The dark web trades wildlife, but mostly as drugs

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Abstract

Contemporary wildlife trade is massively facilitated by the Internet. By design, the dark web is one layer of the Internet that is difficult to monitor and lacks thorough investigation. Here, we accessed a comprehensive database of dark web marketplaces to search across c. 2 million dark web advertisements over 5 years using c. 7k wildlife trade-related search terms. We found 153 species traded in 3,332 advertisements (c. 600 advertisements per year). We characterized a highly specialized wildlife trade market, where c. 90% of dark-web wildlife advertisements were for recreational drugs. We verified that 68 species contained chemicals with drug properties. Species advertised as drugs mostly comprised of plant species, however, fungi and animals were also traded as drugs. Most species with drug properties were psychedelics (45 species), including one genera of fungi, *Psilocybe*, with 19 species traded on the dark web. The native distribution of plants with drug properties were clustered in Central and South America. A smaller proportion of trade was for purported medicinal properties of wildlife, clothing, decoration, and as pets. Our results greatly expand on what species are currently traded on the dark web and provide a baseline to track future changes. Given the low number of advertisements, we assume current conservation and biosecurity risks of the dark web are low. While wildlife trade is rampant on other layers of the Internet, particularly on e-commerce and social media sites, trade on the dark web may increase if these popular platforms are rendered less accessible to traders (e.g., via an increase in enforcement). We recommend focussing on surveillance of e-commerce and social media sites, but we encourage continued monitoring of the dark web periodically, to evaluate potential shifts in wildlife trade across this more occluded layer of the Internet.

Resumen

La web oscura comercializa vida silvestre, pero principalmente como drogas

El internet facilita enormemente el comercio contemporáneo de vida silvestre. Por diseño, la web oscura es una capa de Internet que es difícil de monitorear y carece de una investigación exhaustiva. Aquí, accedimos a una base de datos completa de mercados de la web oscura y buscamos a través c. 2 millones de anuncios web oscuros durante 5 años utilizando c. 7k términos de búsqueda relacionados con el comercio de vida silvestre. Encontramos 153 especies comercializadas en 3332 anuncios (c. 600 anuncios por año). Caracterizamos un mercado de comercio de vida silvestre altamente especializado, donde c. el 90% de los anuncios de vida silvestre en la web oscura eran de drogas recreativas. Verificamos que 68 especies contenían químicos con propiedades farmacológicas. Las especies anunciadas como medicamentos se componen principalmente de especies de plantas, sin embargo, los hongos y los animales también se comercializaron como medicamentos. La mayoría de las especies con propiedades farmacológicas eran psicodélicos (45 especies), incluido un género de hongos, *Psilocybe*, con 19 especies comercializadas en la web oscura. La distribución nativa de plantas con propiedades farmacológicas se agruparon en América Central y del Sur. Una proporción más pequeña del comercio fue para las supuestas propiedades medicinales de la vida silvestre, la ropa, la decoración y como mascotas. Nuestros resultados amplían en gran medida qué especies se comercializan actualmente en la web oscura y proporcionan una línea de base para rastrear cambios futuros. Dada la baja cantidad de anuncios, asumimos que los riesgos actuales de conservación y bioseguridad de la dark web son bajos. Si bien el comercio de vida silvestre prolifera en otras capas de Internet, particularmente en el comercio electrónico y los sitios de redes sociales, el comercio en la web oscura puede aumentar si estas plataformas populares se vuelven menos accesibles para los comerciantes (por ejemplo, a través de

un aumento en la aplicación). Recomendamos enfocarse en la vigilancia de los sitios de comercio electrónico y redes sociales, pero alentamos el monitoreo continuo de la web oscura periódicamente, para evaluar los posibles cambios en el comercio de vida silvestre a través de esta capa más ocluida de Internet.

Introduction

Wildlife trade can present severe conservation, biosecurity, and ethical problems ('t Sas-Rolfes et al. 2019; Fukushima et al. 2020; Cardoso et al. 2021). Increasingly, the Internet facilitates wildlife trade in ways that were not previously possible (Lavorgna 2014; Siriwat & Nijman 2020). Thus, monitoring the Internet for wildlife trade is a conservation and biosecurity priority (Stringham et al. 2021b; Fukushima et al. 2021; Whitehead et al. 2021). Most Internet wildlife trade occurs on publicly viewable websites, known as the *open web* (e.g., e-commerce sites (Heinrich et al. 2019; Ye et al. 2020)); but increasingly, wildlife trade also occurs on the *deep web*, which consists of social media and private messaging apps (e.g., Facebook (Van et al. 2019) and WhatsApp (Sánchez-Mercado et al. 2020)). Prior research has found very small amounts of wildlife traded on the *dark web*, which remains the most obscure section of the Internet (Harrison et al. 2016; Roberts & Hernandez-Castro 2017).

The dark web is different from other layers of the Internet in several ways (Stringham et al. 2021b). First, the dark web requires special software to access, making it more obscured and difficult to access compared to the open and deep web. Further, no search engine exists for the dark web and thus, users must know a website address (i.e., URL) beforehand to be able to visit a site. The purpose of the dark web is to provide anonymity to users; although several successful law enforcement operations suggest that anonymity is not guaranteed (Décary-Hétu & Giommoni 2017; Hiramoto & Tsuchiya 2020; Zhuang et al. 2021). Some of the most well-known and "popular" dark-web sites are marketplaces that sell drugs and other illicit items (Aldridge & Décary-Hétu 2014; Soska & Christin 2015; Cunliffe et al. 2017).

There are currently no known marketplaces specifically dedicated to wildlife trade on the dark web, unlike the open and deep web where wildlife marketplaces are plentiful (e.g., 151 websites trading reptiles (Marshall et al. 2020)). However, some wildlife has been traded on dark-web drug marketplaces and prior studies monitored 5 marketplaces from 2014 to 2017; finding cacti (sold as drugs for their hallucinogenic properties), reptile-skin handbags, and a handful of advertisements for ivory and rhino horns (Harrison et al. 2016; Roberts & Hernandez-Castro 2017).

Here, we provide an extensive examination of wildlife trade on high-traffic portions of the dark web. We accessed the most comprehensive dark-web database available to academic research, consisting of nearly 2 million advertisements from 51 marketplaces spanning from 2014 to 2020. We identified advertisements that traded wildlife, and analysed which taxa are traded and for what purposes. Our study sets out to answer what wildlife is being traded on the dark web.

Methods

We accessed a dark-web database collected by the DATACRYPTO software (described in (Décary-Hétu & Aldridge 2015)). At the time we accessed the database (May 2021), it spanned c. 5.6 years (2014 July 29 to 2020 March 6) and contained c. 1.94 million advertisements across 51 marketplaces (i.e., dark-web websites). Each advertisement contained the following information: a unique identifier, a marketplace identifier, a seller identifier, the date, the title of advertisement, and the text description taken directly from the advertisement. The names of the marketplaces and the identities of the sellers were de-identified by DATACRYPTO prior to us obtaining the data.

We generated 6,959 keywords related to the scientific names, common names, and use-types involved in the illegal wildlife trade (derived from (Stringham et al. 2021a); a full list of search terms is provided in Appendix S1). We searched the dark web database for these keywords, returning advertisements that 'fuzzy' matched to our keywords (i.e., words within a Levenshtein distance of 2 or less, see Appendix S2). This search returned 1,232,462 advertisements. We used a variety of semi-automated and manual methods to identify if advertisements were selling wildlife (Appendix S2). Ultimately, we identified 3,332 advertisements that traded wildlife. We excluded taxa that are used in common agricultural, aquaculture, or farming operations (see Appendix S3 for a list of excluded species). We did not analyse the quantity traded within an advertisement (e.g., mass, volume, number of products, or number of individuals), which were hugely inconsistent both within and across taxa; instead we measured the number of advertisements.

We identified advertised taxa to the most specific rank possible (e.g., species, genus, family). We used the Global Biodiversity Information Facility database (GBIF 2022) to standardize taxonomy and to obtain upstream taxonomic information. For each taxon in each advertisement (i.e., taxon-advertisement combination), we identified the category of wildlife traded: live, dead/raw, or processed/derived (see Appendix S4 for definitions) and the purpose the taxon was being traded for (e.g., drugs, medicinal, pets, decorative), which we called the 'use-type' (See Appendix S5 for full list and definitions of use-types). For some taxon-advertisement combinations, we assigned more than one use-type. For instance, several plants were advertised both for their use as drugs and for their medicinal properties. For species advertised as drugs, we underwent a structured literature search to identify the category of drug (e.g., stimulant, hallucinogen) and the chemical(s) responsible for producing the drug effect (e.g., DMT, psilocybin) (Appendix S6). We did not verify the accuracy of claimed medicinal properties, but simply reported this use-type as (purported) medicinal.

We obtained the IUCN Red List status for each species (IUCN 2021). We used the Global Invasive Species Database to designate if a species is invasive (GISD) (Invasive Species Specialist Group 2015). For each taxon-advertisement combination, we recorded if the seller specified that the specimen was harvested from the wild. For plant species, we obtained their native distributions using the World Geographical Scheme for Recording Plant Distributions (WGSRPD; see Appendix S7 for more details) (Brummit 2001).

We performed exploratory summary analyses on wildlife advertisements, describing taxonomic trends, use-type trends, number and identity of species, and number of advertisements. We examined species that were of conservation concern (i.e., IUCN status, wild harvested) or invasive (i.e., listed in GISD). We quantified geographic hotspots for traded plants using geographic level three of WGSRPD (Appendix S7). Finally, we performed exploratory summaries on the markets and sellers that traded wildlife.

We performed data analysis and data visualization using R (version 4.1.0; *R Core Team* 2022) and used the following packages: *tidyverse* (version 1.3.1) (Wickham et al. 2019); *sf* (version 1.0-7) (Pebesma 2018); *janitor* (version 2.1.0) (Firke 2021); *gsheet* (version 0.4.5) (Conway 2020); *glue* (version 1.6.2) (Hester & Bryan 2022); *lubridate* (version 1.7.10) (Grolemund & Wickham 2011); *ggalluvial* (version 0.12.3) (Brunson 2020); *patchwork* (version 1.1.1) (Pedersen 2020); *networkD3* (version 0.4) (Allaire et al. 2017); *htmlwidgets* (version 1.5.4) (Vaidyanathan et al. 2021); *flextable* (version 0.6.6) (Gohel 2021a); and *officer* (version 0.3.18) (Gohel 2021b). To obtain upstream taxonomic information, we used the *taxize* package (version 0.9.99; Chamberlain & Szöcs 2013).

Results

Overall characteristics

We identified 153 species traded from 3,332 advertisements of wildlife, at an average rate of 595 advertisements per year (Figure 1a; Appendix S8). Most advertised taxa were identifiable to the species level (82% of taxa, 90% of advertisements; Appendix S9). In total, we detected 188 unique taxa (Appendix S10 for full list of species and taxa) and 4,368 taxon-advertisement combinations (Figure 1b). The most common use-type of wildlife was drugs, consisting of 90% of all advertisements and 96 species (62% of the recorded species). However, we could only verify that 68 species actually contained chemicals with known drug properties (Appendix S10). Psychedelics were the most common class of drugs measured by number of advertisements (n = 2,403) and species (n = 41 species). The next most common use-type was for purported medicinal use, consisting of 8% of advertisements and 60 species (39% of species). Half of all traded species (excluding Bacteria) have not been assessed by the IUCN (74 species), while 55 species are categorized as Least Concern and 19 species are threatened (Vulnerable, Endangered, or Critically Endangered). Nine traded species are categorized as invasive by the Global Invasive Species Database (GISD); although none of those species were traded live.

Taxa-use trends

The majority of species traded were plants (Plantae; n = 101 species), followed by fungi (Fungi, n = 28), and animals (Animalia; n = 18) (Figure 1). Plants were the most commonly traded kingdom, with 2,513 taxon-advertisements (58% of total), followed closely by fungi with 1,721 taxon-advertisements (39%), while animals made up only 126 taxon-advertisements (3%) (Figure 1).

Plant species were the most taxonomically diverse kingdom, represented by 55 families and 94 genera (Appendix S10; Appendix S11). Overall, most plants were advertised for their use as drugs (88% of plant advertisements) (Figure 2). Of the 70 plant species advertised as drugs, we verified that 45 of them contained chemicals with known drug properties. Psychedelics were the most common class of drugs with 21 plant species and 947 advertisements (Appendix S12). Likewise, the most commonly traded plant species contained chemicals with known drug properties (Table 1). For example, *Mimosa tenuiflora*, the most common plant traded (n=551 advertisements), contains methyltryptamine (DMT), a psychedelic (Table 1). Three plant species were drug facilitators, meaning they contain a chemical that enables a different drug to become chemically active when ingested (Brito-da-Costa et al. 2020). Other plants were traded for their purported medicinal properties (10% of species; 46 species). Most plants were traded as processed/derived (61% of plant advertisements; 72 species), followed by dead/raw (i.e., dead parts: 30% plant advertisements; 58 species), and few were living plants (9% of advertisements, 15 species) (Appendix S13). Five of the traded plant species are at risk of extinction, including peyote (*Lophophora williamsii*), goldenseal (*Hydrastis canadensis*), and catuaba (*Erythroxylum vaccinifolium*); each listed as Vulnerable by the IUCN. According to the GSID, seven traded plant species are invasive, including coltsfoot (*Tussilago farfara*) and Formosan koa (*Acacia confusa*). The native distributions of traded plants were geographically diverse, spanning every continent except Antarctica (Figure 3). Traded plant species with drug properties had native distributions mostly in Central and South America, while other plant species had native distributions mostly in Europe and parts of Western and Southern Asia (Figure 3; Appendix S14).

The most common fungi species were from the *Psilocybe* genus (83% of fungi advertisements, 1,381 advertisements, 17 species), where *P. cubensis* (commonly referred to as 'magic mushroom') was the most popular species in this study, with 1,189 advertisements (Table 1). Almost all fungi were sold as drugs (96% of listings; Figure 2). Of the 22 species advertised as drugs, we verified that 21 of them contained chemicals with known drug properties. The most common drug class for fungi was psychedelics, found in 19 species and 1,400 advertisements (Appendix S12). The active chemical psilocybin is a psychedelic found in every traded species of *Psilocybe*. There were 11 species advertised for their purported medicinal properties and three species traded as food, including the black truffle (*Tuber melanosporum*). Most fungi were traded as dead/raw (54% of fungi advertisements, 23 species), followed by processed/derived (31% fungi advertisements, 14 species), then live (15% fungi advertisements, 16 species) (Appendix S13). One fungus species, the caterpillar fungus (*Ophiocordyceps sinensis*), is categorized as Vulnerable by the IUCN as it is used and traded for medicinal purposes locally, nationally and internationally. No other traded fungi species were evaluated by the IUCN (except for *Hericium erinaceus*; Least Concern) and no traded fungi were classified as invasive.

Animals were more taxonomically diverse than fungi, having 14 families represented. Animals were traded for a range of use-types, including clothing (i.e., furs, skins), drugs, decorative purposes, pets, medicine, and food. The two most common animal species were the racoon (*Procyon lotor*), traded for clothing (i.e., racoon fur), and the Sonoran Desert toad (*Incilius alvarius*), traded because its secretions contain psychoactive properties (i.e., psychedelic). There were three live species advertised as pets (12 advertisements): the African grey parrot (*Psittacus erithacus*), hyacinth macaw (*Anodorhynchus hyacinthinus*), and goliath beetle (*Goliathus goliatus*). Nine traded animal species are listed as Threatened by the IUCN and one traded animal was categorized as Extinct (western black rhinoceros, *Diceros bicornis longipes*). Two traded animal species were classified as invasive (*Procyon lotor* and *Rangifer tarandus*), although neither were traded as live specimens.

We recorded 17 traded species that were specified by sellers to be wild harvested, in 52 advertisements (median 3 wild-harvested advertisements per species; Appendix S15). Three wild-harvested species are listed as at risk of extinction by the IUCN: *Apostichopus japonicus* (Japanese spiky sea cucumber; Endangered), *Lophophora williamsii* (peyote; Vulnerable), and *Ophiocordyceps sinensis* (caterpillar fungus; Vulnerable).

We observed some animals traditionally implicated in the illegal wildlife trade being advertised in low quantities. This included the tusks of species in the elephant family (Elephantidae) (i.e., ivory, n=22 ads), horns of species in the rhinoceros family (Rhinocerotidae, n=13), and the teeth and skins of tigers (*Panthera tigris*, n=4) and lions (*Panthera leo*, n=3).

We found several traded taxa that did not fit the traditional definition of wildlife trade. Specifically, there were five species of bacteria traded as potential bioweapons, including *Corynebacterium diphtheriae* (causes diphtheria), *Staphylococcus aureus* (causes a variety of infections), and *Clostridium botulinum* (causes botulism).

General market & seller characteristics

Wildlife advertisements constituted a small proportion (0.2%) of all dark web advertisements. Advertisements of wildlife were found in 47 of the 51 marketplaces searched (92%), although the majority of marketplaces (>50%) contained less than 30 wildlife advertisements (Appendix S16). The number of species traded in a given marketplace generally increased as the number of wildlife advertisements in a marketplace increased (Appendix S17). Less than 1% of all dark-web sellers advertised wildlife (1,222 of 155,094 sellers). The majority of sellers listed only a single advertisement of wildlife and thus, a single taxon (>50% of sellers, Appendix S16). The number of wildlife advertisements remained relatively stable over time (Appendix S18).

Discussion

Our results greatly expand on the number of wildlife species known to be traded on the dark web. At the same time, our findings suggest that the dark web is a highly specialized wildlife trade market, consisting primarily of plants, fungi, and animals traded for their properties as recreational drugs. We speculate that other species which meet this criteria may become ensnared in future wildlife trade on the dark web, such as plants that contain methyltryptamines (i.e., DMT containing plants; (Bussmann 2016)), *Psilocybe* fungi, plants with drug properties in Central and South America, or frogs that contain bufotoxin (de Greef 2022) (Figure 3). Our findings are consistent with prior research that found the dark web to mostly trade wildlife as drugs (Harrison et al. 2016; Roberts & Hernandez-Castro 2017). However, we did observe other types of wildlife trade occurring in much smaller amounts, for use as medicine, clothing, decor, rituals, and pets. While this trade is currently minimal, there is always the possibility of this trade expanding in the future.

The quantity of wildlife and number of species traded on the dark web appears to be vastly lower than the open and deep web. We observed c. 600 advertisements of wildlife per year on the dark web across 47 marketplaces. While not directly comparable, other studies with different wildlife-trade contexts (i.e., public e-commerce sites) had a rate of three to over 300 times as many advertisements for a *single* website (i.e., from 2k to 67k advertisements per year: (Xu et al. 2020; Ye et al. 2020; Olden et al. 2021)). Further, while we found 154 species traded on the dark web, other non-dark-web online-trade studies have observed over 2,600 species from one taxonomic kingdom or class (e.g., plants (Humair et al. 2015) and reptiles (Marshall et al. 2020), respectively). This comparison reinforces the notion of the dark web as a highly specialized and small niche market for wildlife as drugs. However, we note that we did not capture the volume of wildlife in a given advertisement and some advertisements may contain tens to hundreds of a given species/product or may represent an ongoing supply of the wildlife. For example, we observed the sale of 200kg of powered *Mimosa tenuiflora* root bark (DMT containing) in one advertisement. Thus, we note that the number of advisements we measured is a conservative measure of any given taxa traded on the dark web.

Given the small number of advertisements and low species diversity, we assume that the current trade on the dark web is unlikely to be a major conservation threat. Nevertheless, we identified trade of three threatened and wild harvested species, which is of potential conservation concern for those species and warrants further investigation. For the same reason, the dark web is unlikely to be a biosecurity concern currently, or is at most of low concern for invasive species. We found nine species traded that are known invasive species (7 plants, 2 animals); however, none were traded alive (i.e., only dead or derived products) and therefore cannot become invasive. We note that the database we used for categorizing invasive species (GISD) does not include many regionally invasive species. Thus, we may have missed categorizing some invasive species traded on the dark web. Yet, of the live specimens traded (31 species), most occurred in limited numbers (i.e., the median number of advertisements was three), which is why we consider this trade to be a low concern for invasive species (Cassey et al. 2018). We did not evaluate the disease risk of traded taxa, which can potentially be hosts or reservoirs for wildlife or human pathogens (Calisher et al. 2006; Liebhold et al. 2012; Fu & Waldman 2022). In terms of legality, we were unable to quantify if traded species were illegal because we did not know what jurisdictions the trades occurred in (Fukushima et al. 2021). Thus, it is possible that some of this trade may be illegal from an environmental (i.e., conservation/biosecurity) legislative standpoint. However, it is more likely that many of these species are regulated for their drug properties. For example, the most common species on the dark web, the magic mushroom (*Psilocybe cubensis*), is illegal to sell or possess in the United States (Pollan 2019).

We did not attempt to verify the validity of dark web advertisements. In general, the validity of any online wildlife advertisement is difficult to verify (i.e., determine if the advertisement is genuine or fraudulent). This is especially true in the case of the dark web, particularly without the help of law enforcement agencies (Stringham et al. 2021b). Prior studies of wildlife trade on the dark web have attempted to verify advertisements (Harrison et al. 2016; Roberts & Hernandez-Castro 2017), however, since we identified substantially more advertisements, this was not feasible during our study. Therefore, it is possible that some advertisements we found were falsified (e.g., fake rhinoceros horns found in advertisements in prior studies (Harrison et al. 2016; Roberts & Hernandez-Castro 2017)).

A serious limitation of monitoring the dark web is that it is not possible to know every location (e.g., website) where wildlife is traded. Specifically, due to the nature of the dark web, we cannot rule out the possibility that there are other sites (marketplaces or forums) where wildlife is traded. Unlike the open and deep web, where either a search engine can find relevant websites, or a company keeps records of what is being sold (e.g., eBay), the dark web keeps no such records. Thus, we very likely did not capture the entirety of wildlife trade on the dark web, although we used the most comprehensive dataset of the dark web available, DATACRYPTO (Décary-Hétu & Aldridge 2015). Further, the sites monitored by DATACRYPTO are the most accessed dark web sites on the Internet. Therefore, if there are other sites on the dark web where wildlife trade is occurring, then we speculate that trade volume is even lower than what we observed on the general illicit marketplaces covered by DATACRYPTO.

We provide a baseline of wildlife trade to be compared against future trade on the dark web. If wildlife trade increases on the dark web in the future, we should turn our collective efforts to reporting illegal trade and enforcing trade regulations. Nevertheless, current wildlife trade is thriving on the open (e-commerce) and deep web (social media, messaging apps) (Hinsley et al. 2016; Sánchez-Mercado et al. 2020; Sung et al. 2021). Thus, in the limited resource landscape of conservation and biosecurity efforts related to wildlife trade (World Bank Group 2016), we recommend most monitoring and enforcement resources be focused on the open and deep web; especially considering the massive amount of trade occurring on social media sites, such as Facebook (Xu et al. 2020). At the same time, we recommend continued regular surveillance of the dark web and encourage new efforts to find any dark-web marketplaces or websites that trade wildlife, but which are not currently known.

Data Availability

The data used in this paper can be downloaded at https://figshare.com/articles/dataset/The_dark_web_trades_wildlife_but_mostly_as_drugs/20063726.

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Tables

Table 1.

The twenty most commonly traded species on dark web marketplaces by number of advertisements. Sixteen of the top twenty species contain chemicals with known drug properties or chemicals that facilitate (i.e., activate) the intake of another chemical with drug properties. For one species, *Mitragyna speciosa*, the drug class depends on the dosage of the active chemical ingested (mitragynine). Four of the twenty species were not found to be drugs but have medicinal properties (labelled as Medicinal in Drug Class). See Appendix S6 for our methods on identifying the drug class and active chemical of each species.

Species	**Common name**	**Kingdom**	**Drug Class**	**Number of ads**
Psilocybe cubensis	Magic mushroom	Fungi	Psychedelic	1,189
Mimosa tenuiflora	Jurema	Plantae	Psychedelic	551
Mitragyna speciosa	Kratom	Plantae	Stimulant, Depressant	237
Banisteriopsis caapi	Yage	Plantae	Facilitator	233
Peganum harmala	Syrian rue	Plantae	Facilitator	151
Nymphaea nouchali	Blue lotus	Plantae	Depressant	101
Salvia divinorum	Salvia	Plantae	Dissociative	100
Passiflora incarnata	Passion flower	Plantae	Medicinal	87
Echinopsis pachanoi	San Pedro cactus	Plantae	Psychedelic	66
Acacia confusa	Formosan koa	Plantae	Psychedelic	63
Calea ternifolia	Dream herb	Plantae	Medicinal	61
Verbascum thapsus	Mullein	Plantae	Medicinal	58
Turnera diffusa	Damiana	Plantae	Anxiolytic	54
Lophophora williamsii	Peyote	Plantae	Psychedelic	52
Psilocybe tampanensis	Magic truffles	Fungi	Psychedelic	50
Diplopterys cabrerana	Chaliponga	Plantae	Psychedelic	43
Psychotria viridis	Chacruna	Plantae	Psychedelic	38
Psilocybe subaeruginosa	Gold tops	Fungi	Psychedelic	33
Erythroxylum coca	Coca plant	Plantae	Stimulant	32

Species	Common name	Kingdom	Drug Class	Number of ads
Handroanthus impetiginosum	Pau d'arco	Plantae	Medicinal	31

Figures

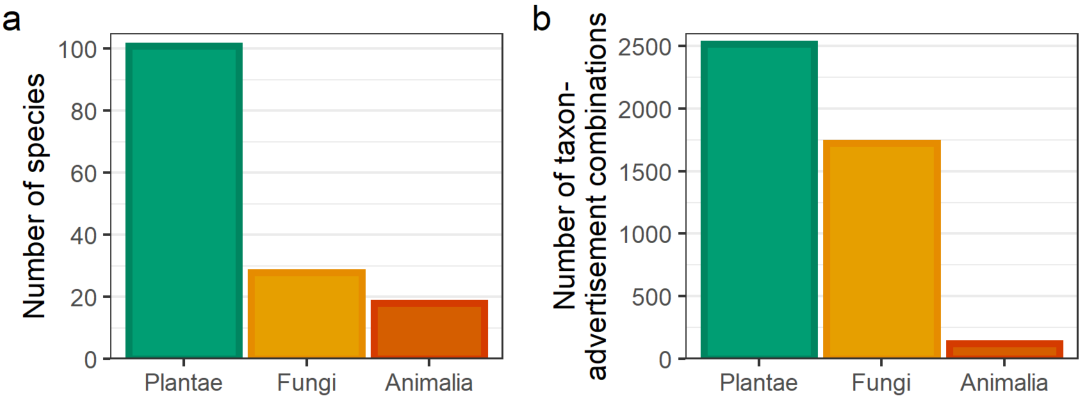

Figure 1.

(a) The number of species traded on the dark web and (b) the number of taxon-advertisement combinations, stratified by taxonomic kingdom.

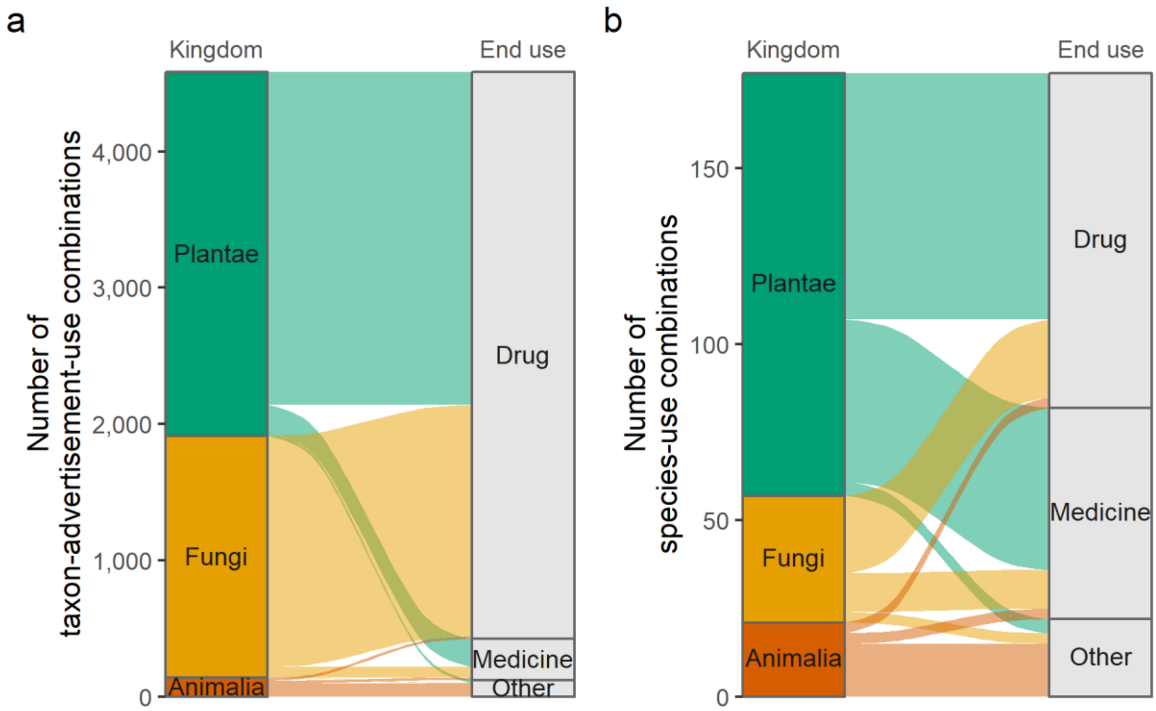

Figure 2.

End use characteristics of wildlife traded on the dark web. (a) Number of taxon-advertisement combinations stratified by end use and (b) number of species stratified by end use. Note that some taxon-advertisement and species had more than one end use. End use definitions can be found in Appendix S5. Advertisements and species of Bacteria are not shown (4 advertisements; 6 species).

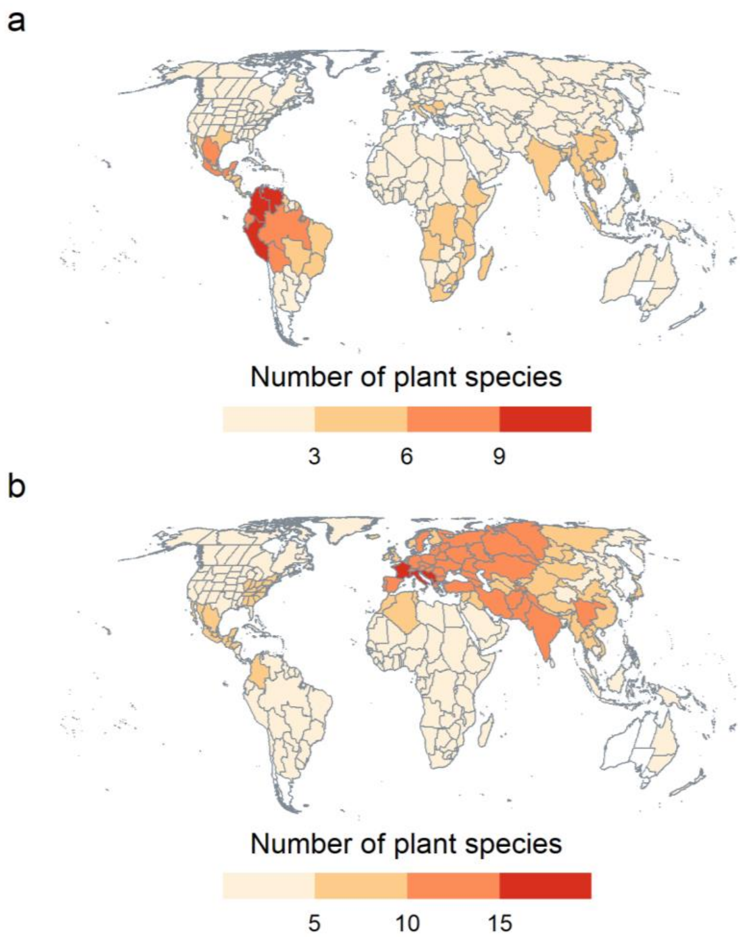

Figure 3.

The native distribution of plant species traded on the dark web stratified by (a) if the plant has verified drug properties (n = 45) and (b) all other traded plants species (n = 56). The number and colours correspond to the number of species in each geographic area. Geographic area borders mostly correspond to either country or country subdivisions (see Appendix S7 for details). White indicates no species having native distributions. There were no traded plant species native to Antarctica. Note this map only shows traded plant species, not fungi or animals.

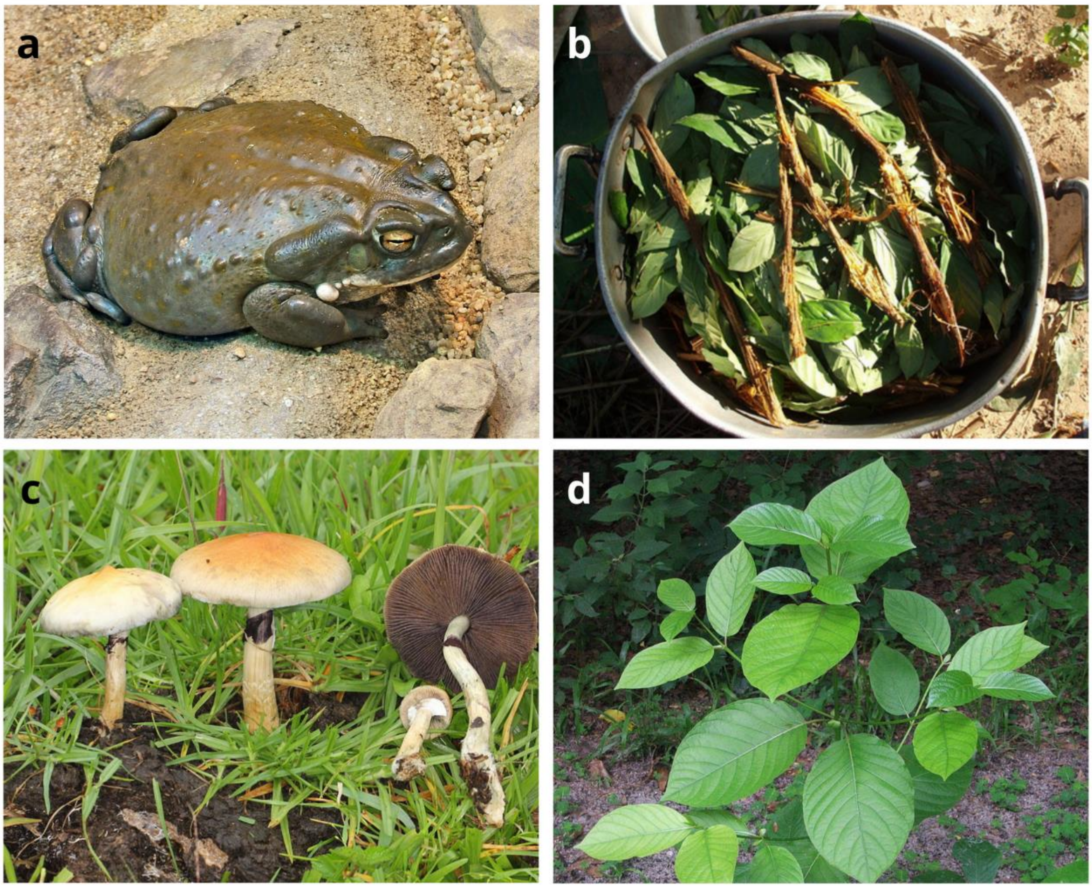

Figure 4.

A sample of species traded on the dark web for their properties as drugs. (a) Sonoran Desert toad (*Incilius alvarius*), whose poison in the parotoid glands contains 5-MeO-DMT, a known psychedelic. (b) A preparation of Ayahuasca containing *Psychotria viridis*, a source of DMT, and *Banisteriopsis caapi*, a liana that contains monoamine oxidase inhibiting alkaliods (MAOIs). (c) *Psilocybe cubensis* contains the psychedelic compound psilocybin. (d) *Mitragyna speciosa* can have stimulant effects in low doses or opioid-like effects in higher doses. Photo credits: (a) Wildfeuer; (b) Awkipuma; (c) Alan Rockefeller; (d) Uomo vitruviano.