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Shifts of trade in Javan ferret badgers *Melogale orientalis* from wildlife markets to online platforms: implications for conservation policy, human health and monitoring

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ABSTRACT: Wildlife trade is increasingly impeding the conservation of imperilled wildlife and is a potential threat to human health. Ferret badgers are extensively traded in China, although the trends, drivers and health implications of ferret badger trade in other parts of Asia remain poorly known. Here, we focus on the pet trade of a little known endemic small carnivore species, Javan ferret badger *Melogale orientalis* in Indonesia, over a 10 yr period (2011–2020). The Javan ferret badger is listed as Least Concern on the IUCN Red List of Threatened Species with an unknown population trend. We aimed to gain insight into the magnitude of this trade, its purposes, price trends, distribution records, health risks and shifts to online platforms. We documented 44 ferret badgers in 11 wildlife markets in Java and Bali and 100 ferret badgers for sale on online platforms. We observed a shift in trade from traditional animal markets only, to trade in these markets as well as online. Asking prices, corrected for inflation, declined significantly from ~USD 37 in 2012 to ~USD 22 in 2020, and were related to the purchasing power in cities where trade occurred. Widespread sale of the species highlights that enforcement continues to be overly passive as any trade in the species is illegal. We recommend that the Javan ferret badger be afforded full national protection and prioritised in monitoring efforts to establish its true conservation status. Additionally, concerted efforts are needed to determine if online trade poses a risk to conservation and human health.

KEY WORDS: Wildlife trade · Java · Bali · Small carnivore · Zoonotic diseases · Covid-SARS

1. INTRODUCTION

The trade in wildlife is extensive throughout Asia, where local people buy animals for a range of purposes, including meat consumption, as ingredients for traditional medicines, for skins and furs, as live pets and for use in a range of household products (Grieser-Johns & Thomson 2005, Nijman 2010). Traditionally, the centres of wildlife trade have been in physical animal markets (also known as 'brick-and-mortar markets', wildlife markets or bird markets). In many countries in Asia, this includes the trade in protected species, often in high volumes (Lee et al. 2005, Zhang et al. 2008, Phelps & Webb 2015). The insatiable appetite for wildlife, as well as a lack of resolve from government authorities to combat illegal trade,

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puts many species at risk of exploitation (Broad et al. 2014). In addition, the demand for different species changes constantly, as do the techniques and strategies used to traffic and sell them (van Uhm 2016).

Recently, wildlife trade has entered the complex and untraceable network of the internet, which facilitates expanding influence over new and more consumers across the globe, whilst also going largely undetected (Siriwat et al. 2019, Van et al. 2019, Xu et al. 2020). In the last decade, the exotic pet trade has particularly benefited from online trade and has diversified the types and frequencies of taxa being offered for sale as pets (Siriwat et al. 2020). The internet acts as a conduit for promoting and popularising new species, which perpetuates public attitudes that a species is available as a pet (Nekaris et al. 2013, Harrington et al. 2019, Siriwat et al. 2020). Online marketing can do significant damage to species conservation by creating demand for animals that may have once been invisible to the public eye. A well-known example includes the popularisation of the slow loris, genus *Nycticebus*. Prior to 2009, most people had no knowledge of these cryptic mammals; however, following the upload of a 'viral' video of a pygmy slow loris *N. pygmaeus* being tickled, desire for it as a pet boomed around the world, directly impacting its conservation (Nekaris et al. 2013). Online marketing also creates a false image that exotic species are suited to domestication, whereas the opposite is often true. Many studies provide ample evidence of suffering and increased mortalities in animals that are removed from the wild to be kept as pets (Gomez & Bouhuys 2018, Siriwat & Nijman 2018), highlighting the need to monitor this trade and uphold animal welfare standards.

Pet trade in both forms (online and in traditional markets) also facilitates the transmission of disease and increases zoonotic spillovers into human populations (Burgos & Burgos 2007, Greatorex et al. 2016). Keeping animals in close proximity in traditional wildlife markets exposes many different species to pathogens to which they would otherwise not have been exposed (Karesh et al. 2005). This exposure time, as well as the unsanitary conditions to which most wildlife and their products are subjected, increases the rate of infection between animals and the risk of developing new disease strains that can infect humans and cross over into other species (Bell et al. 2004, Karesh et al. 2005, Aguirre et al. 2020). Online wildlife trade does not necessarily involve high volumes of animals confined together, but it does involve the opening up of an even greater spatial extent of trade that can facilitate novel transmission opportunities along the trade chain. Increasing the numbers of animals traded in the online space ultimately increases exposure to humans and thus increases disease risk. Depending on the source population of animals, the rate and mode of zoonotic transmission may vary slightly, but all are significant in terms of increasing disease risk (Karesh et al. 2005). Animals sourced directly from the wild, and animals that are captive-bred or 'ranched', have all been implicated in many disease outbreaks, including those involving small carnivore species (Bell et al. 2004).

Extensive influence and outreach of online trade in marketing, rapidly changing trends and popularising new species as pets to broader communities, combined with the difficulties for law enforcers to trace offenders on the internet, has increasingly seen the move of illegal wildlife trade from the brick-and-mortar markets to online platforms (Siriwat & Nijman 2018). Early detection of new trends appearing in online marketplaces is therefore an important part of surveillance to successfully manage and conserve the species they threaten (Siriwat & Nijman 2018).

Ferret badgers comprise a group of 5 mustelid species occurring throughout East and Southeast Asia. They are smaller than other badgers (body-length 33–43 cm), with more elongate bodies, long bushy tails and sharp, pointed snouts. Species are physically similar, and most cannot be readily distinguished by external features. Additionally, even within species, body colours and facial markings can be highly variable. Identification is often only possible by looking at dentition and geographic distribution (Schank et al. 2009, Duckworth et al. 2016b).

Ferret badgers have been understudied for years, likely because of their cryptic nature and less charismatic appearance than many other mammals (Duckworth et al. 2016b). This has led to a very patchy understanding of basic ferret badger ecology, biology, life history traits and general conservation needs. The only ferret badger that we know much about is the small-toothed ferret badger *Melogale moschata* (listed as Least Concern and with a stable population trend on the IUCN Red List of Threatened Species; Duckworth et al. 2016a), and what we know is largely due to its role in being implicated as an intermediate host for the severe acute respiratory syndrome coronavirus (SARS-CoV: Guan et al. 2003). For every other ferret badger (and most small carnivores), conservation interest continues to be low, and so knowledge gaps remain (Shepherd 2012). Herein we look at the Javan ferret badger *M. orientalis*, a ferret badger species that has been scarcely studied, about

which little is known, and which has continued to be implicated in brick-and-mortar market trade, and most recently and problematically, in online trade as well.

The Javan ferret badger is endemic to the islands of Java and Bali and is the only species of ferret badger that is found in Indonesia (Duckworth et al. 2008). To date, there has been no evidence that the Bornean ferret badger *M. everetti*, restricted to northern Borneo, occurs in Indonesian Borneo, but few intensive surveys have been conducted in the central Bornean mountain range, and the species may occur in the Indonesian province of North Kalimantan (Wilting et al. 2016). Indonesia is a significant country in terms of wildlife trade, both globally (Nijman 2010) and domestically (Lee et al. 2005). Locally, many species and their parts and derivatives are sold in violation of national laws and regulations because enforcement is lax and corruption is widespread (Shepherd 2006, Nijman et al. 2019). Small carnivores, including ferret badgers, are mostly sold locally for meat or kept live as pets (Shepherd 2012), but trade in these mammals is often overlooked and continues to be unmonitored (Shepherd 2008, 2012).

Prior to 2008, the Javan ferret badger was listed on the IUCN Red List of Threatened Species as Data Deficient; however, evidence of a wider altitudinal and spatial distribution, and use of highly human-modified habitats, resulted in the recategorization of the species to Least Concern in 2016 (Wilianto & Wibisono 2017). Despite this, it must be noted that the new records outlined by Wilianto & Wibisono (2017) were not based on dedicated studies and were mostly one-time occurrences. The extent, distribution and population size of Javan ferret badgers is therefore still vague and requires further clarification (Duckworth et al. 2016b).

Combining the observations made by Riffel (1991), Yossa et al. (1991), Duckworth et al. (2008), Rode-Margono et al. (2014) and Wilianto & Wibisono (2017) reveals that Javan ferret badgers have been recorded in the wild in just 30 localities (Province of Banten 2; West Java 14; Central Java 4; Yogyakarta: 2; East Java 6; Bali: 2). Most of these records refer to single observations, and it appears that the species has been regularly observed only on Mt. Gede-Pangrango and Mt. Papandayan, both in West Java (Duckworth et al. 2008, Rode-Margono et al. 2014, Campera et al. 2021). A baiting and spot-lighting session conducted by Duckworth et al. (2008) on Mt. Gede confirmed the species was possibly locally abundant. Campera et al. (2021) found Javan ferret badgers to be the third most common carnivore (after the Javan palm civet *Paradoxurus musangus javanicus* and Javan mongoose *Herpestes javanicus*) to be camera-trapped in Cipaganti on Mt. Papandayan. Its distribution and certainty of breeding populations across the rest of Java have yet to be determined.

As far as we are aware, the first records of Javan ferret badgers in trade were made in 2011 when an individual was observed for sale as an exotic pet in one of the animal markets in Jakarta (Kim 2012). In addition, Kim (2012) stated that Javan ferret badgers were offered online but did not provide further details. Prior to these observations, there had been no reports of Javan ferret badgers being detected in brick-and-mortar markets or online trade. Nine more ferret badgers were observed in the same marketplace a year later (Shepherd 2012).

Here we aim to provide comprehensive insight into the trade in Javan ferret badgers following the observation of the first individuals in brick-and-mortar markets in 2011. Specifically, we (1) summarise the observed presence of Javan ferret badgers in brick-and-mortar markets between 2011 and 2020; (2) investigate the role of internet websites in marketing Javan ferret badgers as pets by collecting sale data from online advertisements; (3) make inferences surrounding the distribution and reproductive biology of Javan ferret badgers; and (4) provide details of the first known prosecution case involving a Javan ferret badger.

With these data, we assessed where, on which islands and in which cities, ferret badgers were offered for sale, if prices remained stable over time and if prices were linked to the local economies where animals were being traded. Additionally, we looked at whether a switch in mode of trade has been observed from brick-and-mortar marketplaces to the web. We also assessed the likely sources of these animals and the potential zoonotic health risks involved with their trade, and we highlight further knowledge gaps that need to be filled. Finally, we evaluated Indonesia's protection laws surrounding Javan ferret badger and make legislation recommendations based on our trade and prosecution case observations.

2. METHODS

2.1. Animal market surveys

Over the period June 2011 to February 2020, regular animal market surveys were conducted in the major cities of Java and Bali. Several of us (C.R.S., V.N., K.A.I.N. and M.A.I.) have visited these animal markets on multiple occasions since the mid-2000s

or before (and going back to the early 1990s) and are familiar with their layout, characteristics and trade dynamics. Intensity of market surveys differed over our study period. In 2011–2013, markets were surveyed opportunistically and at a relatively low intensity with a focus on the Special Capital Region of Jakarta and the province of West Java. In 2014, the number of visits was increased and expanded to include several animal markets in the provinces of Central Java, Yogyakarta, East Java and Bali. In 2016, monitoring became more systematic, with more wildlife markets surveyed at least 4 times a year and several markets visited at least every month. The surveying of the animal markets ceased in March 2020 as the outbreak of SARS-CoV-2 (Covid-19) prevented travel to and from markets.

Traders openly sell small carnivores and other mammals in the wildlife markets, so there was no need to resort to undercover techniques to collect the data. Typically, 1 or 2, occasionally 3, surveyors, skilled in market surveys and species identification, walked through markets slowly, recording numbers and species in mobile phones or by memorizing numbers and recording the data in a notebook or on their phones directly after having left the market. We did not survey back alleys, although it is known that trade in wildlife takes place in the alleys around the main markets. We noted species and age class (infant, juvenile, adult) when possible, and took photographs opportunistically. Occasionally, informal discussions were held with the traders about asking prices — these are first quotes, and these would have likely gone down after negotiating or when more than one individual would have been purchased at a time, as is common practice. We did not negotiate, and we did not purchase any wildlife during our surveys.

2.2. Online trade data collection

In August 2020, we searched for Javan ferret badgers for sale in classified ads (e.g. Tokopedia, Shopee, Kaskus, Jualo), Instagram and Facebook using the search terms 'musang biul', 'biul', 'biul selentek', 'teledu' (i.e. the names for ferret badger in Bahasa Indonesia/Bahasa Sunda) in combination with 'jual' (sale). We recorded the location of the seller, the year of posting, the asking price and the number of individuals for sale (if this was unclear, we conservatively estimated it as 1 individual).

Prices were corrected for inflation to August 2020 using an online inflation calculator (e.g. Indonesian Rupiah [IDR] 10 000 in June 2012 is the equivalent of IDR 13 719 in August 2020), and these inflation-corrected prices were then converted to USD using the August 2020 exchange rate of IDR 14 800 to the USD. We added prices, again corrected for inflation, reported by Shepherd (2012) and Kim (2012) for the years 2011 and 2012. Sellers often had different numbers of ferret badgers on offer; in our study, this ranged from 1 to 14 individuals. We compared asking prices with the Indonesian government-recommended minimum monthly wages, which are published annually for each regency and range from ~USD 120 mo^{-1} for some of the less affluent rural regions to ~USD 280 for some of the large city regions.

Due to the potentially sensitive content of our surveys, we used guidelines from Roulet et al. (2017) for covert observations, and the recommendations of Kosinski et al. (2015): (1) we anonymized data after collection; (2) we did not interact with any of the sellers, online group members or administrators; and (3) we do not publish any information that can be attributed to any single individual.

2.3. Seizures and prosecutions

In August 2020, we searched for seizures or confiscations in online open sources, including the major newspapers such as Kompas, Surabaya Post, Jakarta Post, Republika and Jawa Pos. We used the same search terms as above, but in combination with 'BKSDA' (Natural Resources Conservation Agency, the agency that has the power to seize animals) or 'bea cukai' (customs, specifically for potential international trade). Experience with similar searches for other species (e.g. black-winged myna *Acridotheres melanopterus*, Nijman et al. 2018; or Sunda leopard cats *Prionailurus javanensis*, Nijman et al. 2019) suggests that they can locate records as far back as the beginning of our physical market surveys in 2011.

Data were extracted from the Indonesian government website 'Sistem Informasi Penelusuran Pekara', an information database of the courts for each district. We extracted data on prosecutions involving the illegal trade in small carnivores, including the Javan ferret badger.

2.4. Analysis

We considered each observation an independent datapoint, i.e. we do not expect animals to move between markets or to be present both in physical mar-

kets and online platforms. The traders offering wildlife in the physical markets generally did not tend to have online websites as well, and none of the traders we found advertising ferret badgers online appeared to be traders in brick-and-mortar markets.

Where possible, we aged ferret badgers as immatures/adults (i.e. ones with an adult-sized body and proportion) or infants/juveniles (i.e. ones that were clearly not adults). This identification was aided by many of the online traders adding approximate ages in their descriptions.

While there is no information on the litter size of Javan ferret badgers, observations on the other ferret badger species suggest they are between 1 and 4 and up to 5 individuals (Deng 1984, Shie et al. 1988). For calculating seasonality of litters offered for sale, we treated 'litters' of 3 to 5 individuals as single litters and those of 6 to 8 individuals as 2 litters (while larger 'litters' were observed, they lacked details on date of first posting).

When comparing the number of young vs. adults or seasonality of observing litters offered for sale, we assumed equal distributions (age, time) and we used a *G*-test for goodness-of-fit to test for deviations. Only the individuals that were aged were included in this analysis. Changes in prices over time and the link between price and recommended minimum wage were compared using Pearson's correlation coefficients. We accepted significance when $p < 0.05$ in a 2-tailed test.

3. RESULTS

3.1. Numbers in trade

We observed 40 Javan ferret badgers in 10 animal markets in 8 cities in Java and 1 in Bali. Moreover, 1 individual was observed in Bali (E. Wilianto pers. comm.), presumably in Denpasar, and 2 in Ambarawa (Rahardyansyah 2019), in addition to the 1 animal observed by Kim (2012) in Jakarta. The highest numbers were observed in Jatinegara market in Jakarta (21 out of 44), and more were observed in 2012 and 2014 compared to every other year (Table 1).

We found 100 Javan ferret badgers for sale on 7 online platforms (Table 2, Fig. 1) in 51 separate advertisements. Sellers were based in all 6 of the provinces/regions in Java, but we did not find any online sellers offering Javan ferret badgers in Bali (the other part of the species' natural range) nor in any of the other parts of Indonesia such as Sumatra or Kalimantan. Jakarta and West Java stood out as areas where most sellers were based (Fig. 2). The offers for sale were made over the period 2011–2020. The most popular platforms were Instagram (39 ferret badgers offered for sale), Facebook (16), Kaskus (14) and Jualo (13) (Table 2, Fig. 1). We assumed that all individuals were advertised on 1 platform only and were not advertised more than once throughout the sampled study period.

Table 1. Observations of Javan ferret badger *Melogale orientalis* individuals in 11 Indonesian markets across Java and Bali (listed from west to east) over the period 2011–2020. DKI Jakarta: Special Capital Region of Jakarta; DI Yogyakarta: Special Region of Yogyakarta. Shades of grey indicate intensity of the surveys, from light (irregular or single surveys), intermediate (several surveys over the course of a year) to dark grey (monthly surveys). No shading indicates unknown sampling intensity of survey. The record from Jatinegara in 2011 is from Kim (2012) and the record from Pasar Pon in 2019 is from Rahardyansyah (2019)

Province	City, Market	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
DKI Jakarta	Jakarta, Jatinegara	1	12		6	2						21
DKI Jakarta	Jakarta, Barito								1			1
West Java	Bandung, Sukahaji				1	1			1			3
West Java	Garut, Kerkhof				1							1
West Java	Tasikmalaya, Cikurubuk							1				1
DI Yogyakarta	Yogyakarta, Pasty				1							1
Central Java	Semarang, Karimata							2				2
Central Java	Amberawa, Pasar Pon									2		2
East Java	Malang, Splindit								3		1	4
East Java	Surabaya, Bratang									3		3
Bali	Denpasar, Satria				1				4			5
Total		1	12	0	10	3	0	3	9	5	1	44

Table 2. Observations of Javan ferret badger *Melogale orientalis* offered for sale on several Indonesian online platforms (n = 100 individuals). Listed are all provinces/regions within the known range of the species, as well as the number of towns in which the species was advertised (with the number of advertisements in parentheses) for each province. For 3 ferret badgers, the location where the trader was based was unknown; for 8 ferret badgers, age could not be determined; na: not applicable

Province	Towns (ads)	Total (adult:young)	Years	Platforms
Banten	3 (3)	3 (2:0)	2020	Facebook, Shopee
Jakarta	1 (15)	41 (3:35)	2011, 2016, 2018, 2019, 2020	Bukalapak, Facebook, Instagram, Jualo, Kaskus, Tokopedia
West Java	7 (13)	17 (2:14)	2012, 2017, 2019, 2020	Facebook, Instagram, Tokopedia
Central Java	8 (10)	14 (4:10)	2013, 2015, 2016, 2020	Facebook, Instagram, Jualo, Kaskus
Yogyakarta	1 (2)	10 (0:9)	2015, 2019	Jualo
East Java	4 (8)	12 (2:8)	2013, 2016, 2020	Facebook, Instagram, Jualo, Tokopedia
Bali	0 (0)	na	na	na

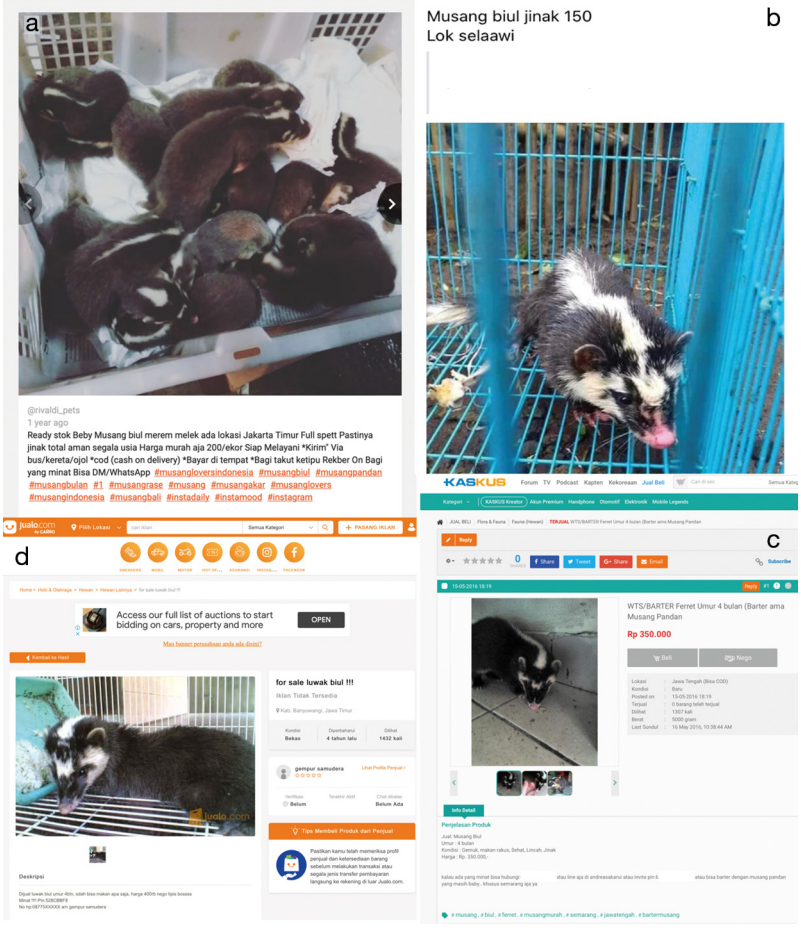

Fig. 1. Examples of online trade advertisements selling Javan ferret badger *Melogale orientalis* in Java, Indonesia, on the top 4 platforms. Clockwise from top left: (a) Instagram; (b) Facebook; (c) Kaskus and (d) Jualo

Across both online and brick-and-mortar marketplaces (n = 144 individuals), we observed more than twice as many young ferret badgers for sale as adults (81 vs. 30), the difference being statistically significant (*G*-test, $G = 27.448$, $p = 0.0001$). A total of 33 individuals could not be aged. We never observed a litter or even a single juvenile in the company of an adult, i.e. there were no mother–offspring combinations, and it is assumed, based on discussions with dealers in brick-and-mortar marketplaces, that all Javan ferret badgers offered for sale were derived from the wild. We observed 9 litters online, posted between 2 February and 9 April. Taking the reported ages into account (ranging from 1 to 2 mo), this suggests all were born in the months of December to March. To observe 9 litters in these 4 months, but none of the other months, strongly suggests an unequal distribution of litters and seasonality in breeding (*G*-test, $G = 19.775$, $p = 0.0001$).

3.2. Shifts to online trade and price developments

Over the course of our study, we noticed a shift from trade occurring mainly in physical brick-and-mortar markets, and some additional offers made online, to trade occurring more frequently online than in brick-and-mortar markets. In 2011, when the first Javan ferret badgers were reported in a Jakarta market, the species was already available online (Fig. 3). Over time, the number of ferret badgers we recorded in the physical markets gradually increased

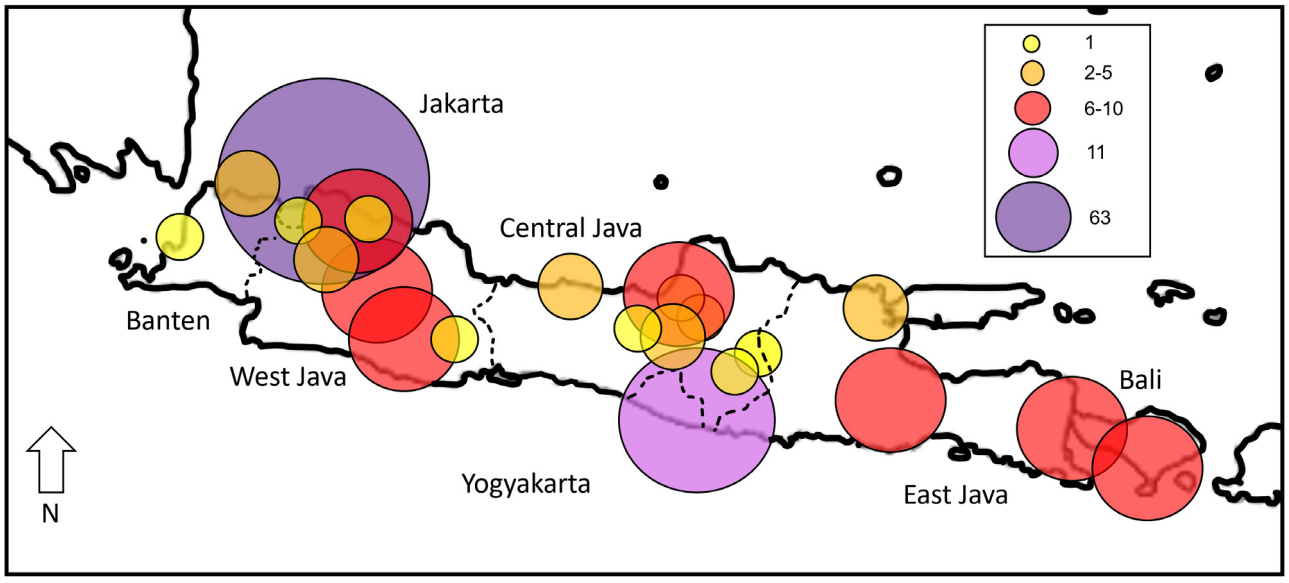

Fig. 2. Trade in Javan ferret badger *Melogale orientalis* in Java and Bali in the period 2011–2020 advertised in physical and online marketplaces. Each circle represents 1 town/city and the number of individuals offered for sale therein. Smallest circles (yellow) equal 1 individual offered for sale, small circles (orange) equal 2–5 individuals, intermediate circles (red) equal 6–10 individuals, large circle (purple) equals 11 individuals, and the largest circle (dark purple) represents 63 individuals

in a linear fashion as did the number of cities where we recorded the species, such that as of 2020, we have observed 44 individuals in wildlife markets in 11 cities. The increase in Javan ferret badgers offered for sale online initially followed a similar gradual increase, but in recent years, this increase has been more intense, and the number of cities where sellers were based likewise increased more steeply. Across the sampling period (2011–2020), the number of cities where ferret badgers were offered for sale was consistently higher for online trade than for brick-and-mortar marketplaces. However, by 2018, the cumulative number of individuals offered for sale online surpassed that offered in brick-and-mortar marketplaces (Fig. 3).

We obtained 84 quotes, both in the physical markets and from online platforms, ranging from USD 10.16 to 46.94 and averaging USD 22.68. We noticed a significant decline in asking prices over the period 2012–2020 (Pearson's r = –0.4347, R^2 = 0.1893, N = 84, p = 0.0001), with prices in 2011 and 2012 averaging USD 37.40 and in 2020 averaging USD 22.29 (Fig. 4).

The government-recommended minimum monthly wage differed substantially between cities where we recorded Javan ferret badgers for sale. The lowest wages of ~USD 120 mo^{-1} were for the cities of Garut (West Java) and Boyolali, and Klaten (Central Java), whereas the highest of USD 282 mo^{-1} was for the city of Bekasi (West Java). We found a significant positive relationship between the government-recommended minimum monthly wage in a city and the mean asking price for a ferret badger in that city (Pearson's r = 0.567, N = 16, p = 0.022) (Fig. 5).

3.3. Seizures and prosecutions

We did not find any cases reported in the Indonesian media where Javan ferret badgers were confiscated. Likewise, we were unable to find any evidence of a smuggling event that was thwarted by Indonesian customs agents. We did find one case in the information database of the courts where a trader was successfully prosecuted for trading a large range of wildlife, and this included a Javan ferret badger. On 11 January 2019, the Indonesian District Courts

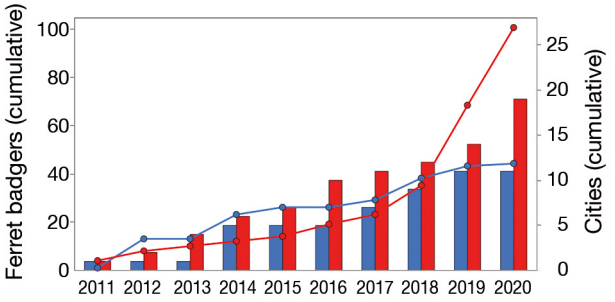

Fig. 3. Shift of trade in Javan ferret badger *Melogale orientalis* from traditional physical markets (blue line: individuals; blue bars: cities) to online platforms (red line: individuals; red bars: cities) as cumulative frequencies

prosecuted a trader dealing in protected and non-protected wildlife via his online pet shop located in a mall in Bandung, West Java. In addition to the Javan ferret badger, other species that were traded online were yellow-crested cockatoo *Cacatua sulphurea*, Brahminy kite *Haliastur indus* and Nicobar pigeon *Caloenas nicobarica* (all protected under Regulation No. 20 of 2018 Ministry of Environment and Forestry [Types of Protected Plants and Animals]). The offender was sentenced to 1 yr and 3 mo in jail and IDR 50 million (USD 3414 at August 2020 exchange rates) fine or an additional 2 mo in jail. Through that same offender, 11 others in the network were prosecuted and a total of 205 live animals and 78 body parts were confiscated.

4. DISCUSSION

4.1. Trade networks and distribution on Java

We observed Javan ferret badgers in 23 cities distributed all over the island of Java, including Jakarta, Yogyakarta and the provinces of West, Central and East Java in physical and online marketplaces (Fig. 2). This pattern may suggest either an extensive trade network, where ferret badgers are sourced from certain areas and then distributed to the different trade centres, or, not mutually exclusively, animals are sourced throughout the island. The observation that asking prices of ferret badgers were linked to the local economies points towards local sourcing and limited movement of animals across Java (Fig. 5). There was no evidence to suggest international trade in the species. If local sourcing did indeed take place, our trade records support the general Javan ferret badger distribution model that the species is widely distributed across Java in scattered localities, with local abundances appearing to be highest in western parts of the island (Tables 1 & 2, Fig. 2; Duckworth et al. 2008, Rode-Margono et al. 2014, Wilianto & Wibisono 2017). Our findings revealed no new localities beyond what we currently know of the species' range (see Duckworth et al. 2016b). Encounter rates with camera-traps have been typically lower for Javan ferret badger than for other similar-sized species (Duckworth et al. 2016b). As a result, absence from records has been historically perceived as potential rarity in many areas, even though most surveys are biased towards detecting typical large target species (such as leopard and rhinoceros) and the habitats that they frequent (primary evergreen forests) rather than small carnivores. Therefore, absence of small carnivore species from surveys that are not targeted to detect them cannot be confirmed as representing actual rarity. The few studies that have recorded ecological occurrences of Javan ferret badger suggest wide habitat use, including human-degraded landscapes (Rode-Margono et al. 2014, Duckworth et al. 2016b, Campera et al. 2021). Our trade observations support the notion that Javan ferret badgers may be more common than previous camera-trap records have suggested (assuming trade animals were indeed sourced locally from the wild and numbers of individuals in trade reflect local abundance). Further intensive studies on Javan ferret badger abundance and population ecology are much needed. Targeted surveys of Javan ferret badger

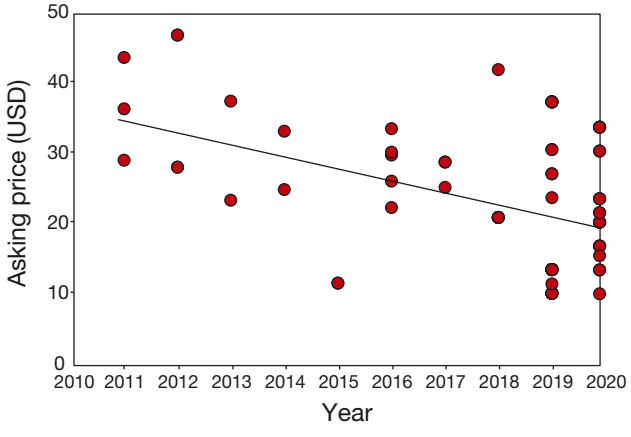

Fig. 4. Relationship between the inflation-corrected asking price for a Javan ferret badger *Melogale orientalis* in physical markets and online and time, showing that prices declined significantly from 2011 to 2020

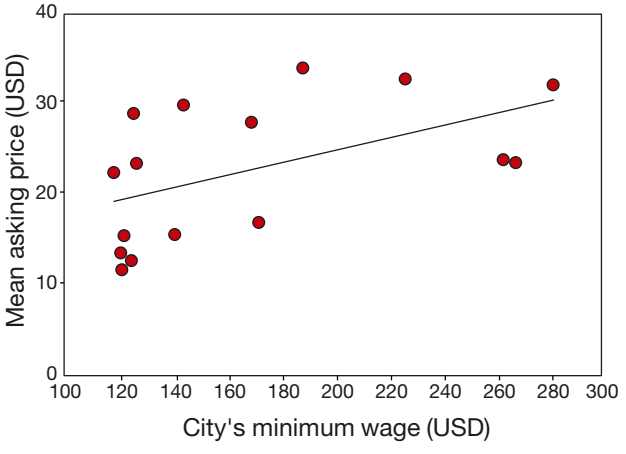

Fig. 5. Relationship between a city's government-recommended minimum monthly wage and the inflation-corrected asking price for a Javan ferret badger *Melogale orientalis* in wildlife markets and online, showing that asking prices were lower in cities where the inhabitants have a lower purchasing power

would enhance detectability and generate reliable estimations of the species' abundance and extent that would inform a true conservation status. We also suggest that there is a general need to purposefully survey secondary forests and degraded areas so that survey efforts are representative of all species that frequent them.

4.2. Volumes in trade and likely origins

To our knowledge, no other observation of a Javan ferret badger had been made in physical marketplaces prior to the observation made by Kim (2012) in 2011. Since then, we have observed a slow increase in the number of ferret badgers sold in brick-and-mortar marketplaces and a more pronounced increase in numbers offered for sale online (Tables 1 & 2, Fig. 3). As previously mentioned, marketing wildlife as pets on online internet platforms has the potential to drive demand amongst their viewers and create awareness that a species is available as a pet (Nekaris et al. 2013), and we have reason to believe that the same is occurring for the Javan ferret badger. The gradual increase in individuals traded over the years and the increased use of online trade platforms provide strong evidence that the internet is playing a significant role in growing an established local pet market for Javan ferret badgers.

Following the first documented occurrence of a single Javan ferret badger in trade in Jatinegara market in 2011, the greatest number of individuals (12) was observed in the same market a year later in 2012 (Table 1). In 2014, the second-highest number of individuals was recorded (10), and this is the first record of individuals being offered for sale in other parts of the species' range (i.e. Bandung, Garut, Yogyakarta and Bali: Table 1). By the end of the survey period (2020), all trade records covered suspected or known Javan ferret badger ranges. In subsequent years (2015–2020), despite the survey effort in brick-and-mortar markets becoming more systematic, numbers of Javan ferret badgers declined significantly (Table 1), whilst the internet trade continued to increase. This likely confirms a marked changeover to trading the species in the online web space rather than in brick-and-mortar marketplaces. It should be noted that even though marketplace trade in Javan ferret badgers after 2014 was significantly less than pre-2014, trade persisted across the island with at least a couple of animals sold each year. We assumed throughout the survey period that ferret badgers were not sold more than once. However, it must be noted that it is possible that several animals were resold and so we may have overestimated how many individuals were actually advertised. It is important that this limitation is addressed in future studies.

It is unclear whether the trade in Javan ferret badger is limited by its abundance or by local demand. The increase in the number of regions sourcing and selling Javan ferret badgers points to a general growing demand; however, there are significantly fewer ferret badgers sold than civets in both brick-and-mortar and online marketplaces. Trade volumes for Javan palm civets were at least 20-fold higher than for Javan ferret badgers in the brick-and-mortar marketplace (Nijman et al. 2014). Nevertheless, the recent formation of 'civet-lover clubs' has no doubt increased public interest in small carnivores generally and has possibly contributed to the increasing demand for Javan ferret badgers (Duckworth et al. 2016b). Regardless of potential abundance limitations, public awareness of Javan ferret badgers as pets may still be quite low, meaning there may exist potential buyers who would purchase ferret badgers if they knew what they were. This highlights the need to deter online trade in the species before it is popularised and the market gains a real foothold. Keeping a watch on any social media content that promotes the Javan ferret badger as a pet or alludes to the development of a 'civet-lover club' equivalent is paramount for timely intervention. In addition, understanding the nuances of what motivates consumers in choosing ferret badgers as pets will be integral in determining whether consumer demand is driven by an appeal for general small carnivore morphologies or this particular species.

Until we have a more conclusive population and distribution data model, we cannot conclude that a limitation lies in local Javan ferret badger abundance, but it is likely. This could especially be the case because the species has historically not been detected in most camera-trap surveys and is apparently rarer than most other small carnivore species including Javan palm civet (Duckworth et al. 2016b). Javan palm civet is a known abundant small carnivore on the island of Java and across most parts of its range, whilst it also inhabits secondary forests and heavily altered areas. Higher numbers of Javan palm civets in trade compared to Javan ferret badgers could reflect higher local abundance. On the other hand, it could indicate that palm civets are simply easier to catch whereas ferret badgers are abundant but more cryptic. It is important to add, that in contrast to Javan palm civet, Javan ferret badgers are currently rare in the small carnivore pet market. Whether this rarity is a product of consumer choice, abundance or other

processes remains unknown. However, any perceived rarity of a product in a market context can quickly generate demand. Javan ferret badger pet trade should therefore be monitored closely. Our findings suggest wild sourcing of ferret badgers, but further evidence is needed to completely rule out captive breeding as a potential source. With no quota to harvest wild individuals, it is not an option to legally set up a captive breeding facility (see Section 4.4). It is important that we determine the origins of the Javan ferret badgers so that we can better assess how trade impacts the status of ferret badgers in the wild.

4.3. Zoonotic health risks and notes on reproduction

Increased human contact with and exposure to Javan ferret badgers through the online pet trade presents a significant and unknown risk for the transmission of zoonotic diseases to pet trade dealers and pet owners (Chomel et al. 2007). To our knowledge, the Javan ferret badger is mainly or exclusively used for the pet trade and not for the meat market, so zoonotic transmission is likely to only occur directly from the handling of live animals. Whether wild-sourced or captive-bred, both pathways of trade are implicated in facilitating the emergence of new zoonotic disease and transmission into human populations (Bell et al. 2004, Karesh et al. 2005, Aguirre et al. 2020). Trade in Javan ferret badgers could also introduce new non-zoonotic pathogens to other species and threaten conservation if these spill into wild populations (Bezerra-Santos et al. 2021).

No formative studies have been conducted on specific Javan ferret badger pathology and so potential zoonotic health risks remain unexplored. This prompts a significant need for research to identify risks associated with Javan ferret badger trade (cf. Joseph et al. 1978). Unlike the small-toothed ferret badger, links to rabies virus outbreaks have not been observed in Javan ferret badgers (Liu et al. 2010, Chang et al. 2015), but sampling efforts on Java thus far have been limited (Joseph et al. 1978). Given that these species are closely related, it is not unlikely that the Javan ferret badger could become an established carrier of the disease in the future. The recent SARS-CoV-2 global pandemic also highlights the need to identify health risks involved with the trade in wildlife if we are to prepare for and avoid the next pandemic (Bezerra-Santos et al. 2021). In addition, every effort should be directed towards increasing public awareness of general health risks involved with keeping exotic animals as pets.

Our findings may also shed light on some important biological features surrounding Javan ferret badger reproduction but will require further studies for validation. Our observations suggest that young were born in December to March, i.e. at the height of the rainy season in Java and Bali. If gestation is comparable to the small-toothed ferret badger (i.e. 57–80 d), then the breeding season for Javan ferret badger must include September and October (Shie et al. 1988). Our observations for Javan ferret badger differ from the reproductive pattern observed in small-toothed ferret badger where mating occurs in March and females give birth in May (Zheng 1987, Wang & Fuller 2003). This is most likely related to marked climatic differences between the 2 species, with one living in temperate regions and the other in tropics very near the equator.

4.4. Policy, management and effective law enforcement

Despite its endemism, lack of clear population and distribution data, overall conservation status and presence in domestic trade, the Javan ferret badger is listed as Least Concern on the IUCN Red List of Threatened Species (Duckworth et al. 2016b) and is not listed as a protected species in Indonesia. It is illegal for wildlife traders to collect and sell non-protected species without the appropriate permits obtained from registration with the BKSDA and the agency under the Directorate General of Forest Protection and Nature Conservation (PHKA) (Shepherd 2008). Unprotected taxa may only be traded domestically or internationally following a harvest and export quota system that has been pre-determined per year in each province. This quota is configured by a board consisting of experts from the BKSDA, PHKA and legal traders, with proof that the new quota is not detrimental to the conservation of the species in question. As there is no quota for the Javan ferret badger, any trade in the species (including captive breeding for commercial purposes) is considered illegal (Shepherd 2012). Enforcement efforts to counter the illegal trade in non-protected species with no quota are known to be particularly poor (Duckworth et al. 2016b). Therefore, in light of our persistent trade observations, we propose that keeping Javan ferret badgers on the non-protected list is likely detrimental to their conservation.

The prosecution incident involving a Javan ferret badger implies that law enforcement is operating at some level to protect non-protected species that have

no annual quota. It is difficult to tell whether confiscation of this species would have occurred in the absence of other protected species. The offender was an Indonesian national who was trading wildlife online as pets. He was also a recidivist of another wildlife smuggling case. After leaving prison, he continued to trade wildlife illegally with an even wider smuggling network. He had 3 Facebook accounts and 2 different mobile numbers that were used to sell animals (both protected and non-protected species). The involvement of a Javan ferret badger in a prosecution is significant, as there is no evidence that this has ever occurred previously. Given the volume of trade in the species observed in online and physical marketplaces from 2012 to 2020, enforcement can still be much improved.

4.5. Recommendations for improved management and increased protection

Javan ferret badgers continue to be detected in the Indonesian wildlife trade even though any trade in this species is not legally permitted. We strongly urge the government of Indonesia to list the Javan ferret badger as a protected species under national legislation as it is important to (1) clarify its legal status in trade with the public; (2) encourage stronger law enforcement actions; and (3) act as a precautionary measure to safeguard the species. We suggest that harsher penalties be applied to deter people trading in Javan ferret badgers, as well as encourage stronger resolve from enforcement authorities to protect native species. Finally, we suggest the IUCN Red List assessment be revisited and accompanied by focussed research on Javan ferret badger life history, population ecology and distribution, as the present assessment of Least Concern likely underestimates the current levels of threats faced by the species, especially in light of ongoing online trade. Until a true conservation status and accompanying threats associated with trade are assessed, we should be treating this species as a conservation priority. Additionally, in light of the recent Covid-19 pandemic, we should be allocating resources towards understanding unknown pathologies of small carnivores to identify and mitigate against emerging zoonotic disease.

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