

Thematic Opinion

Canine Distemper Virus (CDV): an emerging threat to Nepal's wildlife

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Abstract: In this article, we have described the urgency of research on CDV in the domestic and feral dogs roaming in and around the protected areas of Nepal where the already threatened wildlife have been struggling for their existence from the immense anthropogenic pressures.

Keywords: canine distemper; carnivores; conservation; feral dogs; mass extinction

सारांश: नेपालमा मानवद्वारा उत्पन्न अपार चापहरूले गर्दा दुर्लभ जनावरहरूले पहिले देखिनै अस्तित्वको लागि संघर्ष गरिरहेका छन् र नेपालको संरक्षित क्षेत्र तथा उक्त क्षेत्र वरिपरि रहेका घरपालुवा तथा फिरन्ते कुकुरहरूमा हुने केनाइन डिस्टेम्पर भाइरस अनुसन्धानको जरुरी रहेको कुराको वर्णन यो लेखमा हामीले गरेका छौं ।

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1. Introduction

It is known that the government of Nepal has allocated millions of dollars in the conservation of flora and fauna each year. The budget is mainly spent on the projects that focus on population survey and monitoring, awareness generation, training, security, construction, relief aid, support to local people, seminars, meetings, and administrations. But, the budget has not been allocated to the research on wildlife-declining factors, for example, antibiotic resistivity, pesticide poisoning, plant poisoning, and

pathogens like viruses, bacteria, fungi, and parasites (Ghimire et al., 2020). Principally, we consider that pathogens are one of the contributing factors in the wildlife decline in the future; for instance, Canine Distemper Virus (CDV) should be recognized as a critical microbe possessing the capability to lead endangerment of both captive and wild animals.

CDV (order: Mononegavirales, family: Paramyxoviridae, subfamily: Paramyxovirinae, genus: *Morbillivirus*) is a pleomorphic virus

possessing a lipoprotein envelope and a single-stranded negative-sense RNA molecule (Zhang et al. 2017; Sykes 2014; https://talk.ictvonline.org/ictv-reports/ictv_9th_report/negative-sense-rna-viruses-2011/w/negrna_viruses/199/paramyxoviridae, Retrieved on: June 5, 2020). CDV is transmitted via oronasal contact with the virus in secretions or excretions like urine, blood, saliva, droplet nuclei, and large particle aerosol from infected animals (Appel and Summers 1995; Sykes 2014). Therefore, sneezing, coughing, sharing of feed, and food serving utensils with other animals may pose risks of viral contamination and transmission. The virus leads to systemic diseases in a variety of organs, such as in integumentary, gastrointestinal, respiratory, and neurologic systems (Sykes 2014). It can cause immunosuppression; that is why secondary infections by bacteria and protozoa may aid higher mortality of the hosts (Riley and Wilkes 2015; Beineke et al., 2015; Zhang et al., 2017). CDV affects a wide range of host families, including ailuridae (red panda), canidae (dog, fox, raccoon dog, wolf), cercopithecidae (crab-eating macaques, Japanese macaques, and rhesus macaques), cervidae (sika deer), elephantidae (Asian elephant), felidae (Amur leopard, domestic cat, jaguar, jaguarundi, lion, lynx, ocelots, pumas, snow leopard, tiger), hyaenidae (hyena), mephitidae (skunk), mustelidae (badger, ferret, fisher, marten, mink, polecat, stone marten, weasel), myrmecophagidae (tamandu), procyonidae (raccoon), phocidae (seal), suidae (wild boar), ursidae (bear, giant panda), tayassuidae (javelina), and viverridae (binturong, palm civet) all over the world. Critically, the virus is highly susceptible to newly exposed or unvaccinated populations of various animals and contributes to fatal consequences threatening their populations (University of Leeds 2007; Kapil and Yeary 2011); thus, it indicates the need of basic research in virus and its impacts on the animal population in a country like Nepal where the study of diseases is usually neglected or ignored by experts and administration in policy levels.

2. Patterns and distribution of CDV

We used the term 'Canine Distemper Virus' to see the patterns and distribution of CDV in various hosts and searched the articles from Google Scholar, PubMed, and ResearchGate. The last search was done in June 2020. We selected and reviewed 80 articles published in the journals from 1956 to 2019 (Supplementary file). The reviews were mainly focused on a common name, scientific name, family, order, taxonomic serial number (isit.gov), IUCN Red List, habitat, country, continent, and year of publications. We found that this disease was reported in 125 cases in 28 countries in Asia, Europe, North

America, Africa, and South America. Various laboratory techniques like neutralizing antibody tests and histologic assays detected 100% positive cases (Yoshikawa et al., 1989; Pardo et al., 2005), and critically, this virus has been shown to result in 100% mortality in many animals (Pardo et al., 2005). We used Arc map 10.2.1 (Redlands, CA) to prepare maps of CDV cases in the different continents (Figure 1). We also used Excel 2007 Sheet to make a graph of CDV cases according to the hosts' families and their habitat (Figure 2). A line graph was prepared to show CDV cases and numbers of publications at every eight years from 1956 onwards (Figure 3). The reviews revealed that CDV cases were maximum in canidae family and wild animals, although they have been reported in a total of 15 families. The cases were positive in captive, domestic, feral, and wild populations. While analyzing the numbers of published reports as well as cases, they peaked only after 1987. Therefore, CDV is one of the deadly viruses that can affect both wild and domestic animals globally.

3. Challenges to Nepalese wildlife

We hypothesize that the CDV, the poorly addressed threat, can result in a challenging problem to Nepalese wildlife. The hypothesis is supported by a few facts. For example, dogs, the potent reservoirs, transporters, or carrier hosts of CDV, are widely distributed all over the landscapes. Although they can be asymptomatic, CDV can be transmitted in their population (Sidhu et al., 2019). Besides, the CDV-infected dogs can also spread the diseases to the wildlife-proximity areas. In this context, the feral dogs, which usually share overlapping niches of wildlife, can transmit the virus either directly via saliva and respiratory droplets or indirectly via stool and urine. The CDV has already been indicated to cross the species barrier easily and can be transmitted from one species to another (Beineke et al., 2015) and vice versa; for example, in Portugal, CDV found in the wolves was transmitted from the local domestic dogs (Muller et al., 2011), while a major outbreak of CDV in Danish farm mink (*Neovison vison*) resulted from the wildlife reservoirs like fox, raccoon dog, and ferrets (Trebbien et al., 2014). One compelling case of the CDV positivity was reported in the wild and captive macaques in China and Japan (Yoshikawa et al., 1989; Sakai et al., 2008; Sun et al., 2009; Qiu et al., 2011). It may indicate that the animals closely contacting these primates are also susceptible to CDV transmission. In these contexts, Nepal might be prone to CDV because dogs and macaques in city areas usually live closely with humans, especially in the temples, monasteries, and

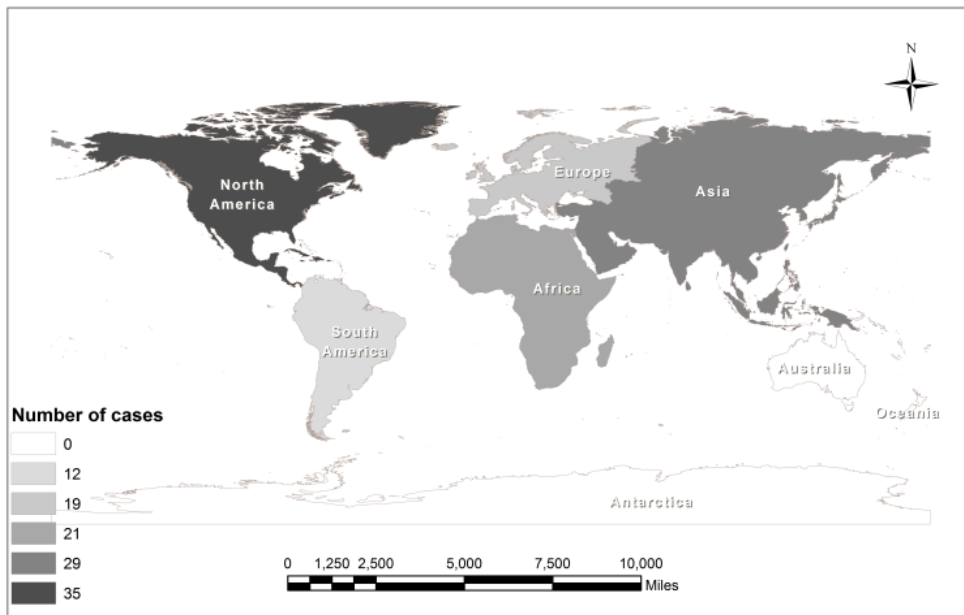


Figure 1. Global Distribution of Canine Distemper Virus (CDV) cases.

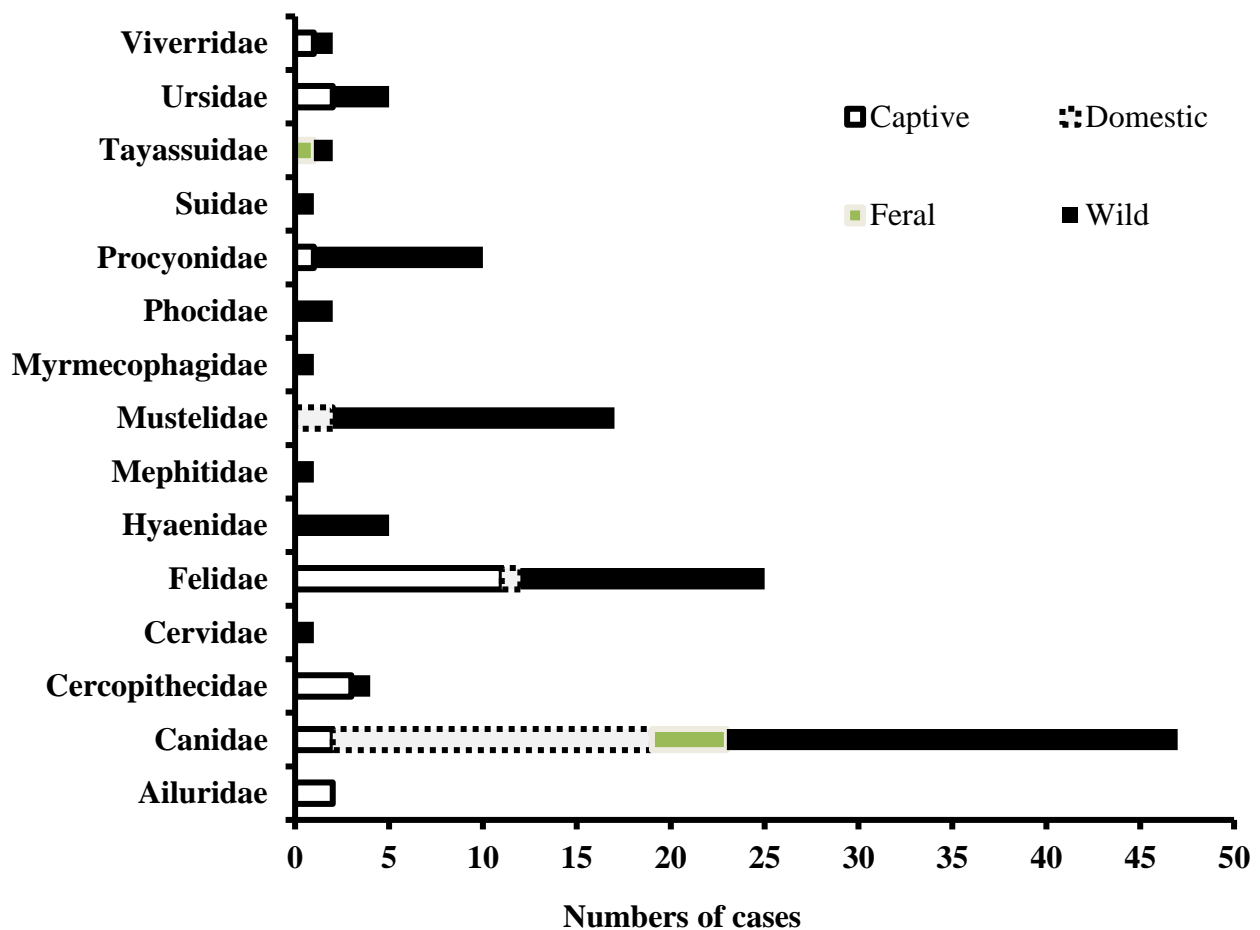


Figure 2. Distribution of CDV cases according to the hosts' family and their habitat.

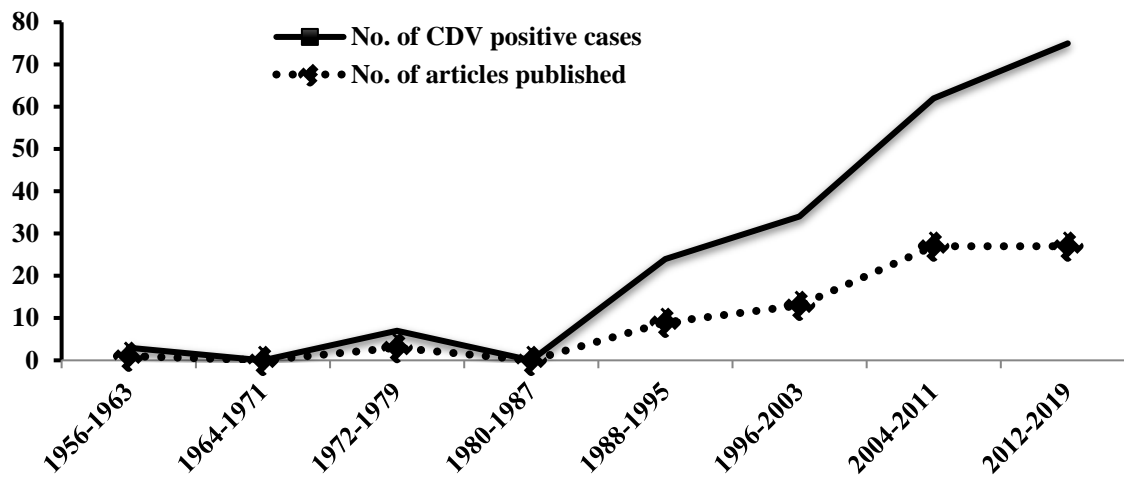


Figure 3. Line graphs showing the CDV cases and numbers of publications at every eight years from 1956 onwards.

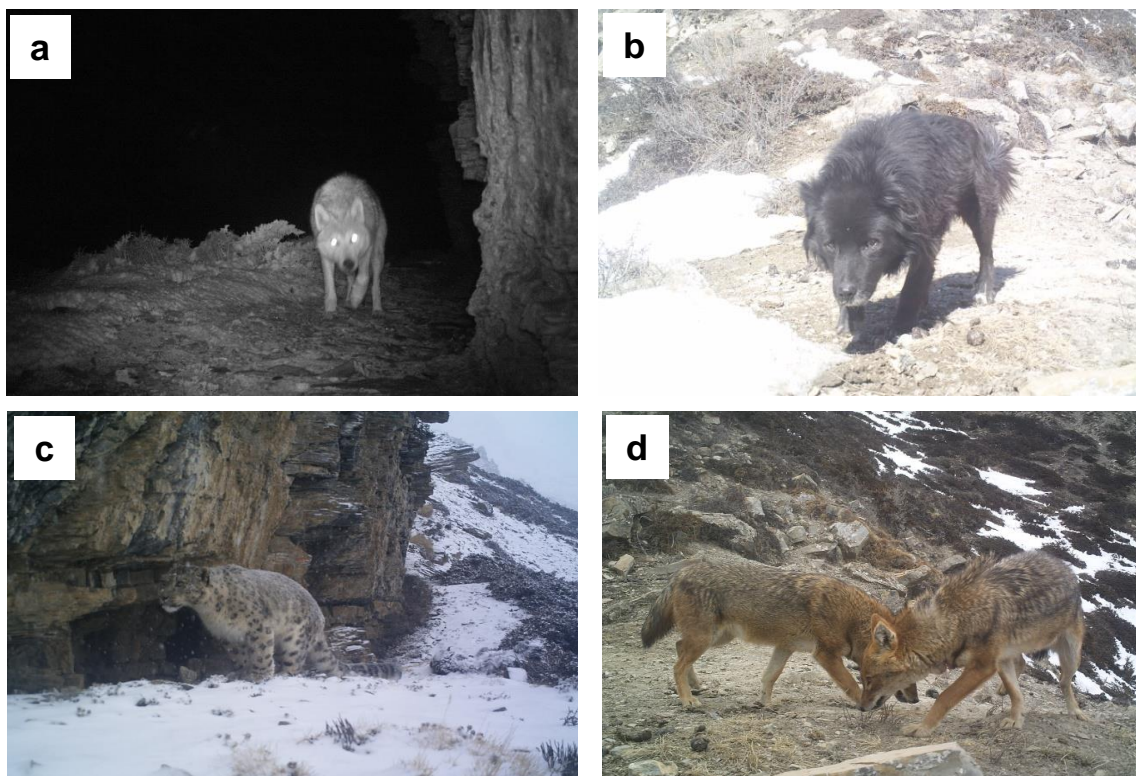


Figure 4. Camera-trapped images in Manang, Annapurna Conservation Area. (a) Himalayan wolf (b) Feral dog (c) Snow leopard (d) Golden jackals. Photos by Tashi R Ghale/ Third Pole Conservancy.

gompas. The transmission of CDV among wild and domestic animals always has negative impacts on the existing populations, particularly on the threatened and endangered species (Berentsen et al., 2013). Therefore, the roles of macaques and feral dogs surviving and roaming in and around the protected areas like National Parks, Wildlife Reserves, and Conservation areas cannot be ignored in threatening the wild fauna. The suspected case also can be evidenced by a previously published article by Debby Ng of the University of Tasmania and the

groups (Ng et al., 2019). The authors detected the CDV in asymptomatic domestic dogs in and around the Annapurna Conservation Area (Ng et al., 2019), the protective home of several threatened species including snow leopards, wolves, Pallas's cats, foxes, and mustelids (Regmi et al., 2020, submitted manuscript) (Figure 4). Therefore, we assume that CDV might be transported by these suspected vectors (dogs) to other susceptible animals in the forest areas and finally, the infection reaches to the top-level predators like snow leopards and wolves

which may lead to the local mass extinction of these animals deteriorating the existing food chain and ecosystem functioning.

Secondly, we hypothesize that the persistence of CDV in tigers and leopards underlies the enhanced evolution of their conflict with human and resulting casualties. The CDV leads to a hard pad disease, a disease characterized by thickening of the skin on the pads of paws and enamel hypoplasia, a disease characterized by the destruction of cells responsible for forming tooth enamel (Hal 1983; Beineke et al., 2015). These two pathologies in the large wild cats might make them incompetent in hunting the natural prey in the wild. That is why they usually come outside the forests for finding the easy prey to hunt, although further evidence-based studies should be conducted to prove this hypothesis. This is because most wildlife scientists traditionally believe that the lack of prey, habitat fragmentation, and degradation may be the reason for increasing human-wildlife conflict (Qamar et al., 2010; Acharya et al., 2017; Gameda and Meles 2018).

4. Conclusion

The single study with CDV positive cases in the dogs of Nepal principally raises the question mark for the concerned authorities and the government who allocate and spend millions of dollars in the welfare of the wildlife despite a negligible fund in the research of the major killer diseases. While habitat destruction, encroachment, illegal hunting, and poaching are the most challenging threats to Nepalese wildlife, the disease can also be a contributing factor in threatening them. In this context, the role of CDV can be critical, leading to mass mortality and, ultimately, the extinction of wildlife (University of Leeds 2007). However, how CDV creates the conservation threat to endangered species in Nepal has not been evaluated yet. Therefore, the government should broadly think about the One Health Concept for the research of CDV, primarily by screening and surveillance of positive cases via rapid diagnostic tests, preparation and publication of disease atlas for the Himalayas and Nepal, exchange of disease data with an open-access database with metadata, and prediction of disease outcomes for forecasting concerning climate change. Then, the research will be vital to the management of CDV among wildlife, especially living in the smaller protected areas with a) a large number of larger home-ranged animals such as tigers in Chitwan National Park; and b) more than ten species of wild felids and canids including snow leopards and Himalayan wolves in the trans-Himalayan habitat like Manang in Annapurna Conservation Area where the large number of feral dogs have been roaming around!

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Availability of data and materials: All data generated or analysed during the research work are included in this research article and its supplementary information files.

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Supplementary file: Report of Canine Distemper Virus (CDV) around the globe.

Host	Genus	Species	Subspecies	Taxonomic Serial Number (TSN)	IUCN Red List Status	Order	Family	Type of Host	Country	Reference
African Wild Dog	<i>Lycaon</i>	<i>pictus</i>		183833	EN	Carnivora	Canidae	Captive	Tanzania	van de Bildt MW et al., 2002
African Wild Dog	<i>Lycaon</i>	<i>pictus</i>		183833	EN	Carnivora	Canidae	Wild	Tanzania	Goller et al., 2010
African Wild Dog	<i>Lycaon</i>	<i>pictus</i>		183833	EN	Carnivora	Canidae	Wild	Zambia	Berentsen et al., 2013
American Black bear	<i>Ursus</i>	<i>americanus</i>		180544	LC	Carnivora	Ursidae	Wild	USA	Stephenson et al., 2015
Amur Leopard	<i>Panthera</i>	<i>pardus</i>	<i>orientalis</i>	726471	CR	Carnivora	Felidae	Wild	Russia	Sulikhan et al., 2018
Apennine wolves	<i>Canis</i>	<i>lupus</i>	<i>italicus</i>		VU	Carnivora	Canidae	Wild	Italy	Di Sabatino et al., 2014
Badger	<i>Meles</i>	<i>meles</i>		621922	LC	Carnivora	Mustelidae	Wild	Japan	Kameo et al., 2012
Badger	<i>Meles</i>	<i>meles</i>		621922	LC	Carnivora	Mustelidae	Wild	Germany	Van Moll et al., 1995
Badger	<i>Meles</i>	<i>meles</i>		621922	LC	Carnivora	Mustelidae	Wild	Germany	Frölich et al., 2000
Baikal Seal	<i>Phoca</i>	<i>sibirica</i>		183835	LC	Carnivora	Phocidae	Wild	Russia	Butina et al., 2010
Bat-eared Fox	<i>Otocyon</i>	<i>megalotis</i>		183835	LC	Carnivora	Canidae	Wild	Tanzania	Carpenter et al., 1998
Bat-eared Fox	<i>Otocyon</i>	<i>megalotis</i>		183835	LC	Carnivora	Canidae	Wild	Tanzania	Roelke-Parker et al., 1996
Binturongs	<i>Arctictis</i>	<i>binturong</i>		726479	VU	Carnivora	Viverridae	Captive	Korea	Hur et al., 1999
Black-backed Jackal	<i>Canis</i>	<i>mesomelas</i>		183818	LC	Carnivora	Canidae	Wild	Namibia	Gowtage-Sequeira et al., 2009
Bobcat	<i>Lynx</i>	<i>rufus</i>		180582	LC	Carnivora	Felidae	Wild	Canada	Daoust et al., 2009
Caspian Seal	<i>Phoca</i>	<i>caspica</i>		622019	EN	Carnivora	Phocidae	Wild	Russia	Kuiken et al., 2000

Cat	<i>Felis</i>	<i>catus</i>	<i>domestica</i>	183798		Carnivora	Felidae	Domestic	Switzerland	Wiener et al., 2013
Coyotes	<i>Canis</i>	<i>latrans</i>		180599	LC	Carnivora	Canidae	Wild	USA	Cyphe et al., 1998
Crab-eating Fox	<i>Cerdocyon</i>	<i>thous</i>		183825	LC	Carnivora	Canidae	Wild	Argentina	Ferreira et al., 2009
Crab-eating Fox	<i>Cerdocyon</i>	<i>thous</i>		183825	LC	Carnivora	Canidae	Wild	Brazil	Megid et al., 2009
Crab-eating Macaque	<i>Macaca</i>	<i>fascicularis</i>		180098	LC	Primates	Cercopithecidae	Captive	Japan	Sakai et al., 2008
Culpeo Fox	<i>Dusicyon</i> (<i>Lycalopex</i>)	<i>culpaeus</i>		726270	LC	Carnivora	Canidae	Wild	Argentina	Martino et al., 2004
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Namibia	Gowtage-Sequeira et al., 2009
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	USA	Pardo et al., 2005
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Tanzania	Carpenter et al., 1998
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Brazil	Nava et al., 2008
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Kenya	Alexander et al., 1994
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Nepal	Ng D et al., 2019
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	China	Jin et al., 2017
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Italy	Martella et al., 2007
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Feral	Turkey	Gencay et al., 2004
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Iran	Namroodi et al., 2015
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Feral	Denmark	Blixenkron-Moeller et al., 1993
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Brazil	Headley et al., 2009
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Brazil	Costa et al., 2019
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	South Africa	Woma and Van Vuuren 2009
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Feral	India	Sidhu et al., 2019
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	USA	Schumaker et al., 2012

Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Portugal	Muller et al., 2011
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Domestic	Zambia	Berentsen et al., 2013
Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	726821		Carnivora	Canidae	Feral	India	Belsare et al., 2014
Fennec fox	<i>Vulpes</i>	<i>zerda</i>		621865	LC	Carnivora	Canidae	Captive	Korea	Woo et al., 2010
Ferret	<i>Mustela</i>	<i>nigripes</i>		180557	EN	Carnivora	Mustelidae	Wild	USA	Kilham et al., 1956
Ferret	<i>Mustela</i>	<i>putorius</i>	<i>furo</i>	727313		Carnivora	Mustelidae	Domestic	Spain	Perpiñán et al., 2008
Fishers	<i>Martes</i>	<i>pennanti</i>		180560	LC	Carnivora	Mustelidae	Wild	USA	Needle et al., 2019
Fox	<i>Vulpes</i>	<i>vulpes</i>		180604	LC	Carnivora	Canidae	Wild	Germany	Frölich et al., 2000
Fox	<i>Vulpes</i>	<i>vulpes</i>		180604	LC	Carnivora	Canidae	Wild	Argentina	Martino et al., 2004
German Shepherd Dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	727313		Carnivora	Canidae	Domestic	Germany	Decaro et al., 2004
German Shepherd dog	<i>Canis</i>	<i>lupus</i>	<i>familiaris</i>	727313		Carnivora	Canidae	Domestic	Gabon	Maganga et al., 2018
Giant pandas	<i>Ailuropoda</i>	<i>melanoleuca</i>		621845	VU	Carnivora	Ursidae	Captive	China	Feng et al., 2016
Giant pandas	<i>Ailuropoda</i>	<i>melanoleuca</i>		621845	VU	Carnivora	Ursidae	Captive	China	Qin et al., 2010
Gray Fox	<i>Urocyon</i>	<i>cinereoargenteus</i>		180609	LC	Carnivora	Canidae	Wild	USA	Hoff et al., 1974
Grey fox	<i>Urocyon</i>	<i>cinereoargenteus</i>		180609	LC	Carnivora	Canidae	Wild	USA	Pope et al., 2016
Grey fox	<i>Urocyon</i>	<i>cinereoargenteus</i>		180609	LC	Carnivora	Canidae	Wild	USA	Needle et al., 2019
Grizzly bear	<i>Ursus</i>	<i>arctos</i>		180543	LC	Carnivora	Ursidae	Wild	USA	Chomel et al., 1998
Hoary Fox	<i>Lycalopex</i>	<i>vetulus</i>		726275	LC	Carnivora	Canidae	Wild	Brazil	Megid et al., 2010
Iberian wolves	<i>Canis</i>	<i>lupus</i>	<i>signatus</i>		VU	Carnivora	Canidae	Wild	Portugal	Muller et al., 2011
Indian fox	<i>Vulpes</i>	<i>bengalensis</i>		621858	LC	Carnivora	Canidae	Wild	India	Belsare et al., 2014
Jagaur	<i>Panthera</i>	<i>onca</i>		180593	NT	Carnivora	Felidae	Wild	Brazil	Nava et al., 2008
Jaguar	<i>Panthera</i>	<i>onca</i>		180593	NT	Carnivora	Felidae	Captive	USA	Appel et al., 1994
Jaguarundis	<i>Puma</i>	<i>yaguaroundi</i>		726257	LC	Carnivora	Felidae	Captive	Costa Rica	Avendaño et al., 2016
Japanese Macaque	<i>Macaca</i>	<i>fuscata</i>		555659	LC	Primates	Cercopithecidae	Wild	Japan	Yoshikawa et al., 1989
Javelina	<i>Tayassu</i>	<i>tajacu</i>		552761	LC	Artiodactyla	Tayassuidae	Feral	USA	Appel et al., 1991

Javelina	<i>Tayassu</i>	<i>tajacu</i>		552761	LC	Artiodactyla	Tayassuidae	Wild	USA	Noon et al., 2003
Leopard	<i>Panthera</i>	<i>pardus</i>		183804	VU	Carnivora	Felidae	Captive	USA	Appel et al., 1994
Leopard	<i>Panthera</i>	<i>pardus</i>		183804	VU	Carnivora	Felidae	Wild	Tanzania	Roelke-Parker et al., 1996
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Captive	USA	Appel et al., 1994
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Wild	Tanzania	Carpenter et al., 1998
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Wild	Tanzania	Roelke-Parker et al., 1996
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Wild	Kenya	Kock et al., 1998
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Wild	India	Mourya et al., 2019
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Captive	India	Ramanathan et al., 2007
Lion	<i>Panthera</i>	<i>leo</i>		183803	VU	Carnivora	Felidae	Captive	Switzerland	Myers et al., 1997
Lynx	<i>Lynx</i>	<i>canadensis</i>		180585	LC	Carnivora	Felidae	Wild	Canada	Daoust et al., 2009
Martes	<i>Martes</i>	<i>melampus</i>		621944	LC	Carnivora	Mustelidae	Wild	Japan	Kameo et al., 2012
Masked palm civet	<i>Paguma</i>	<i>larvata</i>		621984	LC	Carnivora	Viverridae	Wild	Japan	Machida et al., 1992
Mink	<i>Neovison</i>	<i>vison</i>		726284	LC	Carnivora	Mustelidae	Domestic	Denmark	Trebbien et al., 2014
Mink	<i>Neovison</i>	<i>vison</i>		726284	LC	Carnivora	Mustelidae	Wild	USA	Needle et al., 2019
Ocelots	<i>Leopardus</i>	<i>pardalis</i>		552470	LC	Carnivora	Felidae	Wild	Costa Rica	Avendaño et al., 2016
Polecat	<i>Mustela</i>	<i>putorius</i>		621954	LC	Carnivora	Mustelidae	Wild	Germany	Van Moll et al., 1995
Puma	<i>Puma</i>	<i>concolor</i>		552479	LC	Carnivora	Felidae	Wild	Brazil	Nava et al., 2008
Pumas	<i>Puma</i>	<i>concolor</i>		552479	LC	Carnivora	Felidae	Wild	Costa Rica	Avendaño et al., 2016
Pygmy raccoon	<i>Procyon</i>	<i>pygmaeus</i>		621972	CR	Carnivora	Procyonidae	Wild	Mexico	McFadden et al., 2005
Raccoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	Japan	Kameo et al., 2012
Raccoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	USA	Pope et al., 2016
Raccoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	USA	Needle et al., 2019
Raccoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	USA	Hamir et al., 1998
Raccoon dog	<i>Nyctereutes</i>	<i>procyonoides</i>		183821	LC	Carnivora	Procyonidae	Wild	Denmark	Trebbien et al., 2014

Racoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	USA	Hoff et al., 1974
Racoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	USA	(Roscoe 1993)
Racoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Wild	USA	Kilham et al., 1956
Racoon	<i>Procyon</i>	<i>lotor</i>		180575	LC	Carnivora	Procyonidae	Captive	USA	Lednický et al., 2004
Raccoon dog	<i>Nyctereutes</i>	<i>procyonoides</i>		183821	LC	Carnivora	Canidae	Wild	Japan	Kameo et al., 2012
Raccoon Dog	<i>Nyctereutes</i>	<i>procyonoides</i>		183821	LC	Carnivora	Canidae	Wild	Japan	Machida et al., 1993
Red Panda	<i>Ailurus</i>	<i>fulgens</i>		621846	EN	Carnivora	Ailuridae	Captive	USA	Bush and Roberts 1977
Red Panda	<i>Ailurus</i>	<i>fulgens</i>		621846	EN	Carnivora	Ailuridae	Captive	China	Zhang et al., 2017
Rhesus Macaque	<i>Macaca</i>	<i>mulatta</i>		180099	LC	Primates	Cercopithecidae	Captive	China	Sun et al., 2009
Rhesus Macaque	<i>Macaca</i>	<i>mulatta</i>		180099	LC	Primates	Cercopithecidae	Captive	China	Qiu et al., 2011
Sika Deer	<i>Cervus</i>	<i>nippon</i>		180696	LC	Artiodactyla	Cervidae	Wild	Japan	Kameo et al., 2012
Skunk	<i>Mephitis</i>	<i>mephitis</i>		180562	LC	Carnivora	Mephitidae	Wild	USA	Needle et al., 2019
Snow leopard	<i>Panthera</i>	<i>unica</i>		183811	VU	Carnivora	Felidae	Captive	USA	Chinnadurai et al., 2017
South American gray foxes	<i>Dusicyon (Lycalopex)</i>	<i>griseus</i>		726272	LC	Carnivora	Canidae	Wild	Argentina	Martino et al., 2004
Spotted Hyena	<i>Crocuta</i>	<i>crocuta</i>		621907	LC	Carnivora	Hyaenidae	Wild	Tanzania	Carpenter et al., 1998
Spotted Hyena	<i>Crocuta</i>	<i>crocuta</i>		621907	LC	Carnivora	Hyaenidae	Wild	Tanzania	Roelke-Parker et al., 1996
Spotted Hyena	<i>Crocuta</i>	<i>crocuta</i>		621907	LC	Carnivora	Hyaenidae	Wild	Tanzania	Haas et al., 1996
Spotted Hyena	<i>Crocuta</i>	<i>crocuta</i>		621907	LC	Carnivora	Hyaenidae	Wild	Botswana	Chaber et al., 2017
Spotted Hyena	<i>Crocuta</i>	<i>crocuta</i>		621907	LC	Carnivora	Hyaenidae	Wild	Zambia	Berentsen et al., 2013
Stone marten	<i>Martes</i>	<i>foina</i>		621941	LC	Carnivora	Mustelidae	Wild	Germany	Van Moll et al., 1995

Stone marten	<i>Martes</i>	<i>foina</i>		621941	LC	Carnivora	Mustelidae	Wild	Germany	Frölich et al., 2000
Tamandu	<i>Tamandua</i>	<i>tetradactyla</i>		624913	LC	Pilosa	Myrmecophagidae	Wild	Brazil	Lunardi et al., 2018
Tiger	<i>Panthera</i>	<i>tigris</i>		183805	EN	Carnivora	Felidae	Captive	USA	Appel et al., 1994
Tiger	<i>Panthera</i>	<i>tigris</i>		183805	EN	Carnivora	Felidae	Captive	Japan	Nagao et al., 2011
Tiger	<i>Panthera</i>	<i>tigris</i>		183805	EN	Carnivora	Felidae	Wild	Russia	Seimon et al., 2013
Tiger	<i>Panthera</i>	<i>tigris</i>		183805	EN	Carnivora	Felidae	Captive	China	Zhang et al., 2017
Tiger	<i>Panthera</i>	<i>tigris</i>		183805	EN	Carnivora	Felidae	Captive	Switzerland	Myers et al., 1997
Weasel (Siberian)	<i>Mustela</i>	<i>itatsi</i>	<i>sibirica</i>	621955	LC	Carnivora	Mustelidae	Wild	Japan	Kameo et al., 2012
Weasel	<i>Mustela</i>	<i>nivalis</i>		180554	LC	Carnivora	Mustelidae	Wild	Germany	Van Moll et al., 1995
Weasel	<i>Mustela</i>	<i>itatsi</i>		726281	NT	Carnivora	Mustelidae	Wild	Japan	Kameo et al., 2012
Wild Black Bear	<i>Ursus</i>	<i>americanus</i>		180544	LC	Carnivora	Ursidae	Wild	USA	Cottrell et al., 2013
Wild boar	<i>Sus</i>	<i>scrofa</i>		180722	LC	Artiodactyla	Suidae	Wild	Japan	Kameo et al., 2012
Wild Ferret	<i>Mustela</i>	<i>putorius</i>		621954	LC	Carnivora	Mustelidae	Wild	Denmark	Trebbien et al., 2014
Wild fox (red)	<i>Vulpes</i>	<i>vulpes</i>		180604	LC	Carnivora	Canidae	Wild	Denmark	Trebbien et al., 2014
Wild Fox	<i>Vulpes</i>	<i>vulpes</i>		180604	LC	Carnivora	Canidae	Wild	Germany	Denzin et al., 2013
Wild Taiwan ferret-badgers	<i>Melogale</i>	<i>moschata</i>		621924	LC	Carnivora	Mustelidae	Wild	Tiwan	Chen et al., 2008
Wolf	<i>Canis</i>	<i>lupus</i>		180596	LC	Carnivora	Canidae	Wild	Canada	Choquette and Kuyt 1974