African elephant declines driven by ivory demand in China (Wittemyer *et al.* 2014). Despite inherent uncertainties and biases in seizure data, social network analyses can be used to tackle the grand conservation challenge of illegal wildlife trade centered in China (Patel *et al.* 2015). When data are available (e.g., proxy variables) for seizure rates and reporting rates, additional tools such as Bayesian approaches can also improve quantifications of trade trends (Underwood *et al.* 2013).

Finally, ongoing studies of this nature highlight the importance of culturally informed and intracountry trade data in identifying the most destructive pathways that must be managed in order to address conservation challenges within China and globally. It is not sufficient to simply note that China is driving wildlife declines. Studies that link local and global patterns, as we have outlined here, best demonstrate the multiple scales at which such markets operate and present the best hope for identifying where actions should be taken to reduce trade and who

(which city, agency, ministry, etc.) should be responsible for those actions.

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## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

**Figure S1:** Pangolins seized in amount (pangolin individual equivalents) and seizure incident numbers over the study period.

**Table S1:** Dataset

**Table S2:** Bootstrapping results for betweenness and degree centrality for seizure amount by percentage

**Table S3:** Bootstrapping results for betweenness and degree centrality for seizure times in percentage

**Table S4:** Bootstrapping results for key players based on fragmentation index for seizure amount (pangolin individual equivalents)

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