Online trade in wildlife and the lack of response to COVID-19

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Abstract

Wildlife trade has been widely discussed as a likely origin of the COVID-19 pandemic. It remains unclear how the main actors in the wildlife trade chain responded to these discussions and to the campaigns advocating wildlife trade bans. We analyzed the content of ~ 20,000 posts on 41 Facebook groups devoted to wild pet trade and ran a breakpoint and a content analysis to assess when and how the COVID-19 pandemic was incorporated into the discourse within trade communities. Only 0.44% of advertisements mentioned COVID-19, mostly after WHO declared COVID-19 a pandemic. No traders discussed the role of trade in spreading diseases; instead, posts stimulated the trade in wild species during lockdown. COVID-19 potentially offers persuasive arguments for reducing wildlife trade and consumption. This effect was not demonstrated by on-the-ground actors involved in this market. Bans in wildlife trade will not be sufficient and additional strategies are clearly needed.

Keywords: behavior change, COVID-19, online trade, pet trade, wildlife trade ban.

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1 Introduction

Amidst the current global pandemic of COVID-19 (respiratory disease caused by the virus SARS-CoV-2), the topic of emerging infectious diseases (EID) has come to the spotlight once again (Morens et al. 2020). The World Health Organization (WHO) defines EID as those diseases that appear or reappear in a population and that demonstrate a rapid spreading in terms of the number of infected people or new geographical areas (WHO, 2014). Many of these EID are zoonoses, i.e. the disease has originated from an animal and crossed the species barrier to infect humans (e.g. Nipah virus - Epstein et al. 2006).

Human animal transmission has been documented in all three deadly outbreaks of *beta*-coronaviruses, including SARS-CoV, MERS-CoV and SARS CoV-2. These viruses were responsible for outbreaks of severe acute respiratory syndrome (SARS) in 2002, Middle East respiratory syndrome (MERS) in 2012 and COVID-19 in 2019 respectively (Ye et al., 2020). While still too early to assess in SARS-CoV-2, it has been suggested that the highly pathogenic SARS-CoV and MERS-CoV have not adapted sufficiently to humans to exclude the need for animal reservoirs to maintain and propagate themselves (Ye et al., 2020). In this sense, wild animals, even when not the natural reservoir of a coronavirus, may serve as the intermediate amplifying host (Ye et al., 2020). Natural infection by SARS-CoV was identified in wild-caught masked palm civets (*Paguma larvata*) for sale in wildlife markets, but was not present in farmed civets (Guan et al., 2003). Further, it was found that 40% (n=8) of wild-animal traders and 20% (n=3) of workers who slaughtered animals showed presence of anti-bodies to SARS-CoV, however only 5% (n=1) of vegetable traders and none of the human controls (n=60) were seropositive (Guan et al., 2003). Additionally, phylogenetic differences between human and animal S-CoV viruses indicate that, in this case, transmission from humans to animals is highly unlikely (Guan et al., 2003). Although no natural wild reservoir has been confirmed, the hypothesis of a wild civet-to-human transmission pathway brought attention to the role of live-animal markets in increasing the opportunity for transmission of infection to humans (Guan at al., 2003). The potential for infection was emphasized because in many live-animal markets, animals such as poultry, fish, reptiles, and mammals are slaughtered on the spot, and either legally or illegally traded as medicines, meat and pets (Webster, 2004).

For COVID-19, although not yet confirmed, it was initially reported that the intermediate animal hosts of SARS-CoV-2, the virus responsible for the COVID-19 pandemic, were among the wildlife species sold and killed in a live-animal market in Wuhan, where many of the initial

COVID-19 cases were associated (Ye et al., 2020). As a precaution to the possibility that some animals in that live-animal market were involved in the SARS-CoV-2 epidemic, China issued a nationwide ban on terrestrial wild animal consumption, including captive-bred exotic species (Wang et al., 2020). Subsequently, the potential association of COVID-19 with wet markets featured in the media drew attention from those who disagreed with wild animal consumption; thus petitions and campaigns emerged to discourage the purchase of wildlife products and to demand governments to ban wildlife trade in several countries (e.g. Anonymous, 2020a,b).

While the ultimate impact on wild populations remains unclear, some have argued that these measures could be a blessing in disguise for wildlife if halting wild animal trade reduces over-harvesting and limits the contact between human populations and wild species (Pearson et al., 2020). It has been shown, however, that when prohibitions are implemented, clandestine markets often expand to supply the demand; in this context, wildlife trade prevails and monitoring becomes nearly impossible (Harrison et al., 2016). Thus, consumer behavior change, which involves promoting a reduction on the demand for wildlife by understanding consumer's motivations and preferences, has been suggested as a complementary or alternative strategy to blanket bans (Veríssimo & Wan, 2019). The hypothetical but well-advertised link between the COVID-19 pandemic and wildlife trade may reduce consumer demand for wild animals. For instance, when domestic pets and animals from zoos tested positive for COVID-19 after having contact with infected humans, the fear of pets spreading the disease, even with no scientific evidence, resulted in pets being abandoned or killed worldwide (Parry, 2020). It remains yet unknown whether on-the-ground actors involved in the wildlife trade responded to the COVID-19 pandemic and campaigns dissuading wildlife trade or discouraging consumer desire at some level.

Here, we aimed to assess whether, when and how COVID-19 was incorporated into the discourse of traders and consumers of wild animals when selling or purchasing wild species online as pets, and the need of additional strategies to curb wildlife pet trade. Physical wildlife markets may have been forced to close or lessen due to measures to slow the spread of COVID-19. Trade via Web 2.0 platforms such as Instagram and Facebook have already largely replaced brick and mortar trade in many countries (Lavorgna, 2015; Sung & Fong, 2018; Siriwat & Nijman, 2020) and does not suffer the same limitations. For this reason, we recorded the occurrence of wildlife trade over 20,000 posts on 41 social media groups devoted to wild pet trade in two megadiverse countries during the COVID-19 pandemic and examined mentions

of pandemic-related terms in posts uploaded by vendors and potential consumers. We discuss our findings in the light of the potential for behavior change in relation to trading and purchasing wildlife.

2 Methods

2.1 Data collection

We monitored the online trade in two megadiverse countries, Indonesia and Brazil, over seven weeks between 15 February and 5 April 2020. We focused on the early phase of the COVID-19 pandemic, when the public attention was concentrated on the origin of the pandemic associated with wildlife wet markets. We monitored 31 Facebook groups in Indonesia and ten Facebook groups in Brazil, previously known to advertise wildlife for sale. There is minimal overlap of membership between these geographically and language-specific groups. We recorded the total number of posts uploaded during the period and the number of members. For each post, we recorded the number of comments and likes. We compiled the number and content of the posts containing reference to 'COVID-19', 'corona virus', 'lockdown' or 'quarantine', in Bahasa Indonesia for Indonesia and Portuguese for Brazil. We anonymized all records and we did not interact directly with any of the sellers, group members or administrators (following Siriwat et al. 2019's ethical considerations).

2.2 Data Analysis

We conducted a linear regression analysis to assess the trends of accumulated number of posts related to COVID-19. Afterwards, we ran a break point analysis to investigate any links between the main pandemic landmarks – first case reported, national lockdown, and World Health Organization (WHO) classifying COVID-19 as a pandemic (Ali et al., 2020) – and the incorporation of COVID-19-related terms into the advertisements. We used the function 'breakpoints' in the R-package 'strucchange' (version: 1.5-2), which informs the existence of structural changes in linear regression models. For the statistical analysis we used R software (version 3.6.3) and considered significance at $p < 0.05$.

We translated the text content of the posts related to COVID-19 from both countries into English and ran it through the content analysis software Leximancer (version 4.5.1). This program uses automated machine learning to create a concept map that details the most significant themes and concepts in posts using an algorithm that analyses word frequency and co-occurrences. A 'Topical analysis' using a linear clustering algorithm was chosen as it is the

most appropriate for discriminant analysis and provides stability where overlapping of themes occur (Wilk et al., 2017). The program uses weighted word frequencies to identify 'concepts' (displayed as gray circles and identified with black text) that are grouped together with similar 'concepts' to show broader 'themes', identified with colored circles. This process produces a concept map output that can be read as a heat map, such that the warmer the color of the theme, the more salient it is within the data. The higher the number of concepts within a theme implies that it is more prevalent in the text; the size of the circle itself is not indicative of importance. The more overlap the themes have with one another the more linked the two are within the text and direct lines between concepts suggests that they are directly linked through co-occurrence.

3 Results

We compiled 20,615 advertisements including legal and illegal wild species or wildlife-related products – 11,243 in Indonesia and 9,372 in Brazil – posted on the monitored groups. Of these, only 90 posts (0.44% of the total) contained expressions related to COVID-19. Together, the groups presented a potential to reach an upper bound of 201,803 members. The largest monitored group was found in Brazil, which holds around 45,000 members, but the average number of members was 9,305 (SD 1,355). For Indonesia the largest group had 27,253 members, but the average number of members was 5,254 (SD 6,769). The average number of comments per post was 5 (SD 6.7).

The first posts mentioning COVID-19 were published right after the first case confirmed in Brazil and slightly before the first case confirmed in Indonesia (Figure 1). For both countries, there was a significant increase in the number of COVID-19-related posts over time (Brazil: R^2=0.91, R=0.95, p<0.01; Indonesia: R^2=0.65, R=0.80, p<0.01). The break point analysis showed that in the week of 11 March 2020, which coincided with when WHO declared the disease as a pandemic, there was a major change in the number posts related to COVID-19 for Brazil (09 March 2020 ± 1 day CI, F=88.15, p < 0.01). The same happened a week later for Indonesia (20 March 2020 ± 1 day CI, F=563.85, p<0.01) (Figure 1).

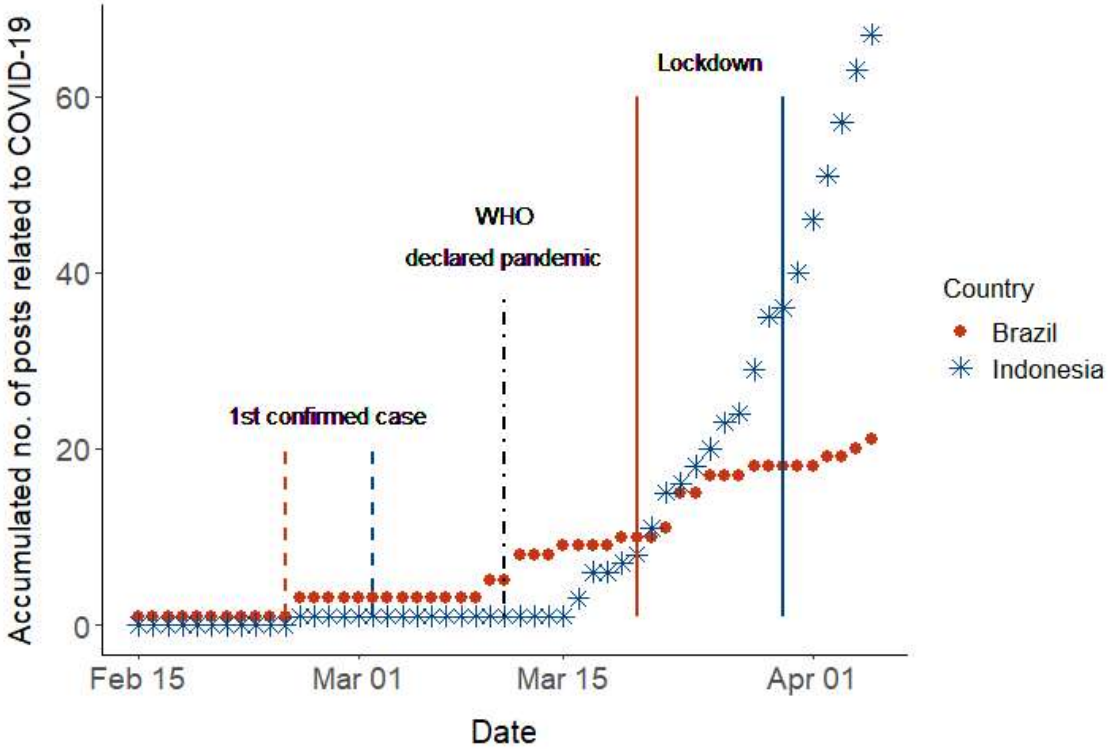

Figure 1. Accumulated number of posts with COVID-19-related content on Facebook groups focused on wildlife trade in Indonesia and Brazil, with the respective important landmarks, i.e. first confirmed case and decreed lockdown in each country and WHO classifying COVID-19 as pandemic.

The topical concept map identified *Sales* to be the most prominent theme within the discourse, followed by '*COVID-19'* and '*lockdown'* (Figure 2). The importance of the theme was supported by the clear overlap and close connection between the concepts *recommend, services, delivery services, transport* and *time*, all of which reflect the traders' ability to complete their sale successfully and deliver their product to the consumer. This theme also showed direct links to the themes *sorry* and *WhatsApp*, which were found to be due to the traders apologizing for delays in delivery and offering further information using the mobile application WhatsApp, which offers encrypted messaging services (Figure 2).

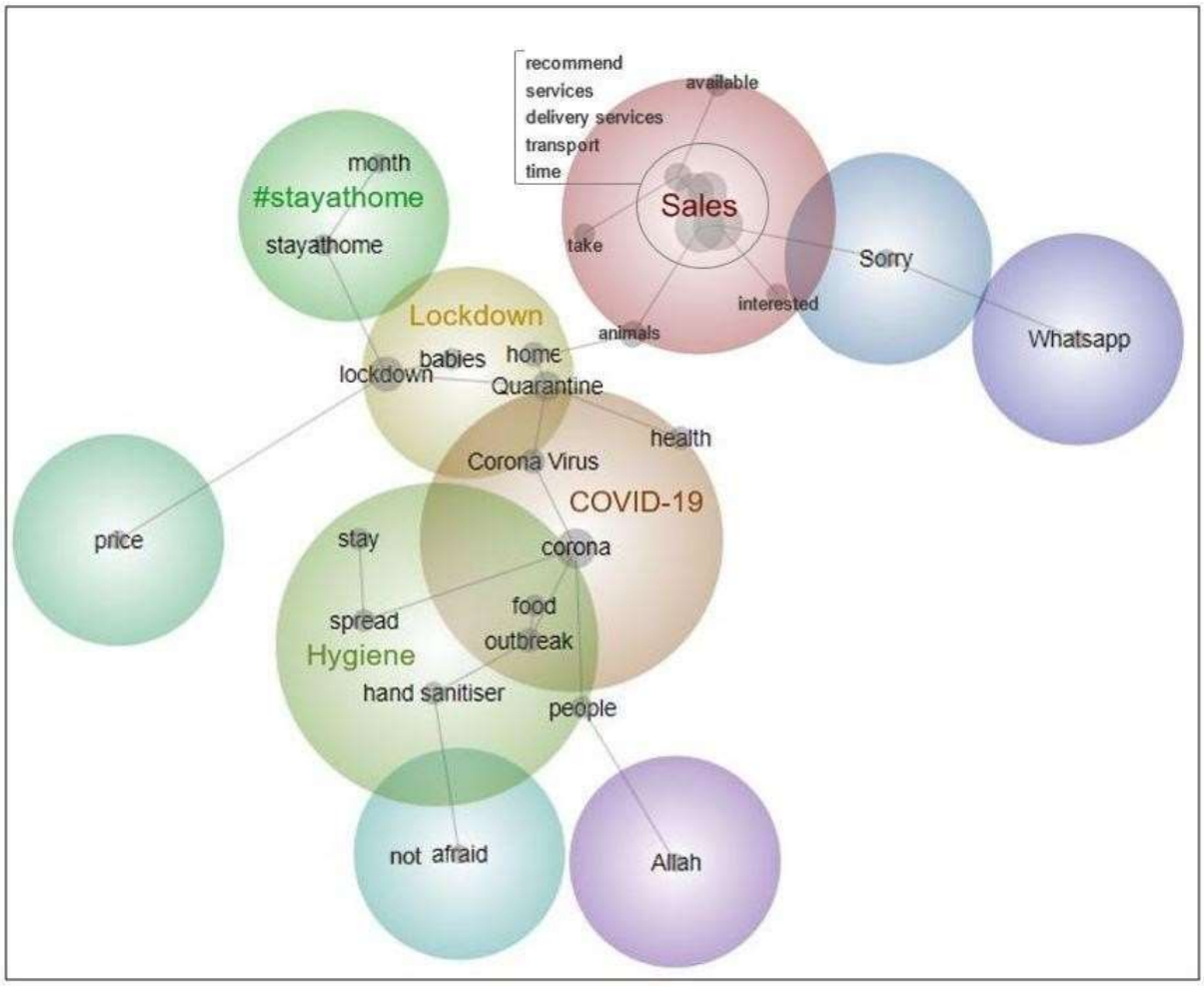

Figure 2. Heat map showing the greatest overlap between the concepts *recommend, services, delivery services, transport* and *time*, and the most prominent themes: *Sales* (red), followed by *COVID-19* (orange) and *Lockdown* (yellow). The warmer the colors (i.e. the closer to red tones) the more salient the theme is within the data. The size of the circle does not indicate importance.

The second most important theme was *COVID-19*, reflecting that while all posts refer to COVID-19 or lockdown within their text, more posts mentioned it only as context to their trading activities, such as delivery delays, as opposed to discussing the impact or risk of the virus actively as their main thought. Three posts from Brazil specifically mentioned the link between animals and COVID-19: two of them stated that animals could not be infected with or transmit COVID-19 and one linked the outbreak to Asian pangolins (*Manis* spp.). One post from Indonesia mentioned the link between SARS and wildlife but prompted no discussion regarding COVID-19. Where posts did have the main theme of COVID-19 itself, the concepts were mostly linked around personal health and hygiene (Table 1).

Table 1. Illustrative quotes from the posts and comments that were qualitatively analyzed show no discourse that positively links the wildlife trade to the spread of COVID-19.

Country	Posting date	Content of the post
Indonesia	1/4/2020	All available, ready to be sold. Lovebird babies and adults. If you come to the warehouse, we will have hand sanitizer to prevent the spread of *Corona Virus*.
Indonesia	31/3/2020	Baby long-tailed macaque available, male female ready. Healthy and tame. Suitable as a *lockdown* friend.
Indonesia	28/3/2020	We are eager to fulfill the requests from government about *lockdown #stayathome*, but if our warriors, our family's backbone *#stayathome* who will take care of our household? our stomach, our children, our debt repayment? We are not those who have a bank account with zeros lined up and even when used for a month or two the money never diminishes. We are daily fighters and the impact will be felt if we don't earn a day's income. We are not following the government's plea to *#stayhome* but as I stated above if we don't work, we don't eat.
Indonesia	21/3/2020	Death is determined by Allah, so don't be scared of *corona virus*. In Banyumas, one person is infected. For people who hoarded the face masks and hand sanitizer, please donate. Please don't use it for yourself.
Indonesia	17/3/2020	Silver linings of the *corona virus*. Flowerpecker birds discount 10-30 percent. For more information please call or chat via WhatsApp.
Brazil	02/04/2020	Animals do not transmit *corona virus* to humans. There is no need to abandon or sacrifice any animal (such as we have seen in the yellow-fever outbreak when people killed monkeys).
Brazil	23/03/2020	Hello customers, I come to inform everyone that up to this date we do not have any information about likely suspension in the delivery services. We do not know how long the delivery services will be maintained during *lockdown*. To help you, we will give a 10% discount to all, and free delivery fees for São Paulo State. Stay at home!
Brazil	15/03/2020	A large proportion of mammals can be infected by a type of *corona virus*, however, COVID19 only infects humans.
Brazil	15/03/2020	It is a pangolin, a rare animal found in Asia, who they suspect that can carry *corona virus*.
Brazil	12/03/2020	I am interested in buying if you can bring me the animal because in times of *corona virus*, it is not suitable to take public transportation.

The concept *quarantine* exists on the map at the exact overlap of *lockdown* and *COVID-19*, perhaps indicating a change of meaning due to semantics between *lockdown* and *quarantine*. Within the *lockdown* theme, the only concept that did not relate specifically to staying at home was the concept *babies*. We found this to be due to the number of baby animals being offered as lockdown was deemed a good time to spend with infant animals, as one would have more time to care for them.

We identified a direct pathway between the concepts of *lockdown* and *price* as many of the traders in both countries were offering discounted prices throughout lockdown duration. The theme 'not afraid' represents a facet of the posts, in which commenters encouraged others not to be afraid of the virus, as illustrated in the quotes "*Death is determined by Allah, so don't be scared of corona virus*" and "*Only 'LosGan'* (a prestigious class of bird) *hunters aren't afraid of corona virus".* The themes *not afraid* and *Allah* were only recorded in Indonesian groups; the remaining themes were shared between Indonesian and Brazilian groups.

4 Discussion

Although there are yet few examples of confirmed clinical diseases in humans arising from the wildlife trade, this activity may have the potential to pose a threat to public health. For instance, with increased Internet access and transportation, the origins of traded animals can be (and often are) many hundreds of miles from their point of sale (Bell et al, 2004; Bush et al., 2014) and during transportation or sale, species that would not naturally contact each other are often kept close in facilities (Woo et al., 2006; Reed et al., 2004). Those are examples of paths to break existent geographical, ecological or behavioral separations between humans, livestock and wild animals, which increases the likelihood of cross-species pathogen transmission (Johnson et al., 2020). Although the COVID-19 pandemic represents a challenge for human health, it also offers an anthropocentric argument for persuading people to stop wildlife trade and consumption. Our findings show the actors involved in the trade of wild pets discussed the connection to zoonosis at a low rate, despite public outcry generated around COVID-19 and calls for widespread wildlife market bans. Among all landmarks, the WHO declaration of COVID-19 as a pandemic seems to have sparked the most engagement in COVID-19 discussions for both countries. Our breakpoint findings differ substantially to those for the number of comments containing COVID-19 related terms recorded on Twitter by Lopez et al. (2020). In their study, both Portuguese and Bahasa Indonesia comments on COVID-19 peaked

when each country had their first case confirmed. It is possible that the WHO declaration may have increased awareness of the risk posed by the virus and influenced the inclusion of COVID-19 related terms in the advertisements (Wise et al., 2020). Considering that many posts addressed concerns about maintenance of sales and delivery services due to a possible lockdown, the breakpoint reflects changes in their logistical and operational arrangements during the pandemic.

Importantly, neither sellers nor consumers discussed the risk of local wildlife trade or human-wildlife interactions as a source of spillover for zoonotic diseases on the monitored online groups. Among the c. 20,000 posts recorded, only one post in an Indonesian group shared a link from ProFauna, an Indonesian wildlife organization, quoting a Chinese doctor, Dr. Zhong Nanshan, attesting a suspicion that SARSCoV-2 had spread from wild animals in a Wuhan market; no comments were prompted by this post. This lack of response is shared by two culturally different countries assessed, one geographically close to the first COVID-19 epicenter and the second far away. Surprisingly, some of the posts and comments encouraged trade in wild animals during the pandemic, affirming that wild animals would provide good companionship during the quarantine period and promoting temporarily reduced prices to stimulate purchases before lockdown.

It is important to recognize that the degree to which people can fully comprehend a risk is based on their own lived experiences. It is possible that if the majority of the traders and consumers have not experienced a known event of direct contamination from contact with animals, they may not perceive a risk. Spillover of pathogens through a pet trade chain was unequivocally confirmed in the past, as in 2003, when a large shipment intended to supply the pet market entered in the USA containing some African rodents infected by Monkeypox virus (Reed et al., 2004). Those infected individuals were housed in close proximity to other animals at pet shop facilities, and infected prairie dogs (*Cynomys* spp.), a North American rodent (Guarner et al., 2004; Reed et al., 2004). Several people from six different states became ill exclusively after having contact with infected prairie dogs purchased as pets, and ever since the importation of African rodents is banned in the country (CDC, 2018). In addition, consumer demand for rodent species in the USA changed considerably after this event (Lankau et al. 2017). A different situation is described for Ebola, in which the natural reservoir of Ebola virus still remains unknown. Close contact with wildlife during Ebola outbreaks has been discussed as a factor of risk after some primary human infections of 2001-2003 Ebola outbreaks were traced back to butchering or contact with infected carcasses of dead gorillas, chimpanzees and duikers

in the wild (Leroy et al., 2004). After the Ebola outbreak in 2018 in the Democratic Republic of the Congo, local wild meat vendors did not consider themselves at occupational risk for infection (Lucas et al., 2020). Yet, local populations interviewed during the Ebola outbreak in West Africa recognized wild meat consumption as associated with the risk of Ebola infection. However, they did not support the decision of banning wild meat consumption because they believed the ban occurred for political reasons instead of human health concerns (Mufunda et al., 2016).

We believe a similar perception may be occurring in the case of COVID-19 and its relationship with wildlife trade. The most common way to be infected by the SARS-CoV2 is by human-to-human contact. This causality can lead to misconceptions. For example, it has been reported that Dayak hunters in Indonesian Borneo associate COVID-19 with modern life and technology due to their perception that the disease travels by plane and impacts urban areas as opposed to the isolated forests in which they live (Thung, 2020). Similarly, Shepherd et al. (2020) found from analysis of both in person interviews and online discussions that Indonesian bird traders were not convinced that Avian influenza existed. They reported that there were instead numerous theories about existence and spread of the virus, including a belief that songbird competitors from other countries had concocted it as a rumor, and determined that while it was recognized as a hindrance to acquiring birds, it was not considered a health threat to the traders. While our sample did not include any markets that were outside of urban cities, nor explore the theories or rumors regarding its origin, we believe sellers and buyers may similarly reject the association of the pandemic with their own activities if they do not experience this pathway of infection themselves. Rather, they may see the claims for banning wildlife trade as a conservationist or political debate that does not reach people involved on the ground. A study of Hong Kong inhabitants detected that 25% of the interviewees had not ceased going to live-animal markets during the pandemic. Although 70% mentioned avoiding visiting live-animal markets as a precautionary measure to prevent transmission of COVID-19, this proportion was considerably lower compared to other activities, such as going to other crowded places (93%) (Kwok et al., 2020).

There was no clear evidence that the volume of online wildlife trade decreased amidst the pandemic and we still found thousands of posts advertising wild individuals, with a potential audience of 200,000 people. These results mirror those of Ordaz-Németh et al. (2017) on wild meat consumption during the 2014-2016 Ebola outbreak. Despite widespread health and hygiene campaigns and the consequent temporary ban on wild meat trade, wild meat

consumption never stopped – although it was temporarily reduced – and some wild meat markets were still operating in West African countries during the critical phase of the Ebola outbreak (Georges-Courbot et al., 1997; Leroy, 2004; Lucas et al., 2020). In contrast, the 2003 outbreak of Avian Flu, Influenza A (H5N1), originated from domestic birds, and the 2009 outbreak of Swine Flu, Influenza A (H1N1), originated from farmed pigs, caused the consumption and export of poultry and pork to decrease substantially, especially as a result of consumers' fear of being infected by consuming the meat (Taha, 2007; Rassy & Smith, 2013). It is unclear whether this pattern demonstrates a difference in consumer perception of wild and domestic species, given that the knowledge of zoonosis from pigs and poultry is established and sustained by the educational system and cultural practices (Burniston et al., 2015; Kuiken et al., 2012; Pappas, 2013), or whether it is a result of nomenclature, with pandemics named after vector species creating more evocative mental imagery and a stronger association between the species and the disease in consumers' minds (Mikhailitchenko et al., 2009).

The intense media coverage and public pressure to ban wildlife trade and consumption in Asian countries, such as China and Vietnam, may contribute to encourage the development of governmental policies on the matter (Carpenter and Song 2016; TRAFFIC, 2020). We found no evidence that they produce behavioral or attitudinal changes within the trade actors selling online. Behavior change literature has shown that health initiatives that aim to reduce risky behaviors trigger *psychological reactance* in which the campaign viewer becomes angry that their behaviors and freedoms are being restricted (Kim et al., 2020). This reaction has been best illustrated with respect to COVID-19 through the commitment to health and hygiene initiatives (Kirk & Rifkin, 2020); it appears possible that this is occurring within wildlife trade communities as well. Campaigns aimed at reducing wildlife trade deal with a complex and uncertain scenario, in which interventions must be context-specific to reduce the impact of psychological pushbacks and increase the likelihood of success (Esmail et al., 2020; Thomas-Walters et al., 2020). The majority of interventions aimed at reducing wildlife demand still do not result in major behavior changes; for instance, only 8% of the target audience changed their behavior due to the mediated health campaigns (Thomas-Walters et al., 2020).

Although associating wildlife trade with the COVID-19 pandemic initially seemed like an opportune behavior change campaign, we could not find evidence that it discourages trade in wild pet markets. Governments, private sectors and communities have to work in collaborative partnerships to develop strategies that also include stakeholders directly involved in the trade (Roe et al., 2020). Additional efforts are needed to ensure that stakeholders interpret the

information on discouraging trade, especially if unregulated or illegal, as economically, morally and medically relevant. In addition, we still lack information on the transmissibility of different zoonosis between humans and wildlife, especially the mode of transmission and the role of intermediate hosts (Daszak et al., 2007). At the same time, countries still lack policies to require mandatory testing for pathogens before or after imports and exports of wild animals (e.g. Smith et al., 2009). Therefore, efforts to detect and monitor pathogens in wild reservoirs and disease outbreaks in animal populations targeted by wildlife markets are particularly relevant. Other actions may include improved regulations addressing enforced hygiene and sanitation procedures by certified breeders (Webster, 2004). Given the evident potential of traded wild animals in increasing the risk of disease spread, educational campaigns directed towards sellers and especially consumers to inform them about the health risks of trading and keeping wild pets would be beneficial. As advocated by Karesh et al. (2005), improved market regulations, or reduction in trade in wild-caught animals could provide a cost-effective approach to decrease the risks for disease for humans, domestic animals, wildlife, and ecosystems. Thus, it is essential to create long-term strategies that are rooted in socio-cultural contexts that adapt to emerging global phenomena such as new pandemics.

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Author contributions

Thais Q. Morcatty and Kim Feddema: Conceptualization, Data curation; Methodology, Analysis, Writing - original draft. **K.A.I. Nekaris** Conceptualization, Methodology, Writing - original draft. **Vincent Nijman:** Conceptualization, Methodology, Writing - review & editing.

References

Ali, M. G., Ahmad, M. O., & Husain, S. N. (2020). Spread of coronavirus disease (COVID-19) from an outbreak to pandemic in the year 2020. *Asian Journal of Research in Infectious Diseases*, *3(4)*, 37-51. doi.org/10.9734/ajrid/2020/v3i430135

Anonymous. (2020a). World Animal Protection End the global wildlife trade. Forever. https://www.worldanimalprotection.org/take-action/end-global-wildlife-trade-forever [accessed 22 May 2020].

Anonymous. (2020b). Coalition to End the Trade https://endthetrade.com/ [accessed 22 May 2020].

Bell, D., Roberton, S., & Hunter, P. R. (2004). Animal origins of SARS coronavirus: possible links with the international trade in small carnivores. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 359(1447), 1107-1114.

Burniston, S., Okello, A. L., Khamlome, B., Inthavong, P., Gilbert, J., Blacksell, S. D., Allen, J., & Welburn, S. C. (2015). Cultural drivers and health-seeking behaviours that impact on the transmission of pig-associated zoonoses in Lao People's Democratic Republic. *Infectious diseases of poverty*, 4, 11. https://doi.org/10.1186/2049-9957-4-11

Bush, E. R., Baker, S. E., & Macdonald, D. W. (2014). Global Trade in Exotic Pets 2006-2012. *Conservation Biology*, 28(3), 663–676. https://doi.org/10.1111/cobi.12240

Carpenter, A. F., & Song, W. (2016). Changing attitudes about the weak: Social and legal conditions for animal protection in China. *Critical Asian Studies*, 48(3), 380-399. doi.org/10.1080/14672715.2016.1196891

CDC. 2003 U.S. Outbreak. (2018). Available online at: https://www.cdc.gov/poxvirus/monkeypox/outbreak.html [Accessed 28 October 2020].

Daszak, P., Epstein, J. H., Kilpatrick, A. M., Aguirre, A. A., Karesh, W. B., & Cunningham, A. A. (2007). Collaborative research approaches to the role of wildlife in zoonotic disease

emergence. In: *Wildlife and emerging zoonotic diseases: the biology, circumstances and consequences of cross-species transmission* (pp. 463-475). Springer, Berlin, Heidelberg.

Epstein, J. H., Field, H. E., Luby, S., Pulliam, J. R., & Daszak, P. (2006). Nipah virus: impact, origins, and causes of emergence. *Current Infectious Disease Reports*, 8(1), 59-65.

Esmail, N., Wintle, B. C., t Sas-Rolfes, M., Athanas, A., Beale, C. M., Bending, Z., ... & Harrington, L. A. (2020). Emerging illegal wildlife trade issues: A global horizon scan. *Conservation Letters*, e12715.

Georges-Courbot, M. C., Sanchez, A., Lu, C. Y., Baize, S., Leroy, E., Lansout-Soukate, J., ... & Swanepoel, R. (1997). Isolation and phylogenetic characterization of Ebola viruses causing different outbreaks in Gabon. *Emerging Infectious Diseases*, 3(1), 59-62.

Guan, Y., Zheng, B. J., He, Y. Q., Liu, X. L., Zhuang, Z. X., Cheung, C. L., ... & Butt, K. M. (2003). Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. *Science*, 302(5643), 276-278. doi: 10.1126/science.1087139

Guarner, J., Johnson, B. J., Paddock, C. D., Shieh, W. J., Goldsmith, C. S., Reynolds, M. G., … & Veterinary Monkeypox Virus Working Group. (2004). Monkeypox transmission and pathogenesis in prairie dogs. *Emerging Infectious Diseases*, 10(3), 426.

Harrison, J. R., Roberts, D. L., & Hernandez-Castro, J. (2016). Assessing the extent and nature of wildlife trade on the dark web. *Conservation Biology,* 30(4), 900-904. doi.org/10.1111/cobi.12707

Johnson, C. K., Hitchens, P. L., Pandit, P. S., Rushmore, J., Evans, T. S., Young, C. C., & Doyle, M. M. (2020). Global shifts in mammalian population trends reveal key predictors of virus spillover risk. *Proceedings of the Royal Society B,* 287(1924), 20192736.

Karesh, W. B., Cook, R. A., Bennett, E. L., & Newcomb, J. (2005). Wildlife trade and global disease emergence. *Emerging Infectious Diseases*, 11(7), 1000-1002. doi: 10.3201/eid1107.050194

Kim, H. J., Lee, H., & Hong, H. (2020). Scale development and validation for psychological reactance to health promotion messages. *Sustainability*, 12(14), 5816. doi:10.3390/su12145816

Kirk, C. P., & Rifkin, L. S. (2020). I'll trade you diamonds for toilet paper: consumer reacting, coping and adapting behaviors in the COVID-19 pandemic. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2020.05.028

Kuiken, T., Fouchier, R., Rimmelzwaan, G., van den Brand, J., van Riel, D. and Osterhaus, A., 2012. Pigs, poultry, and pandemic influenza: how zoonotic pathogens threaten human health. In *Hot Topics in Infection and Immunity in Children VIII* (pp. 59-66). Springer, New York, NY.

Kwok K, Li K, Chan H, et al. (2020) Community responses during early phase of COVID-19 epidemic, Hong Kong. *Emerging Infectious Diseases*, 26(7), 1575-1579. doi:10.3201/eid2607.200500.

Lankau, E. W., Sinclair, J. R., Schroeder, B. A., Galland, G. G., & Marano, N. (2017). Public Health Implications of Changing Rodent Importation Patterns–United States, 1999–2013. *Transboundary and emerging diseases*, 64(2), 528-537.

Lavorgna, A. (2015). The social organization of pet trafficking in cyberspace. *European Journal on Criminal Policy and Research*, 21(3), 353-370. doi.org/10.1007/s10610-015-9273-y

Leroy, E. M., Rouquet, P., Formenty, P., Souquière, S., Kilbourne, A., Froment, J. M., ... & Zaki, S. R. (2004). Multiple Ebola virus transmission events and rapid decline of central African wildlife. *Science*, 303(5656), 387-390. doi: 10.1126/science.1092528

Lopez, C. E., Vasu, M., & Gallemore, C. (2020). Understanding the perception of COVID-19 policies by mining a multilanguage Twitter dataset. *arXiv preprint* arXiv:2003.10359.
Lucas, A., Kumakamba, C., Lange, C. E., Obel, E., Miningue, G., Likofata, J., … & Saylors, K. (2020). Serology and behavioral perspectives on Ebola Virus Disease among bushmeat

vendors in Equateur, Democratic Republic of the Congo, after the 2018 Outbreak. *Open Forum Infectious Diseases*, 7(8). doi:10.1093/ofid/ofaa295

Mikhailitchenko, A., Javalgi, R. R. G., Mikhailitchenko, G., & Laroche, M. (2009). Cross-cultural advertising communication: visual imagery, brand familiarity, and brand recall. *Journal of Business Research*, 62(10), 931-938. https://doi.org/10.1016/j.jbusres.2007.11.019

Morens, D. M., Daszak, P., Taubenberger, J. K. (2020). Escaping Pandora's box—another novel coronavirus. *New England Journal of Medicine*, 382.14, 1293-1295.

Mufunda J, Ndambakuwa Y, Muno-dawafa D, Kobie A. (2016) Is a total ban on business and consumption of bush-meat a sustainable end game for eb-ola outbreak in West Africa: but why now? *Public Health Open J*. 1(1), 4-7.

Ordaz-Németh, I., Arandjelovic, M., Boesch, L., Gatiso, T., Grimes, T., Kuehl, H., Lormie, M., Stephens, C., Tweh, C. & Junker, J. (2017). The socio-economic drivers of bushmeat consumption during the West African Ebola crisis. *PLoS Neglected Tropical Diseases*, 11 (3), e0005450. doi.org/10.1371/journal.pntd.0005450

Pappas, G., 2013. Socio-economic, industrial and cultural parameters of pig-borne infections. *Clinical Microbiology and Infection*, *19*(7), pp.605-610.

Parrish, C. R., Holmes, E. C., Morens, D. M., Park, E. C., Burke, D. S., Calisher, C. H., ... & Daszak, P. (2008). Cross-species virus transmission and the emergence of new epidemic diseases. *Microbiology and Molecular Biology Reviews*, 72(3), 457-470. doi:10.1128/MMBR.00004-08

Parry, N (2020) COVID-19 and pets: When pandemic meets panic. *Forensic Science International: Reports,* 100090. doi.org/10.1016/j.fsir.2020.100090

Pearson, R. M., Sievers, M., McClure, E. C., Turschwell, M. P., & Connolly, R. M. (2020). COVID-19 recovery can benefit biodiversity. *Science*, 368(6493), 838-839. doi: 10.1126/science.abc1430

Rassy, D., & Smith, R. D. (2013). The economic impact of H1N1 on Mexico's tourist and pork sectors. *Health Economics*, 22(7), 824-834. doi: 10.1002/hec.2862

Reed, K. D., Melski, J. W., Graham, M. B., Regnery, R. L., Sotir, M. J., Wegner, M. V., ... & Swain, G. R. (2004). The detection of monkeypox in humans in the Western Hemisphere. *New England Journal of Medicine*, 350(4), 342-350. doi: 10.1056/NEJMoa032299

Roe, D., Dickman, A., Kock, R., Milner-Gulland, E. J., Rihoy, E., & t'Sas-Rolfes, M. (2020). Beyond banning wildlife trade: COVID-19, conservation and development. *World Development, 136,* 105121. doi.org/10.1016/j.worlddev.2020.105121

Shepherd, C. R., Leupen, B. T., Siriwat, P., & Nijman, V. (2020). International wildlife trade, avian influenza, organised crime and the effectiveness of CITES: The Chinese hwamei as a case study. Global Ecology and Conservation, 23, e01185.

Siriwat, P., Nekaris, K. A. I., & Nijman, V. (2019). The role of the anthropogenic Allee effect in the exotic pet trade on Facebook in Thailand. *Journal for Nature Conservation,* 51, 125726.

Siriwat, P., & Nijman, V. (2020). Wildlife trade shifts from brick-and-mortar markets to virtual marketplaces: A case study of birds of prey trade in Thailand. *Journal of Asia-Pacific Biodiversity,* 13(3), 454-46. doi.org/10.1016/j.japb.2020.03.012

Smith, K. F., Behrens, M., Schloegel, L. M., Marano, N., Burgiel, S., & Daszak, P. (2009). Reducing the risks of the wildlife trade. *Science,* 324(5927), 594-595.

Sung, Y.H. & Fong, J. (2018). Assessing consumer trends and illegal activity by monitoring the online wildlife trade. *Biological Conservatio, 227*, 219-225. doi.org/10.1016/j.biocon.2018.09.025

Taha, F.A. (2007). How highly pathogenic avian influenza (H5N1) has affected world poultry-meat trade. *AgEcon Search,* LDP-M-159-02. doi: 10.22004/ag.econ.7360

Thomas-Walters, L.,Veríssimo, D., Gadsby, E., Roberts, D. & Smith, R.J. (2020). Taking a more nuanced look at behavior change for demand reduction in the illegal wildlife trade. *Conservation Science and Practice,* e248. doi: 10.1111/csp2.248.

Thung, P. H. (2020). Why education about zoonotic diseases is not reducing hunting, a view from rural Borneo, POKOK: Using anthropology to mitigate orangutan killing and human-orangutan conflict in Borneo. Retrieved from https://pokokborneo.wordpress.com/blog/

TRAFFIC (2020, July 24) Viet Nam issues ban on wildlife imports & announces closure of illegal wildlife markets. Retrieved from https://www.traffic.org/news/viet-nam-issues-ban-on-wildlife-imports-announces-closure-of-illegal-wildlife-markets/

Veríssimo, D. & Wan, A (2019) Characterizing efforts to reduce consumer demand for wildlife products. *Conservation Biology,* 33 (3), 623-633. doi: 10.1111/cobi.13227.

Wang, H, Shao, J., Luo, X., Chuai, Z., Xu, S., Geng, M. & Gao, Z. (2020) Wildlife consumption ban is insufficient. *Science,* 367 (6485), 1435-1435. doi:10.1126/science.abb6463.

Webster, R. G. (2004). Wet markets—a continuing source of severe acute respiratory syndrome and influenza?. *The Lancet,* 363(9404), 234-236. doi.org/10.1016/S0140-6736(03)15329-9

WHO – World Health Organization, Regional Office for South-East Asia. (2014). A brief guide to emerging infectious diseases and zoonoses. WHO Regional Office for South-East Asia. https://apps.who.int/iris/handle/10665/204722

Wilk, V., Soutar, G. N., & Harrigan, P. (2017). Tackling social media data analysis: Comparing and contrasting QSR NVivo and Leximancer. *Qualitative Market Research*, 22(2). doi:- 10.1108/qmr-01-2017-0021

Wise, T., Zbozinek, T.D., Michelini, G., Hagan, C.C., & Mobbs, D. (2020). Changes in risk perception and protective behavior during the first week of the COVID-19 pandemic in the United States. *PsyArXiv*. doi:10.31234/osf.io/dz428.

Woo, P. C., Lau, S. K., & Yuen, K. Y. (2006). Infectious diseases emerging from Chinese wet-markets: zoonotic origins of severe respiratory viral infections. *Current Opinion in Infectious Diseases*, 19(5), 401.

Ye, Z. W., Yuan, S., Yuen, K. S., Fung, S. Y., Chan, C. P., & Jin, D. Y. (2020). Zoonotic origins of human coronaviruses. *International Journal of Biological Sciences*, 16(10), 1686–1697. doi: 10.7150/ijbs.45472