

Commercial civet farming practices and conservation impacts on wild civet populations in central Vietnam

Mai Trinh Thi (✉ mai.trinh31294@gmail.com)

Save Vietnam's Wildlife, Cuc Phuong National Park, Cuc Phuong, Nho Quan, 430000 Ninh Binh

Russell Gray (✉ russell@svw.vn)

Save Vietnam's Wildlife, Cuc Phuong National Park, Cuc Phuong, Nho Quan, 430000 Ninh Binh

Thong Pham

Save Vietnam's Wildlife, Cuc Phuong National Park, Cuc Phuong, Nho Quan, 430000 Ninh Binh

Hang Tran Thi Thuy

Save Vietnam's Wildlife, Cuc Phuong National Park, Cuc Phuong, Nho Quan, 430000 Ninh Binh

Long Le Kim

VNUHCM – University of Science – Ho Chi Minh City

Long Cao Nhat

Save Vietnam's Wildlife, Cuc Phuong National Park, Cuc Phuong, Nho Quan, 430000 Ninh Binh

Thai Nguyen

Save Vietnam's Wildlife, Cuc Phuong National Park, Cuc Phuong, Nho Quan, 430000 Ninh Binh

Research Article

Keywords: Viverridae, civet coffee, kopi luwak, civet farm, wildlife farms, illegal wildlife trade

Posted Date: July 6th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1806075/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Demand for luxury wild meat and civet coffee has driven the establishment of civet farms in South-east Asia, including in Vietnam. However, little is known about the impacts of these farms on wild civet populations. In 2020, semi-structured interviews were used to explore the status and trade dynamics of 57 commercial civet farms in Lam Dong and Dak Lak provinces, Vietnam. Interviewees comprised civet farm owners as well as local government staff that were mandated to monitor these facilities. The results show that the surveyed civet farms are poorly managed by the authorities in these two provinces and that these operations pose a high level of risk to both wild civet populations and to public health. 64% of interviewed farms reported that they restocked using wild-caught civets and 63% reported disease as a cause of captive mortality, and in one instance a farm reported ~ 200 individuals died at once. A fifth of the farms interviewed kept more civets than registered with the government. High mortality and low breeding success rates were reported by 74% owners; this probably explains some of the reported dependency on using wild-caught civets for restocking. Civet farms in these two provinces are an ongoing threat to wild civet populations and also to public health; farms may currently be beyond regulatory control, and the commercial farming of civets for their meat and for civet coffee should be phased out both as a conservation and pandemic prevention mechanism.

Introduction

Civets (Viverridae) are hunted and trapped for human consumption as food or for use in traditional medicine in Africa and Asia (Carder et al., 2016; Wondmagegne et al., 2011; Nijman et al., 2014; Shepherd, 2012; Shepherd & Shepherd, 2010; Jelil et al., 2018; Noutcha et al., 2020). In some African countries, civet gland is believed to cure a range of disease and illness, including headaches, skin diseases and cancer (Taye, 2009) and female infertility (El-Kamali, 2000). In India, the civet gland is an ingredient of the Ayurvedic holistic healing medicines (Balakrishnan & Sreedevi, 2007; Kumara & Singh, 2007). In South-east Asia civets are known to be traded for their meat, body parts, as pets, and for the civet coffee industry (Shepherd & Shepherd, 2010). In Vietnam, the body parts of civets are soaked in traditional Vietnamese rice wine, which is believed to increase male sexual performance (Robertson et al., 2003), and their scent gland are prescribed to women that are having difficulty giving birth, and to people with psychological disorders (Nash, 1997). Civets are also exploited for their meat, and are one of the most commonly consumed wild mammals in Vietnam (Sandalj et al., 2016; Robertson, 2007; Van Song, 2008), China (Cheng, 2007), and Laos (Johnson et al., 2003). In Vietnam, civet meat, like most other wildlife meat and products are consumed as a luxury item, and not for sustenance (Challender et al., 2015; Dang & Nielsen, 2018; Drury, 2009; Drury, 2011; Ingram et al., 2021; Sandalj et al., 2016; Shairp et al., 2016), and while commercial breeding facilities like civet farms represent the illusion of sustainable wild meat production and trade, lack of regulations, inspections, and accurate record keeping may enable wildlife farms in Vietnam to unsustainably harvest animals from the wild to maintain their livestock.

Commercial civet breeding ('civet farms') has been used to supply the demand for civet meat, civet coffee and other civet products e.g., scent gland fluids (Wondmagegne et al., 2011; Denver, 2003). Over the last twenty years, the number of wildlife farms has grown in some countries in South-east Asia, including in Vietnam (WCS, 2008). In Indonesia, where civet coffee (referred to as *kopi luwak*) is popular, civets are

reported to be captured from forests to restock these farms (Carder et al., 2016). Civet coffee production is now very industrialised; civets are caged and forced to eat coffee, and wild civets are captured to sustain the farms (Carder et al., 2016). Common Palm Civet (*Paradoxurus hermaphroditus*) is the main species kept in civet farms (Carder et al., 2016; Nijman et al., 2014; Shepherd, 2012), though Masked Palm Civet is also commonly observed, as found in the current study. Globally threatened civet species have been also recorded these farms; at least three Owston's Civets (*Chrotogale owstoni*) are known to have gone through civet coffee facilities in Da Lat, Vietnam in 2018 (Willcox et al., 2019). Civet coffee has been produced in Vietnam for nearly a decade, with a kilogramme of civet coffee selling for 40–80 times the price of normal coffee (Nam Giang, 2011). In Vietnam, civet coffee farms are located mainly in the central highlands and in the south (Nam Giang, 2011).

In Vietnam, wildlife farms are regulated under Decree 06/2019/ND-CP and its update Decree 84/2021/ND-CP on wildlife management and Decree 35/2019/ND-CP on administrative violations in forestry. Under Vietnamese law, any species can be commercially farmed provided the origin of the founder stock is legal e.g., from other legal farms, from legally harvested wildlife, or from trade confiscations. Wildlife farms are under management of the Forest Protection Department (FPD) and Vietnam's CITES Management Authority. The latter provides permits for all CITES Appendix 1 listed species, whilst the former can grant permits for CITES Appendix 2 species, as well as any not listed on CITES. The provincial FPD are mandated to monitor and manage any wildlife farms within their jurisdiction. Civet species listed in Group IB of Decree 06 can be exploited under a license, and the law includes some limited provisions for ensuring a legal origin. Civet species listed in group IIB of the same decree can be commercially exploited if permission from the relevant authority is acquired. Trade-confiscated civets listed in group IIB can be legally auctioned or sold to commercial enterprises, including legal wildlife farms.

There are eight Viverrid species in Vietnam, including the Binturong (*Arctictis binturong*), Common Palm Civet (*Paradoxurus hermaphroditus*), Large Indian Civet (*Viverra zibetha*), Large Spotted Civet (*Viverra megaspila*), Owston's Civet (*Chrotogale owstoni*), Small Indian Civet (*Viverricula indica*), Small-Toothed Palm Civet (*Arctogalidia trivirgata*), Masked Palm Civet (*Paguma larvata*), and the Spotted Linsang (*Prionodon pardicolor*). Two of the civet species are listed as globally Endangered (EN), one as Vulnerable (VU), and other four are classified as Least Concern (LC) by the *IUCN Red List of Threatened Species*. However, all civet species are probably far below natural population densities in Vietnam, including in protected areas; hunting, particularly the use of snares, is common in the country's protected areas (Gray et al., 2018) and many of these snares are set to supply demand for the commercial wildlife trade (Belecky and Gray 2020; Gray et al. 2018; Gray et al. 2021)

There has been no published research on the civet farming industry in Vietnam and its potential impacts on wild civet populations. Furthermore, several civet coffee-producing areas in Vietnam are in close proximity to important populations of Owston's Civets, an Annamite Mountain endemic which are rapidly approaching extinction. This research focused on (1) the status of civet farming in southern Vietnam and (2) the trade dynamics of these civet farms so that its impacts on wild civet populations could be assessed.

Methods

Survey area

Lam Dong and Dak Lak provinces produce the highest amount of coffee in Vietnam, and are known 'hotspots' for civet coffee facilities. Lam Dong (11°57'N, 108°26'E) and Dak Lak (12°40'N, 108°3' E) provinces are located in the Central Highlands of Vietnam. The area for coffee production in Lam Dong is estimated at 1,441 km², which accounts for approximately 57% of the total crop area in the province ("Natural resources of Lam Dong", 2020). Around 2,000 km² are used for coffee plantations in Dak Lak (Dinh Doi, 2019) and this represents 32% of the coffee production area for the entire country (Dinh Doi, 2019). Coffee is one of the most important economic products of the two provinces. In 2020, the annual export of coffee in Lam Dong was up to 80 tonnes and valued at US\$ 173 million ("Natural resources of Lam Dong", 2020), accounting for 86% of all agricultural exports. In Dak Lak, coffee contributed to 60% of the province's total income (Dinh Doi, 2019).

Data collection

The surveys were carried out in Lam Dong and Dak Lak provinces in June and December 2020. The main target for the surveys were commercial facilities that kept or sold civets, including for meat and/or for the production of civet coffee (commonly referred to as 'wildlife farms'). Wild meat restaurants were also targeted; these were visited to assess the links between these commercial operations and the captive civet facilities that were visited. In this paper "civet farm" is any captive facility whose main purpose is the commercial exploitation of civets.

CyberTracker and Spatial Monitoring and Reporting Tool (SMART) enforcement software (<https://smartconservationtools.org/>) were used to collect and store the survey data. Data forms were constructed using SMART and then loaded onto standard Android mobile phones. This method was used for two purposes: to enable systematic data collection and so reduce recording errors, and to enable the surveyors to record information in an inconspicuous way (i.e., to avoid the use of pen and paper, or more obvious recording devices). The interviewers would complete parts or all of the data collection form immediately after the interview had been completed and when the interviewee was no longer present. All interviews were conducted in Vietnamese.

Commercial civet farms

In Vietnam, the provincial Forest Protection Department (FPD) is the responsible government authority for managing and monitoring civet farms, including the process of registration and licensing. Details on registered civet coffee farms were first gathered from the FPD of Lam Dong and Dak Lak provinces. The information provided by the FPD was used to identify potential facilities for interviews. Additional facilities were then located based on information given by members of the public, or by using "snowball sampling" (Bryman, 2004), where interviewees at a farm were asked if they knew of other commercial civet farms.

Information on the scale and trade dynamics of civet farms, including of any reports of illegal civet trade, were gathered through semi-structured interviews with owners or employees at each facility. Direct observations of the operations (e.g., number of enclosures, civet species present, numbers of civets, presence

of snare wounds / missing limbs, presence of other traded / commercially bred wildlife), were used to help verify statements made by the interviewees. The majority of the interviews were conducted face-to-face; phone interviews were only carried out when the facilities could not be accessed either because they could not be located, or because the owners did not want the surveyors visiting their facility. Cover stories were used when approaching and interviewing the owners or staff at captive civet facilities. Initially the cover story was that the team were students, researching the economics of civet farms, and responses of civet farm owners to the Covid-19 pandemic. However, after initially struggling to get responses, the survey team changed tactics and posed as either potential buyers of civet coffee or civet meat or as tourism agencies, as several of the facilities were partially marketed towards tourists.

Market and restaurant surveys

Local markets in Lam Dong and Dak Lak provinces that sold agricultural products and had the potential to sell wildlife or wildlife products were surveyed. One or two observers would walk along a market to see whether any wild animals were being sold. If wild animals were detected, semi-structured interviews on the price, quantity, source, trends and species sold were conducted with the sellers.

Restaurants in the survey areas, especially in any touristic areas, were visited to assess whether they sold civet meat and of any links between the restaurants and the civet farms in the surveyed provinces. Restaurants with banners relating to “forest” food, such as “wild chicken” or “wild boar” were also checked for wild civet meat. Cover stories used when surveying the markets and restaurants comprised of posing as wild meat buyers, as well as tourism agencies.

Data analysis

Nonparametric Wilcoxon tests were used to assess pairwise difference between the observed number of civets in facilities in Dak Lak and Lam Dong provinces as the data were not normally distributed. When civets could not be observed, the number of civets reported by interviewees was used as the observed number. The same pairwise test was also employed to compare the size of registered and non-registered facilities; any facilities in the process of registration and inactive farms were excluded from the test data. A Kruskal-Wallis test was used to test for the difference in numbers of civets reported by the FPD, interviewee claims, and by the survey team’s own observations. All analyses were carried out in R statistical software (R Core Team, 2020).

Results

Demographics and data quality

Staff from 57 civet farms were interviewed during the surveys. The majority of interviewees self-identified as the owner or co-owner (98.2%, 56/57), with only one interviewee an employee. 12.3% (7/57) of interviewed civet farms were inactive based on the statement of interviewees. Among the interviewees, 75% of respondents were male and 25% were female. Direct observations on the number of civets, enclosures, and husbandry conditions were possible in 61.4% (35/57) of the facilities.

The establishment year for a civet farm ranged from 1999 to 2019. Fifty-five percent (27/49) of farms interviewed established between 2016–2019. According to the FPD, most civet facilities were small (less than 50 civets) and run as family businesses. In contrast to the interviewee reported figures, the FPD stated that most civet farms were established between 2005 and 2010, when there was a trend to farm civets for civet coffee as the price was high; the number of farms then reduced as the civet coffee produced could not be sold. The number of civet farms registered with the FPD in Lam Dong dropped from 39 in March 2019 to 21 in June 2020. However, approximately 79% (19/24) of civet farm owners stated that they believed demand for civets to sustain other farms or to supply wild meat restaurants was increasing, and that the buyers of their civets were therefore guaranteed.

Number of civet farms

There were 21 FPD-registered civet farms in Lam Dong province, 17 in Dak Lak province, 1 in Dong Nai province. The survey team identified an additional 18 facilities that were not on the registered lists maintained by the FPD (Fig. 1).

Observed and reported species

Binturong (*Arctictis binturong*), Common Palm Civet (*Paradoxurus hermaphroditus*), Masked Palm Civet (*Paguma larvata*), and Small Indian Civet (*Viverricula indica*) were observed (Table 1). Owston's Civet (*Chrotogale owstoni*) was not seen in any facilities, however, 3/19 respondents reported seeing this species in other farms in other provinces and one reported to have kept the species in the past. Common Palm Civet was the most commonly observed civet species accounting for approximately 94% of all civet observations. Seven respondents reported that, except for Common Palm Civet and Masked Palm Civet, other civet species did not eat coffee fruits or ate very few. Small Indian Civets were reported by two respondents to eat some coffee fruits but the scent of the coffee beans produced was considered to be inferior to those produced by Common Palm Civet. A third of the surveyed facilities kept and bred taxa other than civets, including both wildlife and domestic species.

Table 1

Civet species and other wildlife and domestic species seen in civet farms (n: number of each civet species; n_t: total number of civets observed)

Family	Scientific name	Decree 84	Decree 06	IUCN Redlist	Management under	n/n _t	%
Civets							
Vivirridae	<i>Arctictis binturong</i>	x	IB	VU	CITES VN	121/1559	0.77
Vivirridae	<i>Paradoxurus hermaphroditus</i>	-	IIB	LC	Provincial FPD	1478/1559	94.80
Vivirridae	<i>Viverricula indica</i>	-	IIB	LC	Provincial FPD	5/1559	0.32
Vivirridae	<i>Paguma larvata</i>	-	IIB	LC	Provincial FPD	64/1559	4.11
Vivirridae	<i>Viverra zibetha</i> *	-	IIB	LC	Provincial FPD	-	-
Vivirridae	<i>Viverra megaspila</i> *	x	IIB	EN	Provincial FPD	-	-
Vivirridae	<i>Chrotogale owstoni</i> *	x	IIB	EN	Provincial FPD	-	-
Vivirridae	<i>Arctogalidia trivirgata</i>	-	IIB	LC	Provincial FPD	-	-
Other Wildlife							
Mustelidae	<i>Martes flavigula</i> *	-	-	LC	-		
Mustelidae	Melogale sp.	-	-	-	-		
Cervidae	<i>Cervus nippon</i>	-	-	LC	-		
Suidae	<i>Sus scrofa</i>	-	-	LC	-		
Geoemydidae	<i>Heosemys grandis</i>	-	IIB	VU	Provincial FPD		
Hystriidae	<i>Hystrix brachyura</i>	-	-	LC	-		
Hystriidae	<i>Atherurus macrourus</i>	-	-	LC	-		
Phasianidae	<i>Pavo muticus</i>	x	IIB	EN	Provincial FPD		
Columbidae	<i>Columba livia domestica</i>	-	-	-	-		

* Reported to be kept by farm owners in the past

Family	Scientific name	Decree 84	Decree 06	IUCN Redlist	Management under	n/n _t	%
Hylobatidae	<i>Nomascus leucogenys</i>	x	IB	CR	CITES VN		
Elephantidae	<i>Elephas maximus</i>	x	IB	EN	CITES VN		
Phasianidae	<i>Gallus gallus domesticus</i>	-	-	-	-		
Colubridae	<i>Ptyas mucosus</i>	-	IIB	-	Provincial FPD		
Pythonidae	<i>Python bivittatus</i>	-	IIB	VU	Provincial FPD		
Elapidae	<i>Ophiophagus hannah</i>	x	IB	VU	CITES VN		
Varanidae	<i>Varanus salvator</i>	-	IIB	LC	Provincial FPD		
Herpestidae	<i>Herpestes javanicus</i>	-	-	LC	-		
Spalacidae	<i>Rhizomys sp.</i>	-	-	-	-		
Dicroglossidae	<i>Hoplobatrachus rugulosus</i>	-	-	LC	-		
Anabantidae	<i>Anabas testudineus</i>	-	-	LC	-		
Ampullariidae	<i>Pila conica</i>	-	-	-	-		
* Reported to be kept by farm owners in the past							

The average number of observed civets in each civet farm (registered and non-registered) was 30 civets in Dak Lak and 37 civets in Lam Dong, ranging from 3 to 330 civets. The total number of civets in all interviewed facilities were 1559 civets; this number includes 393 civets reported by farms that could not be physically accessed. The average number of civets at each facility in Dak Lak was not significantly different from that in Lam Dong ($W = 471$, p -value = 0.194). The number of civets at non-registered facilities was significantly different to that of registered farms ($W = 325.5$, p -value = 0.001); fewer civets were at non-registered facilities.

For registered facilities, a higher number of civets were reported by interviewees compared to those reported by the FPD, although it was not statistically different ($\chi^2 = 0.17$, p -value = 0.92). The number of civets reported by interviews were slightly lower than that observed by the survey team. Direct observations were made of 1166 civets; however, only 1125 civets were reported by interviewees (41 unaccounted for), and 751 civets were reported by the FPD from registered facilities (415 unaccounted for); proving a somewhat wide disparity in registered farm animals and realistic numbers.

Type of civet farm and main outputs

The outputs of the facilities were civet coffee, civet meat and/or breeding civets. Approximately 22% of civet farms interviewed had a single commercial purpose, most farms had a combination of commercial purposes (Table 2.a). The number of farms that sell both civet meat and live civets accounted for the highest proportion, followed by farms sold civet coffee, meat and live civets. Sixty-eight percent (39/57) farms reported that they sold civets to other farms as founder stock. The main consumers of civet coffee were overseas tourists e.g., overseas Vietnamese, and from Japan, Taiwan, France, Russia, and Korea, reported by 13 farm owners producing civet coffee. The other seven farms that aimed to produce civet coffee had not succeeded in selling it. The reasons given by those seven inactive farms were due to the low survival rates of the captive civets (3/7), civets escaped (1/7), no buyers of civet coffee (1/7), no time (1/7), and unpleasant smell (1/7).

Table 2

Summary of proportional figures/percentages of key survey questions indicating a) trade dynamics, b) impacts of civet farming, and c) law enforcement (N: number of farms met criteria; Nt: Total number of farms responded to the specific question). Note that not all respondents gave clear answers to some questions, or did not answer at all, so the overall sample size of each question occasionally varies.

Term	Criteria	N/Nt	%
a. Trade dynamics			
1. Purpose of farming to produce:	Only civet coffee	7/57	12.28
	Only civet breed	2/57	3.51
	Only civet meat	4/57	7.02
	Civet coffee, tourism, meat	7/57	12.28
	Civet coffee, meat and breed	13/57	22.81
	Civet meat and breed	20/57	35.09
	Civet coffee, tourism, meat and breed	4/57	7.02
2. Working time	Respondents work full time for the civet farms	15/57	26.31
b. Impacts of civet farming			
1. Animal sourcing	Source civets from hunters or live animal sellers beside sourcing from other breeding farms	35/54	64.81
	Source founder civets from hunters only	10/54	18.52
	Restocking discretely (only when the civet die, need to expand, etc.)	34/44	77.27
2. Mortality	Civets die from diseases, injuries, other reasons	41/42	97.62
	Newborn civets die	22/23	95.65
	Wild civets die within 2 months after arriving at farms	19/35	54.29
	Civets not capable to breed or too weak/injured are sent to nearby restaurants	15/28	53.57
3. Husbandry and keeping	Failures in breeding civets by farm operator	20/27	74.07
	Civets escape from the facility	16/47	34.04
	Wood logs inside cages are seen	5/35	14.29
	Many civets are kept in the same cage	5/35	14.29
	Civets are vaccinated, medicines are bought to treat sick civets	11/52	21.15
	Enclosure/individual is marked to differentiate males for switching breeds	4/15	26.67
<i>* N: number of restaurants met criteria; Nt: number of restaurants responded to the species question</i>			

Term	Criteria	N/Nt	%
	Uncleansed faeces are observed	13/35	37.14
4. Further threats from restaurant	Civet meat is offered at the restaurant	28/40*	65.12
c. Law enforcement			
1. Farm registration status	Farmed operated outside of the law (not registered or intending to)	13/57	22.81
	Farms registered with FPD	39/57	68.42
	Total not registered with FPD	18/57	31.58
<i>* N: number of restaurants met criteria; Nt: number of restaurants responded to the species question</i>			

Ownership

A fourth of interviewees (15/57) were working full time for the civet farms (Table 2.a.1). With those working part-time on civet farms, the owners' background was diverse, including current and retired governmental officials (6 respondents), seasonal hunters (3 respondents), and restaurant owners (3 respondents). One civet farm owner was a current government officer of the Forest Protection Department. The owners working in the Vietnamese government reported buying wild civets from hunters (5/6), keeping more species in the farms than registered (2/4) and opening 'ghost farms' (1/6). 'Ghost farm' is a term indicating a farm which is legally registered but does not keep any animals; the registration allows them to legalize illegally caught wild animals that are then sold to other farms or restaurants. In addition to the statements made by a government official, the team observed one civet facility that did not have any civets, but instead sold bamboo rats and other wild animals. Civets with a 'proof of origin' from registered farms could sell at a higher price than those without (5 respondents).

Sourcing civets

The majority of interviewees bought civets directly from hunters or live animal traders to supply their farms (Table 2.b.1). Seven interviewees stated, without a leading question or prompting, that wild civets were cheaper than captive bred animals. The difference in price was to cover the paperwork or certification costs to prove the animal had a legal origin, indicating unregistered animals were not only common, but easier to source and maintain without regulatory interference. Three interviewees who were former seasonal hunters stated that they started civet farms as they saw the number of wild civets had reduced dramatically because of overexploitation, with animals extirpated in their local areas. Additionally, five farms of the 35 farms accessed had civets with visible snare wounds.

Captive mortalities

97% of interviewees reported that they had witnessed premature deaths of their captive civets in the past (Table 2.b.2), with disease (10/16 interviewees), injury (6/16) and over ingestion of coffee beans (5/16) cited as possible reasons. Four small inactive farms in Lam Dong reported that they lost all of their civets because of disease in 2019. One farm in Dak Lak reported a single loss of 200 civets due to disease; the surviving

civets were then reportedly sold at a discount to wild meat restaurants. 54% facilities reported that wild civets would die within two months after being bought from wildlife traders (Table 2.b.2); and were reported refusing to eat, diseased or succumbing to severe injuries caused by hunting traps. Less than half of the respondents reported to have no issues with purchased wild civets.

Breeding success

74% (20/27) of the interviewees reported breeding failures, with civets not producing any young in a year. Six interviewees reported that civets could breed 2 to 3 times per year, producing one to three young each time. Young civets were weaned and could be separated from their mothers at 1.5 months, after this they could be sold as a captive-bred civet (13/13 interviewees). Three facilities that focused on breeding civets claimed that wild civets were relatively more difficult to raise in captivity, with issues that included disease susceptibility, difficulties in establishing breeding pairs, and refusing food in captivity (Table 2.b.3).

Captive management

Management of captive animals was relatively poor and enclosures were small, and little to no attention appeared to be paid to conditions of enclosures or surrounding areas (Table 2.b.3; Fig. 2). Multiple civets were kept in the same enclosure in five farms, with enclosure sizes that ranged from 2 to 10m² and injuries were seen on the civet's bodies e.g., tails, limbs, in all five facilities. External marks, or other forms of individual identification, were only seen in one civet breeding facility in Dong Nai province. 26% (4/15) of civet breeding farm owners knew the importance of marking individuals, especially the males and of the importance of switching breeding pairs if they are related. The other breeding farm owners did not make any statements on the importance of individually marking civets or switching males; the new-born civets in these farms were reported to be weak and died very soon after being born. Civets were also reported to escape from 16 facilities.

Biosecurity and disease management

None of the 57 facilities had separate quarantine areas for new civets nor for civets that required treatment. No gloves or other PPE / protective gear were worn by owners or staff when feeding civets or cleaning enclosures. 21% respondents reported to vaccinate civets (the types of vaccine were not mentioned), or buy chicken and pig medicines to treat sick civets (Table 2.b.3). Bowls used to keep food for animals were unclean and some were observed with fungi. Thirty-seven percent of civet facilities were observed with unclean faeces (Table 2.b.3). The facilities were cleaned using water daily or weekly; one farm which sold civets for meat reported that they only cleaned once a month. 79% of interviewees reported to let civets die if they got sick, and would not buy medication or seek veterinary help since they did not understand about what the disease was, and in their opinion the diseases are incurable. Out of 40 interviewees who provided answers about where they sell their civets, 28 claimed to sell them to restaurants, and fifty-three percent of that subset (15/28) reported to sell weak/injured/sick civets to wild meat restaurants (Table 2.b.4).

Wild meat restaurants

Forty restaurants with banners or advertisements relating to "forest" or "wild" food, like wild chicken or wild boar were checked. Civet meat was commonly sold or available on request at restaurants: 65% (28/40) of

interviewees offered civet meat. All restaurants reported to source civet meat from hunters (28/28), with a minority also sourcing from civet farms (3/28). Two restaurants claimed that they have connections with other restaurants in terms of exchanging wild meat. Three civet farms which all sold civet coffee, civet meat, and live civets, were also operating restaurants so that they could directly supply their restaurants with live animals. None of restaurants that sold wild meat had public advertisements for civet meat and only one restaurant had civet meat on its menu. Without prompting, five interviewees stated that people with high incomes and/or high social status, including government officials, were the main consumers of civet meat. Six restaurants reported that other restaurants would sell wild meat from mongooses, rabbits and squirrels as fake civet meat because this would sell at a higher price. Markets were surveyed but no wild meat (including civet meat) or live civets were seen being sold.

Investment

The investment costs explored included costs of enclosures, breeding pairs, civet food, coffee fruits or any medicines (Table 3.c.2). The reported price for a breeding civet ranged from US\$ 108 to US\$ 520 (23 respondents), and was dependent on market price in each province, sex, and quality of the breeds. Male civets were reported to be more expensive than female civets (5 respondents). It would cost farm owners around US\$ 80 for feeding a civet per annum. The farm fed the animals fresh coffee fruits for 3–6 months a year. The cost for medicines were reported to be very low (22 respondents). Electricity, water or labour costs were not mentioned by interviewees.

Table 3

Summary of average figures indicating a) farm size, b) husbandry, and c) socioeconomics (N: number of farms)

Term	Criteria	Average number	N
a. Farm size	Observed number of civets per farm in Dak Lak	30	17
	Observed number of civets per farm in Lam Dong	37	18
b. Husbandry	Size of civet enclosure in Dak Lak	0.96 x 1 x 1.01 m	26
	Size of civet enclosure in Lam Dong	0.7 x 0.77 x 0.83 m	24
c. Socioeconomics			
1. Investment	Food cost (per civet per day)	US\$ 0.22	32
	Cost of an enclosure (less than 1m each side)	US\$ 23	12
	Cost of a breeding civet	US\$ 230	23
2. Benefits, income, and market price (2020)	Price of raw civet coffee (civet coffee does not go through any processes except sun dry)	US\$ 41	9
	Price of processed civet coffee (civet coffee that is ready to sell commercially)	US\$ 220	14
	Price for a kg of civet meat sold	US\$ 63	25
	Percentage of annual income obtained from civet farms, averaging for all farms surveyed	% 32.1	50
	Percentage of annual income obtained from civet farms, averaging for all farms surveyed, excluding farms did not produce any income yet	% 48.64	33
	Amount (kg) of civet coffee that one civet could produce per annum	9.82	12
d. Law enforcement			
1. Farm registration status	Farmed operated outside of the law	13/57	22.81
	Farms registered with FPD	39/57	68.42
	Not registered with FPD	18/57	31.58

Annual income

The percentage of annual income from civet farms was reported to be low (Table 3.c.2). Removing farms with which either had stated that they had no income or had closed, the average annual income from the

civet farm was under 50%, and 5/50 owners had 75% or more of their annual income from their civet farms; these were large facilities (more than 50 civets) where the interviewees worked full-time.

Market prices

Civets were sold for coffee, meat, and breeding stock (Table 3.c.2). The price for a kg of civet coffee sold were reported to range from US \$17 to US \$108 per kg, averaged US\$41 ± 32, and processed civet coffee price ranged from US \$35 to US \$1299 per kg, averaged US \$220 ± 264; However, these estimates could be biased as the interviewers were playing the role of buyers when inquiring. We have no reason to believe one kg of civet coffee would sell for above \$200-\$300. Various prices of civet coffee came with the quality (fake/real) of civet coffee, coffee varieties, and how civet coffee companies defined their brands. Civet meat sold between US\$ 22 and US\$ 74 per kg, depending on the species of civet and the market price norms. Five facilities stated that civet meat was in high demand; the demand for breeding civets was also high, seven farm owners said they have been propositioned to sell civet breeding pairs but they did not have any spares to sell. Three farms reportedly sold up to 90 civet breeding pairs per annum, six other farms claimed to sell 30–50 civet breeding pairs per annum.

Management and monitoring of wildlife farms

Facility owners must keep a monitoring book for recording the number of civets in their facility and any changes due to births, deaths, or traded animals. Three monitoring books were briefly assessed during the survey; none appeared to be up to date. One facility reported to have sold 30 civets the previous year and this information was not included in their monitoring book, and therefore had not been reported to the FPD.

Twenty-two percent of the interviewed facilities were not registered and therefore operating illegally; this number excludes five civet farms that were in the process of registering with the provincial FPD (Table 3.d.4). Two civet farms in Dak Lak had reported to the FPD that they had stopped operating and were closed, however these were both reported by the owners to be open during the survey. Eight large farms with that kept > 50 civets reported registering only one farm, and would then split their civets between different locations, often in different communes, to avoid any inspection from the authorities. Four facility owners reported that they had bought licenses to sell civets from other registered farms. They would then use these illegally acquired licenses to sell their civets with a higher price to buyers; the extra cost for each civet with a legal origin paper ranges from US\$ 44 to US\$ 87 per animal.

Discussion

This survey provides data and information on the status of commercial civet farming in southern Vietnam. Results showed the capture or trade of wild-caught civets to restock farms is a common activity, partly because of the low breeding success rates and high mortality rates. Several civet farms reported disease as a cause of premature deaths and five reported mass die-offs in captivity; several farms also reported selling dead or weak civets that could not breed to wildlife restaurants. Given the known role of viverrids in zoonotic and infectious disease (Bell et al., 2004; He et al., 2021; Robertson et al., 2006; Shi & Hu 2008; Wicker et al., 2017; Wikramanayake et al. 2021), this is a significant public health concern.

The results indicate that the civet farms in Lam Dong and Dak Lak provinces are a highly probable risk to wild civet populations and to public health, and that current management or regulatory systems are failing to mitigate these risks. Better, more stringent, regulation is unlikely to limit or remove these risks entirely; civets are known to carry a wide range of diseases, and even the most bio-secure captive facility will not be able to reduce these risks to zero. Given these risks, the most pragmatic solution will be to phase out commercial civet farming, including for operations that are focused on supporting the trades in civet coffee and civet meat.

Conservation impacts on wild civet populations

Both registered and non-registered civet farms were engaged in activities that will be impacting wild civet populations. This included restocking using wild-caught civets and laundering wild civets through their facilities, including through 'ghost' farms. The laundering of wild animals through wildlife farms is a known threat to wildlife and has been documented with other taxa in Vietnam (Brooks et al., 2010), and turtles in China (Haitao et al., 2007). Although Common Palm Civet is a very adaptable species, and has been recorded in a variety of rural and peri-urban landscapes (Malla et. al., 2019, Jothish et. al., 2011), in Vietnam there are no similar locality records from the last 20 years, and most observations or records of this species are in blocks of natural habitat, away from high human population densities. Masked Palm Civets are mostly restricted to hilly evergreen forest (Belden et. al., 2014, Semiadi et. al., 2016) and Binturong has not been reliably recorded in the country since 2009 (Shih-chih Yen 2009). All populations of the latter species are probably now restricted to either protected areas or isolated (i.e., inaccessible) blocks of forest. Of the 34 farms that indicated that they used hunters/animal traders to source wild-caught civets, four were located within 2km of a protected area (minimum ~ 500m), namely Cat Tien National Park and Nui Dai Binh Nature Reserve. The civet species recorded, their known status in the wild in Vietnam, the observations of snare wounds, and the statements made by the majority of interviewees that they sourced wild-caught civets to restock their farms, are all strong indicators that these civet farms are sourcing from wild civet populations in protected forests.

Additionally, snaring is a commonly used hunting method in Vietnam's protected areas (Gray et al., 2018; MacMillan & Nguyen, 2018; Long et al., 2017), and is known to have caused a significant decline in a wide range of taxa in the country e.g., Large-antlered Muntjac (Timmins et al., 2016), Saola (Timmins et al., 2020), Silver-backed chevrotain (Nguyen et al., 2019), including civets and other small carnivores (Gray et al. 2021). While hunters and hunting methods were not the focus of the interviewees, given the common occurrence of unselective snaring in Vietnam, and its known effectiveness for capturing nearly all species of civet (excepting the highly arboreal Small-toothed Palm Civet), it is highly probable that a large proportion of the wild-caught civets in the interviewed farms were caught using snares; this is partly supported by the observations of snare wounds in five farms. The proximity of these farms to protected areas that are known to support populations of threatened ground-dwelling hunting-sensitive wildlife, including Owston's Civets, also indicates that the demand for wild civets to re-stock these farms will have impacts beyond the four civet species observed during the surveys.

Animal health implications

Civets are known to be hosts of the zoonotic and infectious diseases (Aparna et al., 2020; Chaiyasak et al., 2020; Vaseem & Raghuram, 2017; Sabeta et al., 2020). Animal disease they carry including Canine Distemper in palm civets (Aparna et al., 2020), and carnivore protoparvovirus (Chaiyasak et al., 2020; Xinyu et al., 2019) that lead to mass die-offs of captive Small Indian Civets in a civet perfume farm in Thailand (Chaiyasak et al., 2020). There were reported mass die-offs of civets (up to 200 civets) at civet farms in the survey area. Captive civets are a potential reservoir of pathogens; when these animals escape or are released into the wild, they could harm wild populations (WCS, 2008).

Public health implications

The link between wildlife trade and zoonoses is well-documented (Bell et al., 2004; Karesh et al., 2005). Captive civets in this study lacked standardized biosecurity measurement, e.g., quarantine of new or sick animals, and would therefore contribute to the transmission and emergence of potential zoonotic diseases if current standards are maintained. A range of pathogens have been detected in the Viverridae family (Wicker et al., 2017), and many of these are zoonotic that could pass to humans. Severe acute respiratory syndrome (SARS) is an infectious disease that comes from wild animals, and through human via consumption of wild meat (Ye et al., 2020; Lee & Hsueh 2020). SARS emerged in Guangdong China in 2002 and 2003 involved more than 8000 people and killed 10% of the patients (Salata et al., 2019). Masked Palm Civets, sold in wet market are possible intermediate host of SARS-CoV (Salata et al., 2019; Cui et al., 2019). There is strong evidence that suggests the COVID-19 pandemic, threatening the human health and nation economics, might also have also emerged from an animal origin (Boni et al. 2020; Lu et al. 2020). Zoonoses, which emerging from wildlife pose detrimental impacts to public health, global economics; civets and other viverrids are considered to be one of the highest risks of zoonotic disease transfer especially in markets such as wild meat restaurants and when kept in farms (Wikramanayake et al. 2021). Therefore, strictly regulating or eliminating high-risk wildlife farms and meat consumption (such as civets) is a public health mechanism that must be considered in Vietnam.

Role of civet farms in supplying consumer demand

It is often argued that captive bred wildlife are a cheaper and more sustainable alternative to wild-caught animals and that these farming systems can help to reduce pressures on wild populations (Phelps et al., 2013; Nogueira & Nogueira-Filho, 2011). Contrary to these statements, the surveyed civet farms did not provide a cheaper alternative; snared or trapped wild-caught civets were sold to restaurants and breeding farms at a cheaper price than the farmed civets. Farmed civets (whether of a genuine farmed origin or not) would have a higher price per kg, partly because of the cost of acquiring licenses or certificates that prove a legal origin.

A large proportion of the surveyed farms had failed to breed civets, and some had to close operations as a consequence; this finding is similar to previous studies of wildlife farms in Vietnam (Brooks et al., 2010; WCS, 2008). Conditions in the surveyed farms are too poor to support captive breeding at a rate that could keep these farms stocked to a level that would supply demand, assuming consumer preferences could shift to farmed civet meat (see Robertson 2007). For now, wild meat consumers in Vietnam prefer wild-caught animals to farmed wildlife (SVW, *unpublished*). Nutritionally insufficient diets, poor captive conditions, and poor welfare standards were observed in the all of the surveyed farms that the research team had access to.

Similar conditions in wildlife farms have been reported before, for a range of species in Vietnam, as well as for other commercial civet farms (Carder et al., 2016).

Another reason for the reported low breeding rates and high mortalities could be the failure to control inbreeding; only one farm marked the individuals and only a third of farms switched males to limit inbreeding. This poor captive management could lead to a decrease in the breeding success of the captive populations and their genetic diversity (Brooks et al., 2010). Inbreeding depression is a known factor contributing to infant mortalities in a range of taxa (Ibáñez et al., 2013; Fuerst-Waltl & Fuerst 2012; Brekke et al., 2010; Mishra et al., 2017). As well as limiting the captive breeding success, poor management of genetic diversity (including inbreeding) will severely limit the role of captive civets in being potential source animals for any releases or reintroductions; this argument is routinely touted as a justification for farming Tigers in Asia (Zhang et al., 2019; Warrick et al. 2010; Tilson et al., 2010), but is unlikely to have any merit. A similar situation is present within the civet farms surveyed.

Role of civets farms in supporting wild civet populations

Civet farms in Vietnam cannot help to conserve wild civet species in the country and represent a threat to wild populations. Interviewees reported poor standards of captive and veterinary care, a dependency on wild civets to restock, and almost no management of breeding individuals. Additionally, civets were often in close proximity to each other, with different animal species kept within the same facility; this will increase the potential for diseases, including emerging infectious diseases and zoonoses. This will be a threat to the sustainability of any captive management operation, as well as to public health; several interviewed farms reported mortality events caused by unknown diseases.

Poor management of civet farms

The monitoring and management of wildlife farms in Vietnam is ineffective and under-resourced (Huong et al., 2020; Nguyen & Dinh, 2020; Brooks et al., 2010). Reliable, objective, corruption-proof, and cost-effective monitoring schemes for farmed wildlife have yet to be fully or even partially implemented in Vietnam, primarily because of issues related to governance and poor legislation (Nguyen & Dinh 2020), including a lack of any third-party oversight. The main monitoring method that the FPD has is based on the registration of a facility, and then subsequent checks on a facility's record book for its animals. Given the discrepancies between the FPD maintained lists, and the observations made by the survey team on the number of farms, as well as the number of civets in registered farms, clearly the current system is not fit for purpose and vulnerable to mismanagement or abuse. Better individual marking methods for captive animals, such as micro-chipping may solve some of these issues, but such systems do not address the root causes of weak governance (including the absence of any third-party oversight) and political apathy.

Civet farms and livelihoods

Wildlife farms are sometimes viewed as a strategy for strengthening food security and alleviating poverty (Noutcha et al., 2020; Nogueira & Nogueira-Filho, 2011; Abebe, 2003). However, in Vietnam, the vast majority of wild meat consumption is as luxury food and has no direct relevance to food security (Bennett, 2002; Brooks et al., 2010; Sirén et al., 2006). This survey showed that most civet farm owners interviewed did not consider farming as their main source of income, only accounting for a third of their income. Additionally, the

reported profits were relatively significant for large farms, which had a fast rotation of animals and stable outputs, but not for the majority of farms which were relatively small in size and therefore vulnerable to changes in market prices and losses of captive civets.

Conclusion

Civets are commonly traded, consumed, and kept in commercial facilities in Vietnam. A significant number of farms are unregistered, which revealed the dark side of the wildlife farm industry, which is legal and often promoted in Vietnam. The husbandry conditions of civet farms were poor and did not meet the standards for biosecurity. Sick civets were not treated and quarantined in a separate area, which caused mass die-offs of many civet farms. The demand for these civets to sustain restaurants and wildlife farms might have driven the local extirpation of many civet populations.

Based on our finding, we propose to prohibit commercial wildlife farming of endangered species. Globally threatened species which are listed in the IUCN Red list should not be farmed for commercial purposes in Vietnam. Farms should only keep and breed normal wild species, which authority have proof that they can breed well in captivity, and these farms still need to be monitored well. The decision for determining a species that is able to raise in captivity should depend on their fertility, wild population status and impacts of farming activity on their existence. This list of species capable to farm should be published on website of CITES Vietnam. CITES Vietnam could also collaborate with conservation organizations in the country to have more inputs and support to make the list.

Since wildlife farming is still being seen as a way to alleviate the poverty, bring income to some people, and supply the high demand, closing all the farms immediately will be an unrealistic task as also for a huge number of animals needed to rescue if these farms close. One thing we could do to prevent further impacts of these farms is halting the new establishment of civet farms, or farms of any protected priority species. The existing farms will need to be checked and monitored regularly so that violations will not occur, together with increasing punishments for violations, and developing a method for individual tagging. To reiterate, civets are a high-risk for zoonotic disease transfer throughout all of the markets in which they occur in Vietnam, and their trade which relies on snare trapping is a major driver of extinctions. If regulatory management actions are not feasible due to lack of resources and personnel to enforce them, then the only other option is to phase out civet farms and consumption in Vietnam entirely.

Declarations

ACKNOWLEDGEMENT

We would like to give sincere thanks to Wild Planet Trust and Wildlife Reserves Singapore for funding the study. Thanks Mr. Le Ky Son for their assistance in conducting the interviews. We would also like to thank Daniel Willcox on his valuable edits and suggestions throughout the process of writing the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

Funding

This work was supported by Wild Planet Trust and Wildlife Reserves Singapore

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

Material preparation, data collection and analysis were performed by Trinh Thi Mai, with analysis and editorial support from Russell J. Gray and Pham Van Thong. The first draft of the manuscript was written by Trinh Thi Mai with assistance from all listed authors. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data Availability

Data will be made available upon request to the corresponding author.

References

1. Abebe YD (2003) Sustainable Utilisation of the African Civet (*Civettictis civetta*) in Ethiopia. 17
2. Aparna, Abraham S, Prathiush PR, Sobha, Ramachandran J(2020) Canine distemper outbreak in palm civets and its implications in animal health
3. Balakrishnan M, Sreedevi MB (2007) Captive breeding of the Small Indian Civet *Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803). 36, 5
4. Belden G, Jukie A, Megom N, Unggang J (2014) Lowland records of masked palm civet *Paguma larvata* from Sarawak, Malaysian Borneo. *Small Carnivore Conservation* 51:56–58
5. Belecky M, Gray TNE (2020) Silence of the snares: Southeast Asia's snaring crisis. WWF International
6. Bell D, Robertson S, Hunter PR (2004) Animal origins of SARS coronavirus: Possible links with the international trade in small carnivores. *Philosophical Trans Royal Soc Lond Ser B: Biol Sci* 359(1447):1107–1114. <https://doi.org/10.1098/rstb.2004.1492>
7. Bennett EL (2002) Is There a Link between Wild Meat and Food Security? *Conserv Biol* 16(3):590–592. <https://doi.org/10.1046/j.1523-1739.2002.01637.x>
8. Boni MF, Lemey P, Jiang X, Lam TTY, Perry BW, Castoe TA, Robertson DL (2020) Evolutionary origins of the SARS-CoV-2 sarbecovirus lineage responsible for the COVID-19 pandemic. *Nat Microbiol* 5(11):1408–1417
9. Brekke P, Bennett PM, Wang J, Pettorelli N, Ewen JG (2010) Sensitive males: inbreeding depression in an endangered bird. *Proceedings of the Royal Society B: Biological Sciences*, 277(1700), 3677–3684
10. Brooks EGE, Robertson SI, Bell DJ (2010) The conservation impact of commercial wildlife farming of porcupines in Vietnam. *Biol Conserv* 143(11):2808–2814. <https://doi.org/10.1016/j.biocon.2010.07.030>
11. Bryman A (2004) *Social Research Methods*, second edn. Oxford University Press, New York

12. Carder G, Proctor H, Schmidt-Burbach J, D'cruze N (2016) The animal welfare implications of civet coffee tourism in Bali. *Anim Welf* 25(2):199–205. <https://doi.org/10.7120/09627286.25.2.199>
13. Chaiyasak S, Piewbang C, Banlunara W, Techangamsuwan S (2020) Carnivore protoparvovirus-1 associated with an outbreak of hemorrhagic gastroenteritis in small Indian civets. *Vet Pathol* 57(5):706–713
14. Challender DW, Harrop SR, MacMillan DC (2015) Understanding markets to conserve trade-threatened species in CITES. *Biol Conserv* 187:249–259
15. Cheng MH (2007) SARS source back on the menu. *Lancet Infect Dis* 7(1):14. [https://doi.org/10.1016/S1473-3099\(06\)70676-4](https://doi.org/10.1016/S1473-3099(06)70676-4)
16. Cui J, Li F, Shi ZL (2019) Origin and evolution of pathogenic coronaviruses. *Nat Rev Microbiol* 17(3):181–192
17. Dang Vu HN, Nielsen MR (2018) Understanding utilitarian and hedonic values determining the demand for rhino horn in Vietnam. *Hum Dimensions Wildl* 23(5):417–432
18. Denver M (2003) Procyonidae and Viverridae. In *Procyonidae and Viverridae* Eds Fowler, M. & Miller, E. Elsevier Science, St. Louis, Missouri
19. Dinh Doi (2019) Định vị cho cây cà phê Đắk Lắk [Finding way for Dak Lak coffee]. *Dak Lak News*. <http://baodaklak.vn/channel/3483/201904/dinh-vi-cho-cay-ca-phe-dak-lak-ky-1-5628903/>
20. Drury RC(2009) Identifying and understanding consumers of wild animal products in Hanoi, Vietnam: implications for conservation management (Doctoral dissertation, UCL (University College London))
21. Drury R (2011) Hungry for success: urban consumer demand for wild animal products in Vietnam. *Conserv Soc* 9(3):247–257
22. El-Kamali HH (2000) Folk medicinal use of some animal products in Central Sudan. *J Ethnopharmacol* 72(1–2):279–282. [https://doi.org/10.1016/S0378-8741\(00\)00209-9](https://doi.org/10.1016/S0378-8741(00)00209-9)
23. Fuerst-Waltl B, Fuerst C (2012) Effect of inbreeding depression on survival of Austrian Brown Swiss calves and heifers. *J Dairy Sci* 95(10):6086–6092
24. Gray TN, Hughes AC, Laurance WF, Long B, Lynam AJ, O’Kelly H, Ripple WJ, Seng T, Scotson L, Wilkinson NM (2018) The wildlife snaring crisis: An insidious and pervasive threat to biodiversity in Southeast Asia. *Biodivers Conserv* 27(4):1031–1037
25. Gray TN, Belecky M, O’Kelly HJ, Rao M, Roberts O, Tilker A, Signs M, Yoganand K (2021) Understanding and solving the South-East Asian snaring crisis. *Ecol Citiz* 4:129–141
26. Haitao S, Parham JF, Lau M, Tien-Hsi C (2007) Farming endangered turtles to extinction in China. *Conserv Biol* 21(1):5–6
27. He WT, Hou X, Zhao J, Sun J, He H, Si W, ... Su S(2021) Total virome characterizations of game animals in China reveals a spectrum of emerging viral pathogens. *BioRxiv.preprint*
28. Huong NQ, Nga NTT, Long NV, Luu BD, Latinne A, Pruvot M, ... Olson SH(2020) Coronavirus testing indicates transmission risk increases along wildlife supply chains for human consumption in Viet Nam, 2013–2014. *PloS one*, 15(8), e0237129
29. Ibáñez B, Moreno E, Barbosa A (2013) Parity, but not inbreeding, affects juvenile mortality in two captive endangered gazelles. *Anim Conserv* 16(1):108–117

30. Ingram DJ, Coad L, Milner-Gulland EJ, Parry L, Wilkie D, Bakarr MI, Abernethy K (2021) Wild meat is still on the menu: progress in wild meat research, policy, and practice from 2002 to 2020. *Annu Rev Environ Resour* 46:221–254
31. Jelil SN, Nag S, Hayward M, Ramírez-Chaves HE(2018) Poaching record of a Common Palm Civet *Paradoxurus hemaphroditus* from Assam, India. 6
32. Johnson A, Singh S, Dongdala M, Vongsa O (2003) Wildlife hunting and use in the Nam Ha National Protected Area: Implications for rural livelihoods and biodiversity conservation. December 2003. Wildlife Conservation Society, Vientiane, Lao PDR
33. Jothish PS (2011) Diet of the common palm civet *Paradoxurus hermaphroditus* in a rural habitat in Kerala, India, and its possible role in seed dispersal. *Small Carnivore Conservation* 45:14–17
34. Karesh WB, Cook RA, Bennett EL, Newcomb J (2005) Wildlife Trade and Global Disease Emergence. *Emerg Infect Dis* 11(7):3
35. Kumara H, Singh M (2007) Small carnivores of Karnataka: Distribution and sight records. *J Bombay Nat History Soc* 104:153–160
36. Lee PI, Hsueh PR (2020) Emerging threats from zoonotic coronaviruses—from SARS and MERS to 2019-nCoV. *J Microbiol Immunol Infect* 53(3):365
37. Long B, Gray T, Lynam A, Seng T, Laurance W, Scotson L, Ripple W (2017) Reversing “Empty Forest Syndrome” in Southeast Asia. *Natl Geographic Voices* 8:1–6
38. Lu R, Zhao X, Li J, Niu P, Yang B, Wu H, Wang W, Song H, Huang B, Zhu N (2020) Genomic characterisation and epidemiology of 2019 novel coronavirus: Implications for virus origins and receptor binding. *The Lancet* 395(10224):565–574
39. MacMillan DC, Nguyen QA (2014) Factors influencing the illegal harvest of wildlife by trapping and snaring among the Katu ethnic group in Vietnam. *Oryx* 48(2):304–312
40. Malla G, Ray P, Johnson J, Sivakumar K (2019) First photographic record of Common Palm Civet *Paradoxurus hermaphroditus* from the mangroves of Andhra Pradesh, India. *Small Carnivore Conservation* 57:10–13
41. Mishra SP, Mishra C, Nayak G, Mishra P, Sahoo N, Sahu SK(2017) Effect of inbreeding on mortality of captive tiger. *Explor Anim Med Res.* 2017a, 7(1), 69–73
42. Nam Giang (2011) Chồn hương ở xứ sở cà phê [Common Palm Civets in the land of Civet coffee]. *Thanh Nien News*. <https://thanhnien.vn/chon-huong-o-xu-so-ca-phe-post211405.html>
43. Nash S (1997) Fin, feather, scale and skin: Observations on the wildlife trade in Lao PDR and Vietnam. Fin, feather, scale and skin: Observations on the wildlife trade in Lao PDR and Vietnam. TRAFFIC Southeast Asia, Malaysia
44. Natural resources of Lam Dong (2020) *Lam Dong News*, <https://lamdong.gov.vn/HOME/ABOUT/SitePages/tai-nguyen-thien-nhien.aspx>
45. Nguyen A, Tran VB, Hoang DM, Nguyen TAM, Nguyen DT, Tran VT, Tilker A (2019) Camera-trap evidence that the silver-backed chevrotain *Tragulus versicolor* remains in the wild in Vietnam. *Nat Ecol Evol* 3(12):1650–1654

46. Nguyen DH, Dinh TM(2020) Legal framework for wildlife farming benefits species conservation and preventing wildlife crimes in Vietnam. E3S Web of Conferences, 175, 03025.
<https://doi.org/10.1051/e3sconf/202017503025>
47. Nijman V, Spaan D, Rode-Margono EJ, Roberts PD, Nekarlis KAI (2014) Trade in Common Palm Civet *Paradoxurus hermaphroditus* in Javan and Balinese markets. Indonesia 51:8
48. Nogueira SSC, Nogueira-Filho SLG (2011) Wildlife farming: An alternative to unsustainable hunting and deforestation in Neotropical forests? Biodivers Conserv 20(7):1385–1397.
<https://doi.org/10.1007/s10531-011-0047-7>
49. Noutcha MAE, Amadi HU, Okiwelu NS (2020) Wildlife harvesting and bushmeat trade in Rivers State, Nigeria: The resilience of the African civet, *Civettictis civetta* (Carnivora: Viverridae) and records of rare species. J Ecol Nat Environ 12(3):117–119. <https://doi.org/10.5897/JENE2020.0840>
50. Phelps J, Carrasco LR, Webb EL (2013) A Framework for Assessing Supply-Side Wildlife Conservation. Conserv Biol 28:244–257
51. R Core Team (2020) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>
52. Robertson SI, Trung TC, Momberg F (2003) Hunting and trading wildlife: An investigation into the wildlife trade in and around the Pu Mat National Park, Nghe An Province, Vietnam. Hunting and trading wildlife: An investigation into the wildlife trade in and around the Pu Mat National Park. Nghe An Province, Vietnam. SFNC, Vinh, Vietnam
53. Robertson SI, Bell DJ, Smith GJD, Nicholls JM, Chan KH, Nguyen DT, Tran PQ, Streicher U, Poon LLM, Chen H, Horby P, Guardo M, Guan Y, Peiris JSM(2006) Avian influenza H5N1 in viverrids: Implications for wildlife health and conservation. Proceedings of the Royal Society B: Biological Sciences, 273(1595), 1729–1732. <https://doi.org/10.1098/rspb.2006.3549>
54. Robertson SI (2007) The status and conservation of small carnivores in Vietnam. The status and conservation of small carnivores in Vietnam p 273. University of East Anglia, Norwich
55. Sabeta CT, Marston DA, McElhinney LM, Horton DL, Phahladira B, Fooks AR (2020) Rabies in the African Civet: an incidental host for Lyssaviruses? Viruses 12(4):368
56. Salata C, Calistri A, Parolin C, Palu G(2019) Coronaviruses: a paradigm of new emerging zoonotic diseases. Pathogens and disease, 77(9)
57. Sandalj M, Treydte AC, Ziegler S (2016) Is wild meat luxury? Quantifying wild meat demand and availability in Hue. Vietnam Biol Conserv 194:105–112
58. Semiadi G, Ross J, Hearn AJ, Macdonald DW, Mathai J, Augeri DM, Wilting A (2016) Predicted distribution of the masked palm civet *Paguma larvata* (Mammalia: Carnivora: Viverridae) on Borneo. Raffles Bulletin of Zoology
59. Shairp R, Veríssimo D, Fraser I, Challender D, MacMillan D(2016) Understanding urban demand for wild meat in Vietnam: implications for conservation actions. PloS one, 11(1), e0134787
60. Shepherd CR, Shepherd LA(2010) The trade in Viverridae and Prionodontidae in Peninsular Malaysia with notes on conservation and legislation. 4

61. Shepherd CR (2012) Observations of small carnivores in Jakarta wildlife markets, Indonesia, with notes on trade in Javan Ferret Badger *Melogale orientalis* and on the increasing demand for Common Palm Civet *Paradoxurus hermaphroditus* for civet coffee production. 47:4
62. Shi Z, Hu Z (2008) A review of studies on animal reservoirs of the SARS coronavirus. *Virus Res* 133(1):74–87
63. Shih-chih Y(2009) Activity pattern and habitat selection of the medium-to-large terrestrial mammals in Cat Tien National Park, Vietnam. MSc thesis, Institute of Wildlife Conservation, National Pingtung University of Science and Technology, Pingtung, Taiwan. [in Chinese]
64. Sirén AH, Cardenas JC, Machoa JD (2006) The Relation Between Income and Hunting in Tropical Forests: An Economic Experiment in the Field. *Ecol Soc* 11(1):art44. <https://doi.org/10.5751/ES-01640-110144>
65. Taye T(2009) The African Civet Cat (*Viverra civetta*) and its life supporting role in the livelihood of smallholder farmers in Ethiopia. *A Conference on International Research on Food Security, Natural Resource Management and Rural Development, University of Hamburg*
66. Tilson R, Nyhus PJ, Muntifering JR(2010) Yin and yang of tiger conservation in China. *Tigers of the World*,439–451
67. Timmins RJ, Duckworth JW, Robichaud W, Long B, Gray TNE, Tilker A(2016) *Muntiacus vuquangensis*. *The IUCN Red List of Threatened Species* 2016: e.T44703A22153828. <https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T44703A22153828.en>. Accessed on 28 June 2022
68. Timmins RJ, Hedges S, Robichaud W(2020) *Pseudoryx nghetinhensis*. *The IUCN Red List of Threatened Species* 2020: e.T18597A166485696. <https://dx.doi.org/10.2305/IUCN.UK.2020-1.RLTS.T18597A166485696.en>. Accessed on 28 June 2022
69. Van Song N (2008) Wildlife Trading in Vietnam: Situation, Causes, and Solutions. *J Environ Dev* 17(2):145–165
70. UNEP-WCMC (2022) Protected Area Profile for Viet Nam from the World Database on Protected Areas, June 2022. Available at: www.protectedplanet.net
71. Vaseem M, Raghuram V (2017) Case Report: Rabies in a Small Indian Civet *Viverricula indica*. *Int J* 6(1):330–333
72. Warrick DM (2010) Inbreeding depression in captive white tigers: methods for purifying tiger lineages. *Zoos' Print* 25(10):7–13
73. WCS (2008) Commercial wildlife farms in Vietnam: A problem or solution for conservation? *Wildlife Conservation Society*. Hanoi, Vietnam
74. Wicker LV, Canfield PJ, Higgins DP (2017) Potential pathogens reported in species of the family Viverridae and their implications for human and animal health. *Zoonoses Public Health* 64(2):75–93
75. Wikramanayake E, Pfeiffer DU, Magouras I, Conan A, Ziegler S, Bonebrake TC, Olson D (2021) A tool for rapid assessment of wildlife markets in the Asia-Pacific Region for risk of future zoonotic disease outbreaks. *One Health* 13:100279
76. Willcox D, Lees C, Hoffmann R, Roopali R, Duckworth JW (eds) (2019) Conservation Strategy for Owston's Civet *Chrotogale owstoni* 2019–2029. *Save Vietnam's Wildlife, Vietnam and the IUCN SSC*

Small Carnivore Specialist Group

77. Wondmagegne D, Afework B, Balakrishnan M, Gurja B (2011) Collection of African Civet *Civettictis civetta* perineal gland secretion from naturally scent-marked sites. *Small Carniv Conserv* 44:14–18
78. Xinyu T, Min CS, Yifan W, Lien SM, Chan A, Hui TX, Taoqi H (2019) Canine parvovirus-2c (CPV-2c) infection in wild Asian Palm Civets (*Paradoxurus hermaphroditus*) in Singapore. *J Wildl Dis* 55(4):965–969
79. Ye Z-W, Yuan S, Yuen K-S, Fung S-Y, Chan C-P, Jin D-Y (2020) Zoonotic origins of human coronaviruses. *Int J Biol Sci* 16(10):1686–1697. <https://doi.org/10.7150/ijbs.45472>
80. Zhang W, Xu X, Yue B, Hou R, Xie J, Zou ZT, Zhang Z (2019) Sorting out the genetic background of the last surviving South China tigers. *J Hered* 110(6):641–650

Figures

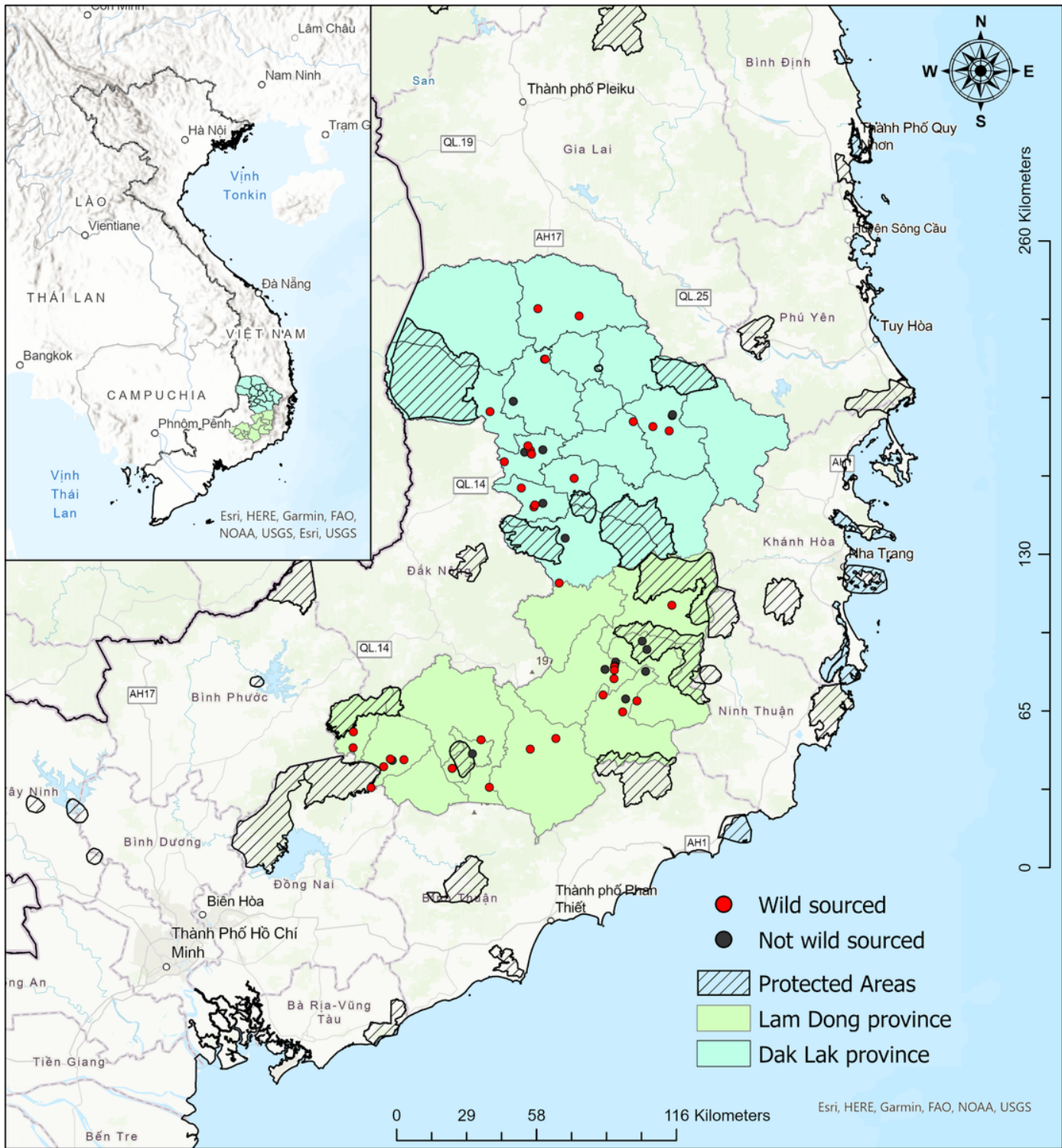


Figure 1

Distribution of interviewed facilities in Lam Dong and Dak Lak provinces, Vietnam in relation to protected areas (UNEP-WCMC, 2022). Black dots show the location of interviewed civet farms that did not indicate their animals were sourced from the wild; red dots are the locations of farms which indicated they may source animals from the wild.



Figure 2

Examples of standard civet enclosures at three farms during the surveys. Enclosures are typically small, made of metal mesh or bars, and have open bottoms so faeces and urine can be washed with water from the floor below (or collected for coffee).