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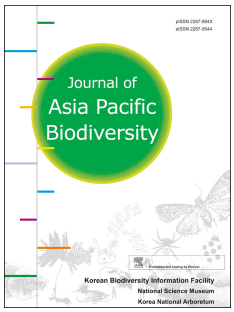

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Original article

A preliminary assessment of the wildlife trade in badgers (*Meles leucurus* and *Arctonyx* spp.) (Carnivora: Mustelidae) in South Korea

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ABSTRACT

We provide a preliminary assessment of a previously overlooked wildlife trade, the legal trade in badgers (*Meles leucurus* and *Arctonyx* spp.) and badger-derived products in South Korea. A new phase of the trade emerged in the 1990s with the establishment of wildlife farms to supply demand for badger as an edible and medicinal resource, including as a substitute for Asiatic black bear (*Ursus thibetanus*), a CITES Appendix I species. We trace the continued existence of badger farms to supply trade between 2001-2020, supplemented by imported badger-derived products and some apparent illegal harvesting of wild *Meles leucurus* in South Korea. The range of badger-derived products available to consumers has diversified during the last two decades and now encompasses human food, traditional medicine, cosmetics, dietary supplements and accessories. We recommend improved monitoring and regulation of the trade, given that legal farming, and potential illegal wild harvest, may present important risks to: (i) wild *Meles leucurus* populations in South Korea and *Arctonyx* spp. populations in Asia, which are currently poorly monitored; (ii) the welfare of traded badgers, as territorial mammals with specific social and housing needs; (iii) human health, with mustelid farms now in greater focus as potential sources of novel zoonotic diseases.

Keywords: Mustelid, Small carnivore trade, Republic of Korea, Wildlife farming, Zoonotic diseases

Running title: Badger trade in South Korea

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Introduction

Global wildlife trade involves billions of wild animals and plants each year, across a wide taxonomic and geographic range, and encompasses a great diversity of products and uses (Warchol 2004; Rosen and Smith 2010; Scheffers et al. 2019). It is a multibillion-dollar industry, with the global value of the legal trade in wild animals alone estimated to range between US$2.9-4.4 trillion in the two decades between 1997-2016 (Andersson et al. 2021). This trade provides a valuable source of food (Chardonnet et al. 2002; Cawthorn and Hoffman 2015; Haas et al. 2019) and is an important economic activity (Roe 2008; Sumaila et al. 2016; Andersson et al. 2021), including for some of the world's poorest communities. When carefully regulated and managed, wildlife trade may also have the potential to help conserve biodiversity, for example by providing economic incentives for habitat conservation (Carruthers 2008) or for the sustainable management of wild populations of commercially valuable species (Lichtenstein and Carmanchahi 2012).

However, unsustainable trade in wildlife is acknowledged to be a major threat to global biodiversity (Bennett et al. 2002; Challender et al. 2015; Scheffers et al. 2019). There has been considerable attention given to better understanding the impact of illegal wildlife trade on biodiversity (see, for example, Zimmerman 2003; Rosen and Smith 2010; Margulies et al. 2019; 't Sas-Rolfes et al. 2019). However, legal wildlife trade is often poorly regulated (Dutton et al. 2013), particularly for less well-known species, leading to unsustainable use (Schlaepfer et al. 2005; Nijman 2010; Jensen et al. 2019; Marshall et al. 2020). Inadequate regulation of wildlife trade can also result in poor welfare conditions of traded animals (Baker et al. 2013; Bando et al. 2019) and the emergence or spread of disease, with negative consequences for human health and well-being (Bell et al. 2004; Karesh et al. 2005; Swift et al. 2007; Shivaprakash et al. 2021).

In light of the wide-ranging impacts of wildlife trade for biodiversity and human society, Scheffers et al. (2019) advocate a proactive approach to identify emerging or future trends in trade. Common species that may not be currently traded in large quantities can rapidly transition to being heavily traded due to novel cultural demand, which may result in the new use of a species, the resurgence in use of a species, or the use of a species that was never used historically (see, for example, Nijman and Nekaris 2017), or its substitution for another species which is difficult to obtain as a result of scarcity, high value, or strict protection (see, for example, Williams et al. 2017). Such sudden and steep increases in demand can have severe consequences for the status of affected species, sometimes over a short period of time. For example, while its trade has a long history, the recent surge in demand for helmeted hornbill (*Rhinoplax vigil*) ivory is believed to have led to widespread extirpation of the species in Sumatra and in West and Central Kalimantan, Borneo, resulting in the upgrading of the species to Critically Endangered status on the IUCN Red List (Collar 2015; Beastall et al. 2016). Moreover, where a species is subject to novel trade, it can face a regulation gap (for example, it may not be listed on The Convention on International Trade in Endangered Species of Wild Fauna and Flora

(CITES), or its trade may be insufficiently regulated at a local or national level). In these circumstances, the newly traded species can become threatened extremely quickly (Schlaepfer et al. 2005).

Confounding the problems of rapid changes in trading patterns is a widespread lack of information on how trade impacts most species. The majority of studies, and global attention, on wildlife trade have focussed on charismatic species already known to be threatened by trade (Chen et al. 2015). Much less is known about how exploitation affects more common or neglected species, or the broader consequences of their trade. These significant knowledge gaps hamper our understanding of the impacts of trade on the majority of traded species and make it difficult to predict those species that may become targets of trade in the future, as existing sources become depleted or cultural preferences change. This prevents the timely development of appropriate regulation to safeguard species before they become heavily impacted by changing patterns in trade.

The trade in wild and captive badgers, medium-sized carnivoran mammals, is an example of a currently neglected wildlife trade. A range of species in this diverse group is known to be traded, both legally and illegally. The trade in badger-derived products is most well-known in Europe and Asia from the use of badger fur for luxury shaving brushes, with China being the world's largest exporter (OEC 2019). *Meles* badgers (including European badger *Meles meles* and Asian badger *Meles leucurus*) are protected under the Bern Convention on the Conservation of European Wildlife and Natural Habitats, but DNA sequencing of shaving brushes sold in the Netherlands and Spain revealed that several supposed hog badger (*Arctonyx* spp.)-derived brushes were in fact *Meles*-derived products (Domingo-Roura 2006). Badger-derived products are also used for other purposes and in some cases there is good evidence for the occurrence of trade. In Russia and Mongolia, *Meles leucurus* are hunted for their skins, which may be sold locally (Proulx et al. 2016). Into the late 20th Century, badger fat and lard were regularly traded in the Soviet Union and in Czechoslovakia (Griffiths 1993), while the wide variety of badger-derived products used in Europe has included badger leather (rural Finland) and a woven cloth made of badger hair (Romania) (ibid). A bushmeat trade in *Meles*, *Arctonyx* and ferret-badger (*Melogale* spp.) species has been recorded in south-eastern, southern and central China (Lee et al. 2004; Lau et al. 2010; Chen et al. 2015); Vietnam (Nash 1997); Laos, including for illegal export to wildlife markets on the Laos-Thailand border (Nash 1997); and Indonesia (Shepherd 2012). In Europe, *Meles meles* meat was eaten in Germany and the Netherlands historically (van Wijngaarden and van de Peppel 1964) and in south-central Europe until at least the early 1990s (Griffiths 1993). In Zambia and Guinea, honey badgers (*Mellivora capensis*) have been reported in bushmeat trade (Begg et al. 2013).

Badgers, their body parts and badger-derived products have also been recorded in local trade for use in traditional medicine across a wide range of countries. In Mongolia, *Meles leucurus* are traded domestically for use in traditional medicine (Clark and Javzansuren 2006; Wingard and Zahler 2006). Surveys of wildlife markets in Ulaanbaatar have documented the sale of badger fat oil, which is used to produce balms, and live badgers, which are bled for badger blood (Parkinson et al. 2008; Saveljev et al. 2014). In rural Cambodia, the use of products derived from *Arctonyx* and *Melogale* spp. in traditional

medicine has also been recorded (Ashwell and Walston 2008; Gray et al. 2014). In medieval France, a range of *Meles meles* body parts were used by apothecaries, including bone, dried blood, brain, testicles and liver (Bourand 1989). Throughout Europe, badger fat and lard were historically used in traditional medicine, particularly to create ointments for the treatment of chest complaints, rheumatism and other muscular ailments, notably back pain (Griffiths 1993; Cheeseman and Neal 1996). The use of honey badger in traditional medicine has been reported from West Africa (Mashele et al. 2021), Tanzania (TAWIRI 2009; De Luca and Mpunga 2013), Zambia (Proulx et al. 2016) and South Africa (Rowe-Rowe 1992), although some authors suggest the species may be used even more widely (Do Linh San et al. 2016).

The impact of trade on wild badger populations is largely unknown, as information on the status of badger populations and the nature and magnitude of threats they face is often scarce, and there is comparatively little known of the breeding habits of many badger species. It is at least suspected that *Meles* spp. may be sensitive to offtake rates. *Meles meles*, the best studied species to date, is known to breed relatively slowly, producing only two or three cubs in spring, with usually only one female in a social group breeding at any one time (Rogers et al. 1997). Ecological studies involving *Meles meles* populations have shown them to be slow to recover from lethal control; Cheeseman et al. (1993) reported that their study population took 10 years to return to its original size after culling in just a few social groups. Trade in wild *Meles* spp., and potentially other badger genera, may therefore represent a potential threat to wild badger populations (Griffiths 1993). Trade has previously been identified as a particular concern in Asia (Lau et al. 2010), where badger populations are often under-researched and rarely monitored (Robichaud 2010; Shepherd 2012; Proulx et al. 2016), meaning that unsustainable trade in badgers may go unnoticed. A better understanding of the badger trade in Asia could provide information useful for trade regulation and to inform monitoring programs that ensure early detection of any detrimental trends, with the aim of maintaining stable wild badger populations.

The Republic of Korea (henceforth, South Korea) represents a location where a currently overlooked trade in badgers occurs. The wild harvesting of the native badger, *Meles leucurus*, for its fur and for use in traditional medicine has occurred since at least the 1950s (Won and Smith 1999). However, in the 1990s, badger farms were established across the country, primarily to supply increased demand for a trade in badger body parts for traditional medicine, notably as a substitute for Asiatic black bear (*Ursus thibetanus*) (Jo et al. 2018), and as an edible food resource (Bae et al. 1997). Farms were stocked with either *Meles leucurus* or non-native *Arctonyx* spp.; there is evidence that badgers were imported from China (Bae et al. 1997), although it is unclear whether imports covered only non-native *Arctonyx* spp. or also included *Meles leucurus*. It is also uncertain whether badgers were also imported from other countries. This new phase of the badger trade in South Korea may have been stimulated by South Korea's ascension to CITES in 1993, given that the Asiatic black bear is a CITES Appendix I species. Although there is limited data available before 2001, when badgers were formally listed as domestic livestock (Jo et al. 2018), it is known that in 1997 there were already 60 farms housing

a total of 1066 badgers (Bae et al. 1997). By 2001, 4318 badgers were recorded on badger farms across South Korea (Ministry of Agriculture and Forestry 2002).

A shift from harvesting wild animals to wildlife farming as the primary legal means of supplying a wildlife trade has occurred with a number of different species, for example the Chinese giant salamander (*Andrias davidianus*) (Cunningham et al. 2016) and the Asiatic black bear (Hinsley et al. 2022) in China. However, the practice of wildlife farming remains highly contentious. Proponents of wildlife farming have argued that it may reduce pressure on wild populations, if farmed products either saturate demand or undercut the market for wild harvested products by providing better quality, cheaper alternatives (Jiang et al. 2007). There is some evidence for this, notably in cases where legal farming was more cost-efficient than illegal poaching; the species involved bred well in captivity and farms did not rely on re-stocking with wild animals; and the laundering of illegal, wild-harvested products was effectively restricted (Tensen 2016). For example, the introduction of American alligator (*Alligator mississippiensis*) farming in the United States, when coupled with the strengthening of anti-poaching legislation, has been credited with playing an important role in the recovery of wild populations by providing incentives for the protection of alligator habitat (particularly nest sites) and captive breeding of hatchlings for wild release, while providing a reliable, high-quality alternative to poached alligator products (Moyle 2013). However, in other examples wildlife farming has failed to alleviate pressure on wildlife populations. Wildlife farms may simply be incapable of meeting consumer demand, or may even stimulate a growth in demand by legitimising consumption (Tensen 2016). In some cases, the products of wildlife farms may be more expensive (Kirkpatrick and Emerton 2010) or otherwise less desirable for consumers than those believed to originate from wild sources (Drury 2009), resulting in parallel legal (farmed) and illegal (wild-harvested) markets (Phelps et al. 2014; Vu et al. 2022). Wildlife farming may also raise separate concerns, such as the occurrence of unsuitable welfare conditions (Bando et al. 2019), or the potential risks of disease transmission to animal or human populations (Can et al. 2019). For example, tiger (*Panthera tigris*) farming in China is not thought capable of meeting demand for tiger-derived products (Gratwicke et al. 2008) and is believed to increase the acceptability of tiger consumption (Rizzolo 2021). Given the high degree of uncertainty around wildlife farming, more information is needed on trade and wildlife farming across a diverse array of species, in order to build a better understanding of species specific factors influencing sustainability.

These patterns in the trade of *Meles leucurus* and *Arctonyx* spp. in South Korea have received little attention and the broader impacts of the trade are poorly understood. While *Meles leucurus* is listed as Least Concern (LC) on the IUCN Red List (Abramov 2016), the species is believed to be in decline globally and its status on the Korean Peninsula is poorly known (Proulx et al. 2016). Furthermore, at least one member of the *Arctonyx*, the greater hog badger (*Arctonyx collaris*), is known to be threatened by trade (Duckworth et al. 2016). Discussions with wildlife researchers in South Korea prior to commencing this study indicated an assumption that the badger trade had largely disappeared following a brief peak in the early 2000s. In this study, we investigate the validity of this assumption, evaluating

official Korean data for captive badger populations between 2001 and 2020. We aim to establish the current scale and extent of badger farming in South Korea as a source of badger-derived products for wildlife trade, as well as the range of badger-derived products available for sale and their main uses. Based on this information, we discuss potential implications of current trade for the status of wild badger populations, for the welfare of captive animals, and for human health.

Material and methods

As detailed below, we searched the published scientific literature, government reports which provided husbandry advice to badger farmers, as well as publicly available agricultural databases, to collate relevant information on the trade in badgers in South Korea between 2001 and 2020.

In order to establish the scale of badger farming in South Korea to supply the legal trade in badger products, we compiled data on the number of households involved in running badger farms and the number of captive badgers kept on badger farms between 2001-2020 from the Ministry of Agriculture, Food and Rural Affairs (MAFRA) website (https://lib.mafra.go.kr). We understand that MAFRA data on badger farms were collected at a town or city level, before being escalated to provincial and national agricultural records. For the period 2015-2020, data were also available for the number of farmed badgers from the AgriX (in English: Agriculture and Forestry Business Information System) website (http://uni.agrix.go.kr). We believe AgriX data were self-reported by farmers. As explained below, there are suspected issues associated with the 2020 MAFRA data, particularly from the province of Gyeonggi-do, which were highlighted in comparisons of the two data sources. However, these suspected issues do not fully explain the discrepancy between the MAFRA and AgriX datasets. We therefore include both the MAFRA and AgriX data in our analyses for comparison.

The MAFRA database categorised badgers as either: 'true badgers' (*Meles leucurus*), 'hog badgers' (*Arctonyx* spp.), or "hybrids", without clarifying which *Arctonyx* species are involved. The exact taxonomic status of the "hybrids" is unclear, given a lack of supporting evidence that these different genera are able to crossbreed. Instead, this category could refer to different *Meles* and *Arctonyx* species, to hybrids between *Meles* species, to hybrids between *Arctonyx* species, or simply be the result of misclassification of *Meles* or *Arctonyx* badgers (for example, different colour morphs that might appear to be different). We compiled these data over time to investigate whether there was a change in the reported types of badgers that were farmed in South Korea between 2001 and 2019.

We also conducted an online search for information on the management of badger farms and the public sale and use of badger-derived products. Between July and November 2021, we searched for the keywords: *badger* (오소리), *wild badger* (야생 오소리) and *badger farm* (오소리 농장) on the largest search engines in South Korea: Naver (https://www.naver.com/), Google (https://www.google.co.kr/) and Daum (https://www.daum.net/), to locate online news articles,

websites of badger farms, blogs by current badger farmers, and e-commerce retail platforms selling badger-derived products. The criteria for inclusion in our analysis were that an article or webpage was in Korean and included information about the farming of badgers, or sale of either badgers or badger-derived products, either by sellers or to consumers in South Korea. We repeated this process until we were unable to identify any new material that met these criteria. This process allowed us to identify categories of badger-derived products for sale. On platforms selling live badgers or badger-derived products we then cascaded our search using the identified product categories - *badger* (오소리), *badger oil* (오소리 오일 and 오소리 기름), *badger extract* (오소리 진액 and 오소리 엑기스), *badger cream* (오소리 크림), *badger essence* (오소리 에센스), *badger cosmetics* (오소리 화장품) and *badger shaving brush* (오소리털 쉐이빙 브러쉬 and 오소리털 면도솔) - to locate individual retailers and badger-derived products.

Results

Scale of badger farming to supply wildlife trade in South Korea

Between 2002 and 2018 there was a steady decline in the number of households recorded as being involved in badger farming, from a peak of 182 in 2002 to just 34 households (MAFRA) in 2018 (Figure 1). The number of farmed badgers fluctuated strongly between 2001 and 2020, with a recent decline from peaks in 2005 (7591 animals) and 2013 (6939 animals). However, the picture for 2020, the most recent year for which data is available, is obscured by a notable discrepancy between the two data sets. Although the number of farmed badgers reported by MAFRA for 2020 was 1975, AgriX reported that there were in fact almost double the number of farmed badgers (3937 animals) still present on South Korean farms, which would represent a slight increase on the previous year.

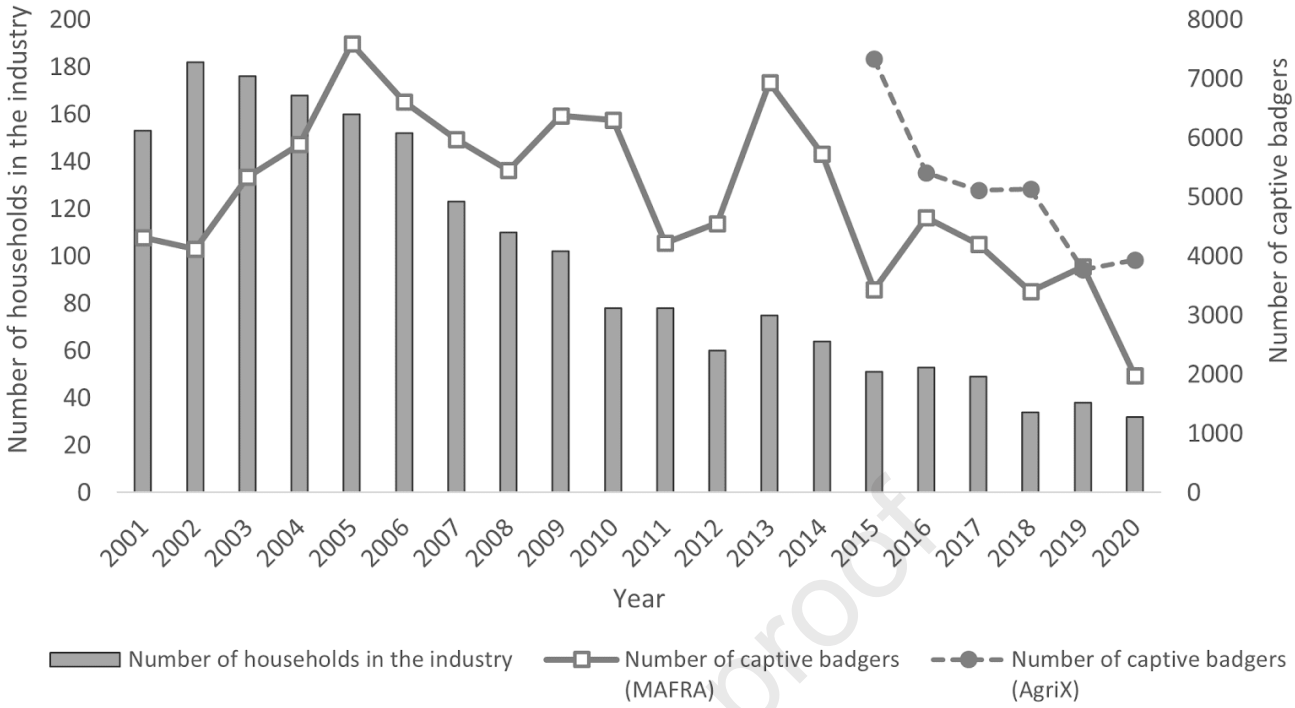


Figure 1. The number of households listed as legal badger farms in South Korea and the reported number of badgers farmed between 2001 and 2020, from records of Ministry of Agriculture, Food and Rural Affairs (2001-2020) and AgriX (2015-2020).

Types of badger farmed in South Korea

In each year between 2001 and 2019, all three categories of badger used by MAFRA ('true' badgers (*Meles leucurus*), hog badgers (*Arctonyx* spp.), and "hybrids") were recorded from badger farms in South Korea (Figure 2). Until 2010, *Meles leucurus* was the dominant reported type of farmed badger, after which there were strong fluctuations year on year resulting in either *Meles leucurus* or "hybrids" being reported as the most commonly kept animals. The number of *Arctonyx* spp. on badger farms was small throughout the study period, never exceeding 1000 animals and declining to 258 animals in 2020.

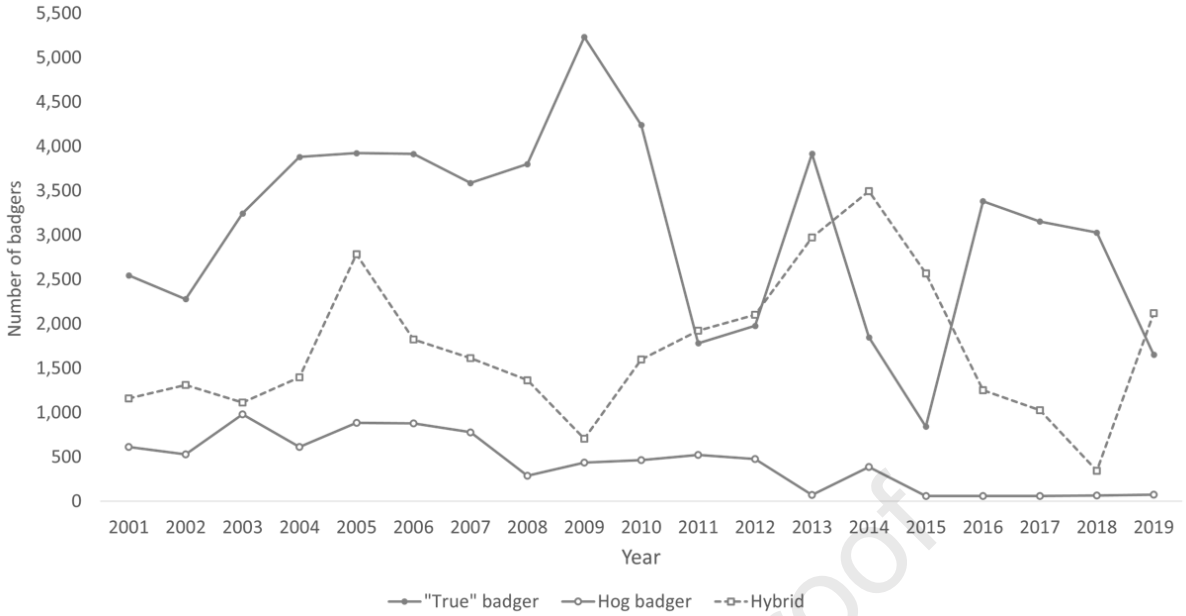
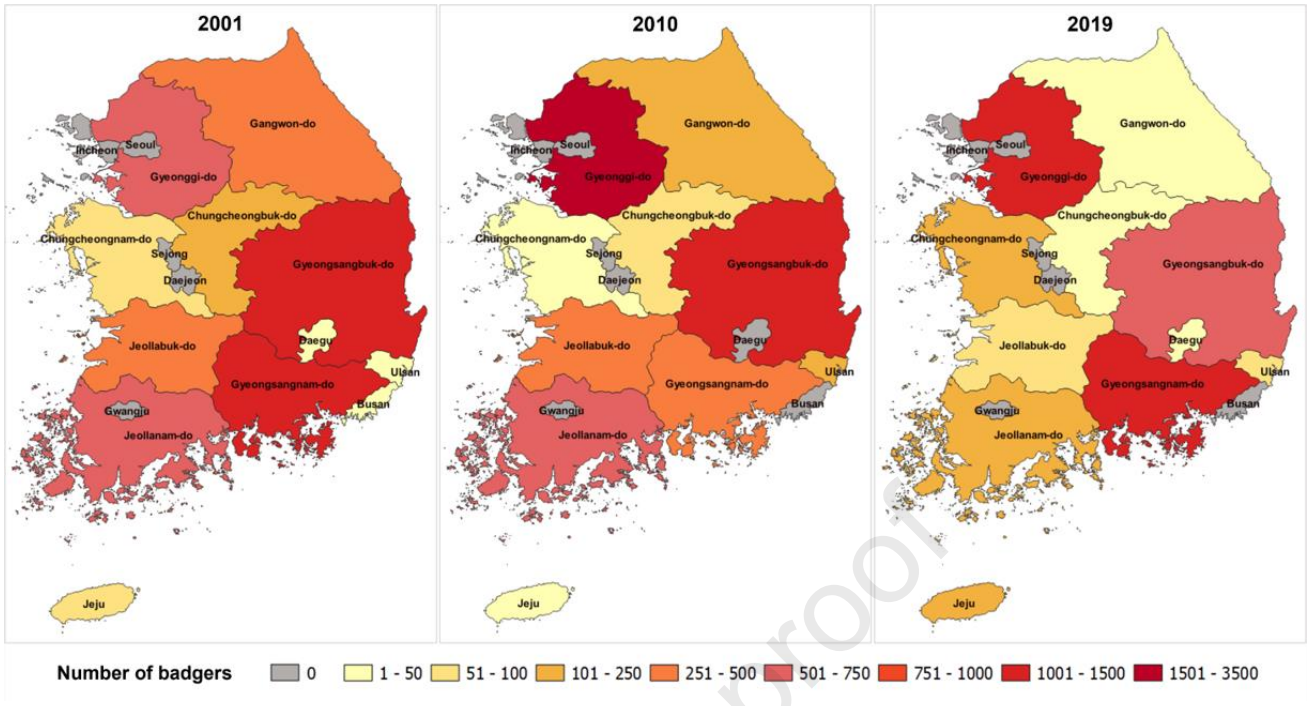


Figure 2. Reported number of captive badgers farmed in South Korea between 2001-2019, from records of Ministry of Agriculture, Food and Rural Affairs (MAFRA). "True" badgers refer to *Meles leucurus*; hog badgers refer to *Arctonyx* spp.; the taxonomic classification of "hybrids" is unclear.

Location of badger farms in South Korea

Captive badgers were rarely reported from city districts, with the exception of Ulsan, but badger farms were reported from every rural province in South Korea in 2001, 2010 and 2019 (Figure 3). The aforementioned decline in the overall number of households reported to be involved in badger farming is visible across all provinces, and, by 2019, the only province where >5 households were involved in badger farming was Gyeongsangnam-do (Figure 4). This shift towards a smaller number of larger farms is most notable for Gyeonggi-do, where 1400 farmed badgers were reported in 2019 linked to just a single household.



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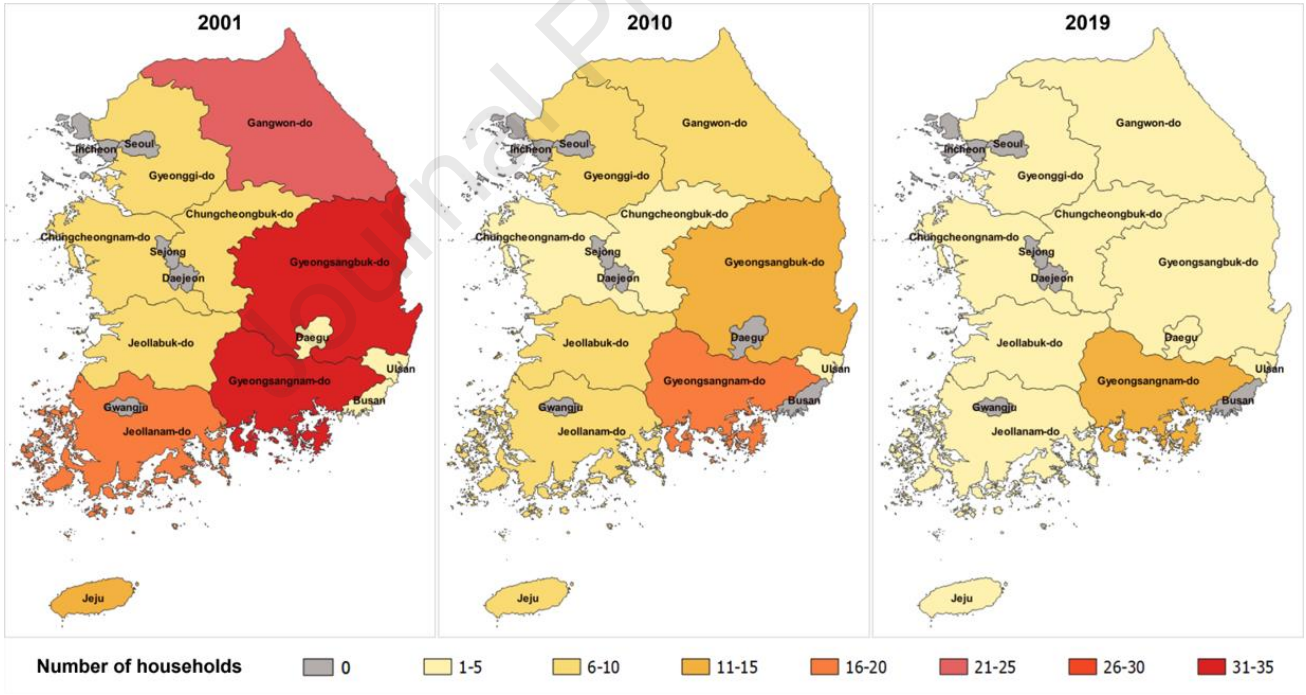
278 **Figure 3.** Reported number of captive badgers on badger farms in South Korea by province in 2001,
279 2010 and 2019, from Ministry of Agriculture, Food and Rural Affairs (MAFRA) records.



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281 **Figure 4.** Reported number of households involved in running badger farms in South Korea by province
282 in 2001, 2010 and 2019, from Ministry of Agriculture, Food and Rural Affairs (MAFRA) records.

283

284 *Availability of badger-derived products in South Korea*

285

286 Badger-derived products were found for sale on 17 different e-commerce shopping platforms
287 in South Korea, which included several of the largest such platforms in the country. Badger products

were also available on three websites directly linked to badger farms, one cosmetics website, and a Korean-language site operated by a company located in the Korean Autonomous Region of China.

A wide range of badger-derived products were reported for sale (Table 1). These were promoted for use in traditional Korean medicine, cosmetic products, human consumption as food and nutritional supplements, as well as accessories such as car seat covers and shaving brushes. In addition, the sale of live badgers was also recorded. Badger-derived products which we did not find evidence of, but which were previously reported by Jo et al. (2018), were badger hide carpets and badger leathers (although these may refer to the badger hides sold as car seat covers).

Badger shaving brushes were specifically available from Korean resellers, who sold products from manufacturers in China, the USA, Italy, Portugal, Germany and the British Crown Dependency of the Isle of Man. All other badger-derived products were marketed as either originating from South Korea, or from China or Russia.

Table 1. Non-exhaustive table of badger derived products marketed in South Korea

Badger derived product	Use category	Product use examples
Badger extract	Traditional medicine	Increased sexual stamina; to aid recovery from illness
Soaked gallbladder liquor (processed and unprocessed)	Traditional medicine	Treatment of liver disease (for example, hepatitis); fatigue relief; eyesight improvement. Promoted as a direct substitute for bear bile.
Badger oil	Traditional medicine and Cosmetics	Pain relief (treatment for burns); skincare
Badger oil facemask	Cosmetics	Facial skincare
Badger oil soap	Cosmetics	Skincare and hygiene
Badger oil cream	Cosmetics	Moisturising cream; whitening; anti-ageing; skin toner
Badger shaving brush	Accessories	Shaving brush
Badger hide	Accessories	Car seat cover

Badger nutritional supplement capsules	Human consumption	Dietary (nutritional) supplement
Badger meat	Human consumption	Sold frozen for cooking
Badger meat	Human consumption	Served as cooked meat and stew in a restaurant
Badger	Live trade	Badger farming
Badger cub	Live trade	Pets

302
303
304 **Discussion**
305
306 Our findings show that the wildlife trade in badgers in South Korea is still ongoing. While the
307 number of households involved in domestic badger farming steadily declined between 2002 and 2018,
308 the number of farmed individual badgers fluctuated strongly but did not show a matching overall decline
309 between the start and end of our study period, with close to 4000 badgers being reported on farms in
310 2001 and 2019 (as discussed below, it is difficult to draw conclusions about 2020, due to concerns over
311 the reliability of the MAFRA data for that year). This indicates a trend towards a smaller number of
312 households running increasingly large badger farms. In some regions, notably Gyeonggi-do and Jeju-
313 do, the total number of animals on badger farms actually increased during this time period (Figure 3).
314 The continued existence of domestic badger farms and the fairly high number of badgers kept on those
315 farms, indicates that there is still demand for badger-derived products. Badger-derived products are now
316 being advertised for a diverse range of uses (Table 1), beyond those purposes (badger fur, badger body
317 parts for traditional Korean medicine, badger meat for human consumption) that had been reported in
318 the literature prior to the legal recognition of badger farming in 2001 (Bae et al. 1997; Won and Smith
319 1999).
320 The agricultural records used in our study constitute the only monitoring data on badger trade
321 or badger farming in South Korea that we are aware of. These data provide records of the number of
322 households involved in the farming of badgers and the number of farmed animals. However, there may
323 be reliability issues even with these data and we found a strong discrepancy between the reported
324 number of farmed badgers in 2020 in the MAFRA and AgriX data sets (Figure 1). There was a
325 particularly large difference in the 2020 figures reported from a single province, Gyeonggi-do. AgriX
326 reported 1533 farmed badgers in Gyeonggi-do in 2020. By contrast, MAFRA reported just 4 badgers
327 in Gyeonggi-do in 2020, despite recording close to 1500 badgers in each of the previous four years
328 (2019 - 1400 badgers; 2018 - 1550 badgers; 2017 - 1400 badgers; 2016 - 1550 badgers). As a result, we

suspect that the figures reported by AgriX may provide a more accurate measure of the true number of farmed badgers in 2020. The results from Gyeonggi-do in 2020 may have resulted from human error, such as the incorrect inputting or relaying of records between the various stages in the reporting process, with MAFRA data understood to have been collected at a town or city level, before being relayed to the provincial level, and then finally being relayed to MAFRA itself at a national level.

The use of badger-derived products in traditional medicine is clearly not unique to Korea, or even Asia. However, South Korea presents the only example we know of where commercial exploitation of badgers has emerged as an intended species substitute for bears, specifically as a direct substitute for bear bile (Table 1. Also see, Jo et al. 2018). This is currently a legal trade, with badger gallbladders and derived products (notably a soaked gallbladder liquor) publicly available for sale online on e-commerce shopping platforms. Substitution of other species for bear bile does occur elsewhere; in Vietnam, domestic cattle or pig products have instead been recorded being used as a substitute for bear bile (Willcox et al. 2016), despite having notably different chemical compositions (Hagey et al. 1993; Feng et al. 2009). In South Korea, badger is also promoted as having value in its own right and is advertised for a wide range of uses in traditional medicine, not all of which are associated with species substitution for bear (Table 1).

A range of other badger-derived products is now available to consumers (Table 1). While this apparent diversification of the range of badger-derived products available to consumers has coincided with the introduction of legal wildlife farming, we cannot conclusively prove that it is the result of changes to the supply of badger body parts. One example of a new type of product is badger-derived cosmetics, which seem to have emerged during our study period and are now being marketed for a wide range of uses, including skin whitening, anti-ageing, moisturising and skin toning. Currently, they still occupy a niche market in South Korea, given the limited number of websites they appeared on, including only a single dedicated cosmetics website. However, conservationists should remain alert to changes in consumer demand for such products, which could quickly lead to badgers shifting to become a more heavily traded species (Scheffers et al. 2019), as South Korea is both one of the world's largest consumer markets and exporters of cosmetics (Lee and Youn 2019). Badger-derived cosmetics have also recently been reported from China (Zuo 2018).

The trade is also now international in nature. Badger shaving brushes manufactured in a wide range of countries in Asia, Europe and North America were sold to Korean consumers by local resellers. A number of other badger-derived products (for example, badger gall bladders, badger-derived dietary supplements and badger hide car seat covers) were available for import from China and Russia, either directly from producers or via Korean resellers. For example, one Naver Smart Store selling badger-derived products was operated by a Korean company that served as a purchasing agency (importer) for "health food" products from Russia. Although some badger products originating in China were marketed to Korean consumers as being derived from wild badgers from Paektusan (in Korean:

백두산), a mountain on the border of the Democratic People's Republic of Korea (henceforth, North Korea) and China which is often held to have particularly important cultural significance to Koreans, the provenance of these products is unverified. It is apposite to note that the mountain's Chinese name, Changbaishan (in Chinese: 长白山), is also used to refer to the surrounding mountain range.

We acknowledge the limitations posed by gathering data only from government sources in representing the actual number of individuals traded, or of relying on online sources to evaluate the range of badger-derived products available to consumers. In particular, our approach was unlikely to detect clandestine trade, trade on social media, or trade in languages other than Korean. Despite these limitations, we believe our approach provides a valuable initial assessment of a neglected wildlife trade and is particularly well suited to providing insight into the scale and extent of legal badger farming in South Korea as a source of badger-derived products for trade, as well as the range of badger-derived products likely to be publicly and legally available for sale.

Specific Considerations

Given the identified links between the farming of badgers and bears in South Korea, and the recent decision by the South Korean government to end all bear farming in the country on ecological and welfare grounds (Ministry of Environment 2022), it is pertinent to consider whether a similar approach to badger trade and farming would be justified. To do this, we discuss the potential implications of this study's findings about the trade in badgers in South Korea and where key knowledge gaps have been identified, for wild badger populations, the welfare of traded badgers, and human health.

Impact of trade on wild badger populations

The volume, and therefore potential impact, of wildlife trade should be assessed relative to the abundance of the population traded. Unfortunately, although the species is listed as Near Threatened in South Korea, there is a deficit of reliable data on *Meles leucurus* populations on the Korean Peninsula (Proulx et al. 2016), which makes it difficult to confidently conclude that even modest (illegal) wild harvest would not have a negative impact on the species' status. Some studies have claimed that wild *Meles leucurus* populations in South Korea are currently stable, citing improvements in habitat availability and perceived reductions in illegal hunting (see, for example, Lee et al. 2016). Other assessments have been less optimistic, noting that there is limited evidence to support this assessment and that there remains particularly little information on the status of, or threats to, *Meles leucurus* populations on the Korean Peninsula (Proulx et al. 2016). A recent study in Pyeongchang, South Korea, recorded 36 badger setts within a 57km^2 area (Bae et al. 2021), which may indicate a comparable density of badgers to in northern Italy (Balestrieri et al. 2016) and in Ireland (Sleeman et al. 2009), for example,

but a considerably lower density of badgers than in the UK (Judge et al. 2014). However, this further illustrates the knowledge gap concerning *Meles leucurus* populations in South Korea, as extrapolating to abundance from sett counts relies on multiple assumptions, which may or may not hold, particularly if exposure to human-driven mortality (for example, poaching for trade in their body parts) leads to changes in badger social structure and movements (Parrott et al. 2012).

While Bae et al. (1997) noted that initial government support for the establishment of badger farming in South Korea was in part intended to reduce pressure on the country's wild *Meles leucurus* population, we caution that it may potentially have the opposite effect in the long-term. An important risk is that the presence of a legal trade in badger-derived products may facilitate unsustainable, illegal trade. The illegal poaching of *Meles leucurus* is known to still occur in South Korea (Kang 2022), although there are currently no data on how many wild badgers are illegally harvested and the impact on local badger populations (Lau et al. 2010). A legal market for farmed badger in South Korea could allow illegally poached wild badger-derived products to be sold to unsuspecting consumers. That legal wildlife farms might facilitate illegal trade in wild animal body parts is well known from more high-profile species elsewhere in Asia, such as the tiger trade in China (Rizzolo 2021) and Malayan porcupine (*Hystrix brachyura*) trade in Vietnam (Brooks et al. 2010).

Legal badger trade may also impact wild populations through the stocking of badger farms with wild-born *Meles leucurus*. The exact origins of the initial source animals for South Korea's badger farms are unclear, but this is known to have included both imported and native animals (Bae et al. 1997). We also note that there is no reliable information on the current proportion of animals on Korean badger farms that were (legally) born in captivity, compared to being (illegally) harvested from the wild. While badgers are evidently bred on badger farms in South Korea (Bae et al. 1997), badgers are difficult to breed in captivity and breed relatively slowly (Bae et al. 1997; Jo et al. 2018). This raises the concern that the presence of a legal trade in badgers may have historically – and may continue to - result in wild animals being illegally harvested to supplement captive bred stock on badger farms. While further work is needed to explore the potential links between badger farms and wild populations, Jo et al. (2018) suggested that Korean badger farmers have indeed engaged in trapping wild *Meles leucurus* to restock their farms, encouraged by the rising value of badger-derived products. The restocking of wildlife farms with wild animals is known to occur elsewhere. For example, illegally harvested wild *Arctonyx* spp. and *Meles leucurus* have been used to supplement the trade of captive-bred animals on badger farms in China (Chen et al. 2015; Zuo 2018).

Another important risk presented by the farming of badgers in South Korea is the accidental introduction of non-native badgers into wild populations. Badgers, of unverified identity or origin, have been reported to have escaped from Korean badger farms and mixed with native *Meles leucurus* populations (Jo et al. 2018). There are numerous examples where the introduction of small or medium-sized, non-native carnivores to an ecosystem has threatened native species due to the introduction of a

novel predator, novel diseases, competition, or hybridisation (see, for example, Bonesi and Palazon 2007; Gardarsson and Einarsson 2008; Kauhala and Kowalczyk 2011; Breitenmoser et al. 2019).

While the number of non-native *Arctonyx* spp. kept on badger farms in South Korea is now small, it is also important to consider the impact that import of these non-native animals may have on *Arctonyx* spp. populations in their native range. This is particularly apposite given the unknown taxonomic status of the "hybrid" badgers on Korean badger farms, of which there were 2120 in 2019 according to MAFRA and which could in fact be different species or colour morphs of either *Arctonyx* spp. or *Meles* spp. In many locations where they occur, *Arctonyx* spp. populations are believed to be in decline and are increasingly fragmented, due to habitat destruction and over-harvesting from the wild (Helgen et al. 2008; Duckworth et al. 2016). Any future demand for *Arctonyx* spp. to stock farms in South Korea would potentially put further pressure on wild populations.

Animal welfare consequences of trade

Meles leucurus are social animals, which live in family groups and construct complex den systems (setts) in which they raise their young. Given the difficulty of breeding badgers in captivity, advice provided to badger farmers in South Korea in the 1990s recommended a range of measures that raise welfare concerns, including the construction of holding pens with wire or concrete floors to prevent badgers digging and so prevent their escape; separation of juveniles from adults in order to prevent infanticide; and hormone injection in female badgers to induce breeding (Bae et al. 1997). These conditions violate, at least in part, all three of the core elements of animal welfare: the basic health and functioning of the animal, the affective state of the animal, and the ability of an animal to live as it is adapted (Paquet and Darimont 2010). This advice is still presented to badger farmers on the MAFRA website and we are not aware of any government policies which have been introduced since to improve welfare standards, neither are we aware of any government monitoring of welfare conditions on badger farms.

Zoonotic disease risk of trade

A related concern is the potential zoonotic disease risk that badger farms in South Korea may present. Captive animals in close confines with other animals and humans allow pathogens, including potential zoonotic diseases, to spread more easily, particularly where farmed animals occur at high densities (Daszak et al. 2020). Animals which escape or are released from wildlife farms can also facilitate the spread of diseases, some of which may be zoonotic, to wild animal populations (see, for example, Kauhala and Kowalczyk 2011). Among mammals, the order *Carnivora* are known to carry a particularly high diversity of unique zoonotic pathogens (Han et al. 2016) and previous studies have highlighted the risk of zoonotic spillover in mustelids specifically. Following the 2004 SARS outbreak

in Asia, Dong et al. (2007) identified Chinese ferret-badgers (*Melogale moschata*) in southern China as potential sources of novel coronaviruses with substantial zoonotic infectious potential. An outbreak of SARS-CoV-2 on a Danish mink farm in 2020 highlighted the risk of two-way zoonotic disease transmission on mustelid farms (Oude Munnink et al. 2021), as have subsequent outbreaks on mustelid farms in both Europe and the USA (Diaz et al. 2021).

We note that several factors may contribute to a particularly high zoonotic disease risk associated with badger farms in South Korea. The status of badgers in South Korea as a domestic species, but not a major livestock species, means that animals are slaughtered by farmers on individual badger farms, with resulting concerns over the hygiene standards present in slaughter facilities. Other specific concerns include the current lack of guidelines on biosecurity on badger farms; the ongoing sale of live badgers, including the sale of cubs as pets (Yeongcheon Badger Farm 2015); the use of badger meat for direct human consumption as food; and reports of both the introduction of wild animals to the stock on badger farms and the mixing of escaped captive animals with wild *Meles leucurus* populations (Jo et al. 2018). The general trend in our data towards a smaller number of larger badger farms between 2001-2020 is notable, given that it may mean a larger number of animals occurring in close confines with each other and a potentially higher disease risk (Daszak et al. 2020). Animals experiencing high levels of stress, which can be the result of poor welfare conditions, may also be more susceptible to infection, carry a higher viral load, increase the shedding of microbes and, therefore, present a greater risk of serving as sources of zoonotic disease (Humphrey 2006; Daszak et al. 2020). Some of these concerns may be able to be addressed by better regulation. However, Clair et al. (2022) previously cautioned that zoonotic disease outbreaks may still occur on mustelid farms despite heightened biosecurity measures and that sufficiently rigorous biosecurity measures may be difficult for industry to maintain, and governmental agencies to regulate, over a long time period.

Policy options for badger farming, building on experiences of bear farming

While further research is clearly needed into the potential risks to wild *Meles leucurus* populations on the Korean Peninsula, the continued occurrence of illegal poaching, as well as reports of the restocking of badger farms with wild animals and the release of captive badgers into the wild, suggest that badger farming in South Korean likely does not currently meet the criteria established by Tensen (2016) to evaluate whether wildlife farming benefits species conservation. Only a small number of households in South Korea appear to directly benefit from legal badger farming, while badger farms appear to present many of the same risks as bear farms to animal welfare and as potential sources of novel zoonotic diseases. It is therefore difficult to identify any significant economic or ecological benefits of badger farming in its current form. In light of this and against the backdrop of the recent agreement between government and civic groups in South Korea to close all bear farms in the country by 2026 (Powell and Choi 2022), we recognise that South Korean policymakers may wish to consider

opportunities for the alignment of policies on badger farming with those on bear farming. If South Korea chooses to align its approach to badger farming with its approach to bears, we recommend a phased approach. This would involve a transition period in which existing badger farms would be required to avoid breeding new captive animals or introducing new wild animals to their captive stock. At the end of this transition period all badger farms would be closed. While the consumptive nature of the trade means that at the end of this transition period there would likely be no captive badgers left on farms, given the indeterminate genetic and health status of captive animals and the potential impacts on wild *Meles leucurus* populations in South Korea, captive animals should not be released into the wild without a comprehensive risk assessment. The use of a phased approach and the provision of financial compensation for current badger farmers may lessen the impact on individuals involved in what is currently a legal trade. Any closures introduced would also need to be effectively enforced, given that evidence from the bird trade in Vietnam suggests that poorly enforced wildlife trade bans may be even less effective in minimizing public health risks than regulated legal trade (Fournie et al. 2013).

A prominent concern about phasing out wildlife farming, particularly in the absence of a good understanding of consumer demand, is whether a reduction in the availability of legal farmed products would increase demand for wild-harvested products. These might take the form of wild badger products, either illegally harvested in South Korea or legally imported from Russia or China, or substitute products from other (potentially threatened) species. While a recent study on the closure of all bear farms in Vietnam found that it will likely not lead to an upsurge in demand for wild bear products (Davis et al. 2022), this cannot be conclusively ruled out. Therefore, in order to reduce the risk of potentially stimulating unsustainable demand for wild badger products, phasing out commercial badger farming in South Korea would likely need to be coupled with a ban on trade in badger-derived products. We note the important concerns raised by Roe et al. (2020) over sometimes inappropriate use of wildlife trade bans, but we believe that a ban on the trade in badger-derived products in South Korea, the world's 10th largest economy and with a GDP-per capita almost 3x the world average in 2020 (World Bank 2020), would not negatively impact a number of key issues they identify for conservation and sustainable development. First, phasing out badger farming (particularly with appropriate support for current badger farmers) would not adversely impact large numbers of livelihoods, given that only 32 households managed all badger farming in South Korea in 2020 (Figure 1 and Figure 4). Second, that trade does not currently provide any beneficial function for conservation, for example by providing suitable incentives for local communities to actively protect species and the habitat they depend on, given that trade is either supplied by wildlife farms, or illegal and unregulated poaching. This approach may also be locally appropriate for South Korea's experience of wildlife trade regulation. While 'incomplete' legislative efforts to regulate the bear trade in South Korea since the 1990s have resulted in the persistence of poor animal welfare conditions for traded animals, are expected to result in ongoing financial costs for civil society and have been perceived as a national reputational risk (Ministry of Environment 2022), an outright ban on tiger trade in the same time period is believed to have been

widely successful, despite South Korea having previously been one of the world's largest markets for tiger bone (Nowell 1999). The reasons for South Korea's apparent success with outright wildlife trade bans as a policy tool are currently not well understood and may be due to a range of factors. However, one advantage of trade bans is that they can potentially increase social stigma around consumption (Rizzolo 2021) and the importance of social stigma, norms and conventions has previously been identified as a particularly important influence on different consumption choices in South Korea (see, for example, Kim and Jang 2014; Yoo and Yoon 2015).

Recommendations

This study highlights a need for considerably greater research effort on neglected aspects of wildlife trade, particularly the legal trade of overlooked species. This would help conservation science to become proactive in identifying emerging and future trends in wildlife trade and its implications for biodiversity and human health. In this study we present a case study of an overlooked wildlife trade, the trade in badgers (*Meles leucurus* and *Arctonyx* spp.) in South Korea, where important knowledge gaps exist which are relevant to the potential impacts of that trade. In this context, we recommend that further work is needed by ecologists, veterinarians and criminologists to investigate: the status of wild *Meles leucurus* populations on the Korean Peninsula; the taxonomic status of the "hybrid" badgers and why they appear to have become increasingly common on South Korean badger farms since 2010; management practices on badger farms and why there has been an apparent consolidation in the industry, resulting in a smaller number of larger farms; the current extent of illegal harvesting of wild *Meles leucurus* in South Korea to supply trade, either through the stocking of badger farms or the entry of illegal, wild badger-derived products into legal markets; and consumer demand for badger-derived products in South Korea, as well as likely consumer behaviour change if the supply of legal badger-derived products was reduced (for example, as a result of new restrictions on badger farming). The lack of research on each of these topics to-date contrasts with higher profile wildlife trades. For example, consumer demand has been an important subject of investigation for the bear bile trade in Vietnam and China (see, for example, Dutton et al. 2011; Davis et al. 2019) and could help inform the design of appropriate policy interventions. In addition, targeted research on trade that was unlikely to be captured by this study, such as trade on social media or in languages other than Korean, could help detect alternative trade routes and markets.

This study also highlights an apparent monitoring and regulation gap. On the basis of the current lack of monitoring of badger trade in South Korea, beyond the collection of basic agricultural records on badger farming, we recommend the need for improved monitoring and regulation in order to ensure that badger farming does not threaten the status of wild badger populations or the welfare of captive animals, that appropriate biosecurity standards are met on badger farms, and that illegally harvested badgers or their body parts are not entering the market. This should include on the ground monitoring

and reporting on badger farm facilities. Given the absence of reliable data on consumer demand and uncertainty over the response of consumers to reduced supply of legal farmed products, we caution that any attempt to phase out badger farming may need to be coupled with a ban on the trade in badgers and badger-derived products to ensure that supply does not simply shift to wild (and potentially illegal) badger-derived products.

Parties to CITES may wish to investigate the potential implications of trade for the species identified in this study. There may be a case for listing *Meles leucurus* and *Arctonyx* spp. on Appendix II of CITES, on the grounds that in some examples they are suspected to be either globally or locally threatened by trade (see, for example, Lau et al. 2010; Duckworth et al. 2016) and regulation could help ensure that trade is sustainable and does not lead to a worsening conservation outlook for these species. This could be beneficial, for example, in serving to regulate trade from China (where several *Meles leucurus* populations are threatened) to South Korea, particularly in the event of closure of South Korea's badger farms. The risks of CITES listing for these species (Challender et al. 2021) are more difficult to determine with any certainty. However, the possibility of unintended consequences resulting from CITES listing would need to be carefully considered given that the development of badger farming in South Korea was partially in response to trade shifting from a CITES-listed species (the Asiatic black bear) to non-listed species (*Meles leucurus* and *Arctonyx* spp.).

Conclusions

A neglected and poorly regulated legal trade in badgers and badger-derived products continues to operate in South Korea, supplied by domestic badger farms, with a pronounced shift towards a smaller number of larger farms over the past two decades, and supplemented by international trade in wild and captive badger-derived products, as well as potentially some domestic, illegal wild badger harvest. The range of badger-derived products available to consumers in South Korea appears to have broadened since 2001, including a diversification into the cosmetics sector. We suggest that the conservation risks of this trade, to both South Korea's native *Meles leucurus* population and potentially to *Arctonyx* spp. in their native range, has so far been insufficiently assessed, while there has been little focus on, or regulation of, the welfare of traded animals. We also caution that badger farms may potentially present an overlooked zoonotic disease risk, particularly if welfare conditions are compromised. Despite this, the trade remains largely unmonitored, except for the annual collection of agricultural records on badger farms and the number of animals farmed. As a result, we strongly recommend increased monitoring of trade and further targeted research, which would help ensure that better information is available, particularly around consumer demand, illegal practices and clandestine trade routes, which can then be used to inform future policy approaches.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relation ships that could have appeared to influence the work reported in this paper.

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Table caption

Table 1. Non-exhaustive table of badger derived products marketed in South Korea

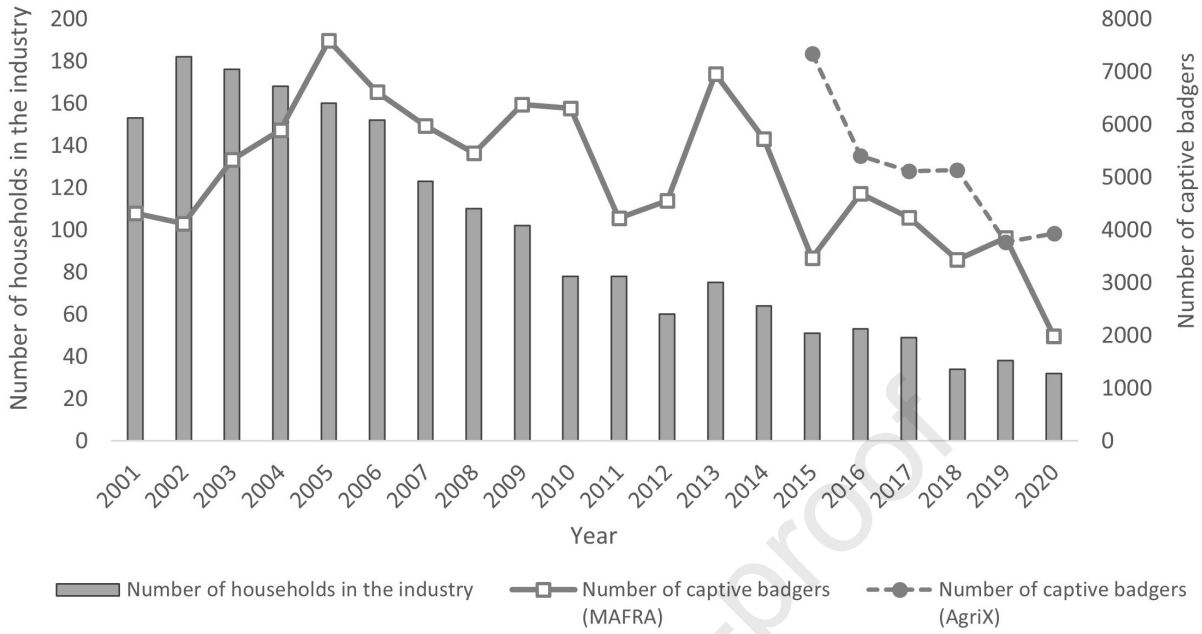
Figure legends

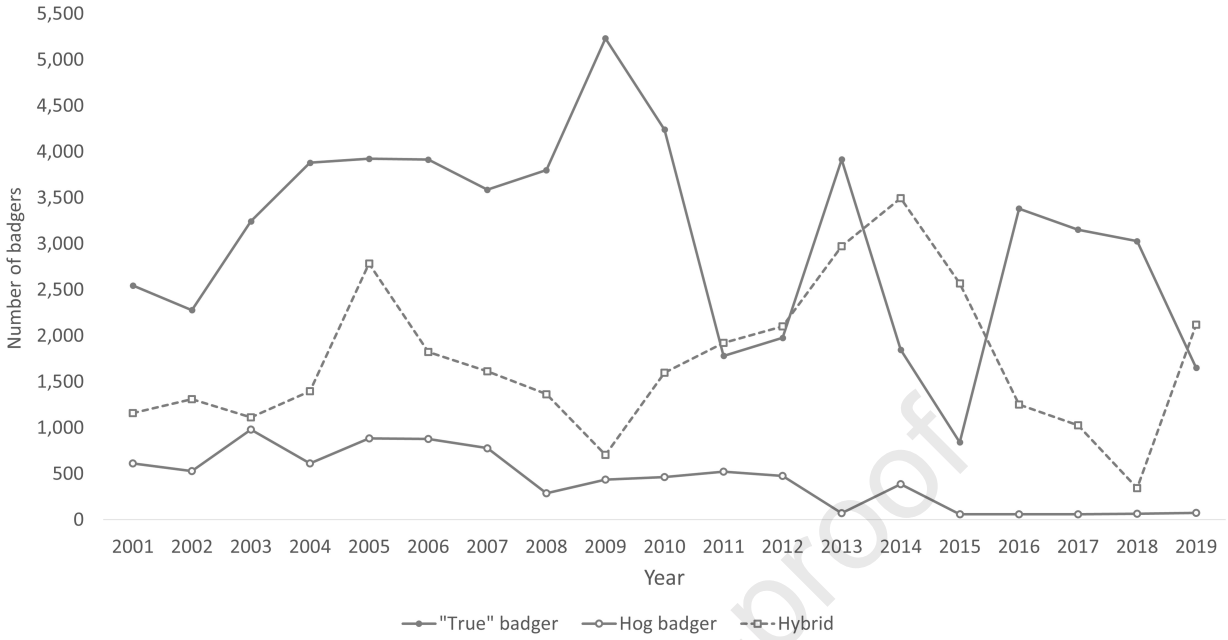
Figure 1. The number of households listed as legal badger farms in South Korea and the reported number of badgers farmed between 2001 and 2020, from records of Ministry of Agriculture, Food and Rural Affairs (2001-2020) and AgriX (2015-2020).

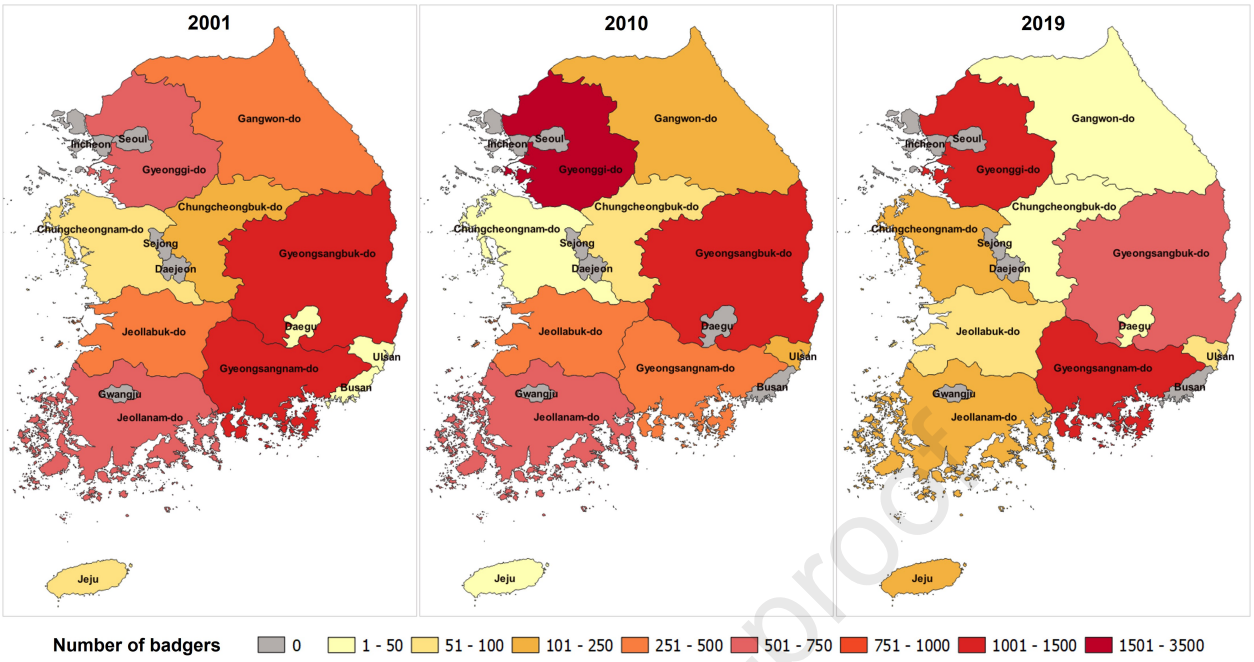
Figure 2. Reported number of captive badgers farmed in South Korea between 2001-2019, from records of Ministry of Agriculture, Food and Rural Affairs (MAFRA). "True" badgers refer to *Meles leucurus*; hog badgers refer to *Arctonyx* spp.; the taxonomic classification of "hybrids" is unclear.

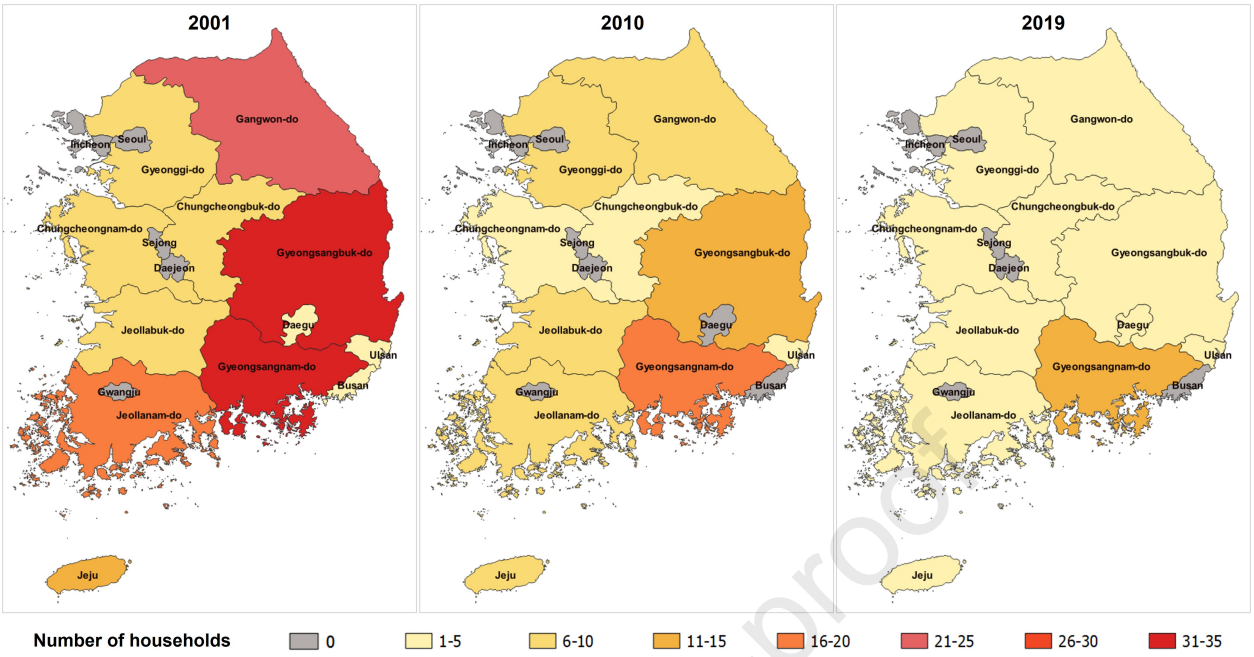
Figure 3. Reported number of captive badgers on badger farms in South Korea by province in 2001, 2010 and 2019, from Ministry of Agriculture, Food and Rural Affairs (MAFRA) records.

913 **Figure 4.** Reported number of households involved in running badger farms in South Korea by province
914 in 2001, 2010 and 2019, from Ministry of Agriculture, Food and Rural Affairs (MAFRA) records.









Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: