

# Global Challenges of Small Mammalian Carnivores: A Review

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## ABSTRACT

Small mammalian carnivores are playing various important roles in ecosystems by influencing the structure of ecosystem and also providing various ecosystem services. In the present study, the major categories of threats faced by small carnivores were reviewed. This study revealed that biological resource use and land use change are the leading threats for small carnivores. These species need great concern globally, particularly in Southeast Asia and Madagascar. This review has encouraged research and constant monitoring of current status which will be helpful in conservation of small carnivores in future.

**Key words:** Conservation, Ecosystem, IUCN, Small carnivores, Threat.

## Introduction

A large scale of conservation strategy is focused on large mammalian carnivores as these species often play an important role in ecosystems and serve as umbrella and flagship species for an ecosystem (Ray *et al.*, 2013). Large carnivores are apex carnivores in their habitat and they can exhibit direct and indirect downstream effect on subordinate carnivores and herbivores (Ripple and Beschta, 2012; Le Roux *et al.*, 2019). In previous studies, it has been claimed that the loss of large carnivores has benefited the subordinates and small carnivores to the extent that the rapid growth and expansion of these species have adversely impacted the function of ecosystem (Prugh *et al.*, 2009; Ritchie and Johnson, 2009; Brashares *et al.*, 2010). On the other hand, it has been observed that some species of small carnivores (non-apex carnivores) have changed their range, over the past century, to that extent where they can protect themselves from predation and competition with large carnivores (Haswell *et al.*, 2017; Hody and Kays, 2018; Jachowski *et al.*, 2020). In 2009, a declin-

ing population trend was reported in 62% of small carnivore species of America (Belant *et al.*, 2009). Do Linh San *et al.* (2013) reported that 27% species of small carnivore's population in mainland Africa was in decreasing trend and most of the half species population trends were not recorded. On the other hand, since 2015, 6 species of small carnivores were listed down and 19 species were up listed in a higher category of IUCN (González-Maya, 2018).

The study of the status of small carnivores gives immense knowledge of their importance in the structure and function of ecosystem. These species can influence the structure of ecosystem through downstream effects on herbivores which in turn affect the primary producers. For example, the decline of small mustelids led to the increasing densities of Arvicolinae species and plant damage (Hambäck *et al.*, 2004; Roemer *et al.*, 2009). They also play important roles in other processes of ecosystem such as long-distance dispersal of seed, alteration in phosphorus and nitrogen levels in soil (Jordano *et al.*, 2007; Gharajehdaghypour *et al.*, 2016). Small carnivores also benefit human society provid-

ing many ecosystem services. They may reduce the risk of rabies (Braczkowski *et al.*, 2018) and lyme disease (Levi *et al.*, 2012) by decreasing the rodent populations. In Europe, it has been reported that golden jackals remove >158 million rodents and >13000 tons of domestic animal waste through scavenging (Ćirović *et al.*, 2016). Moreover, the endemic small carnivore species can also help the native prey species by controlling the intrusion of non-native prey species. For example, in Great Britain, the suppression of invasive gray squirrels by pine marten (*Martes martes*) creates a shelter for the native red squirrels (Twining *et al.*, 2021). Due to the importance of small carnivore species in ecosystem, it is necessary to understand how they are reacting to global change. In this context, the present study aims to review the global threats of small carnivore species.

### Major categories of threats for small mammalian carnivores

In a recent study, the order/Carnivora was studied utilizing the data of IUCN Red List of Threatened Species (global assessment data and range data; IUCN, 2020) with special reference to terrestrial and semi-terrestrial carnivores. They estimated 27 large and 229 small carnivores based on the weight using the dataset PanTHERIA (Jones *et al.*, 2009). According to their study, 3, 20 and 30 small carnivores were recorded as Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) respectively whereas 1, 4 and 10 large carnivores were listed as CR, EN, and VU respectively (Marneweck *et al.*, 2021).

In the present study, the major categories of the threats of small carnivores are discussed under the following sub-headings and also presented in fig. 1.

#### Biological resource use

The use of biological resource was one of the leading threats that affect almost 96% of threatened small carnivores. This category refers to poaching and overhunting though the reasons for such activities are regionally different. The highest species affected by this threat was in Southeast Asia. Southeast Asia is identified as a priority region for conservation due to its illegal wildlife trade and killing of many carnivores for the demand of its meat as luxury edible item (Willcox *et al.*, 2014; Gray *et al.*, 2018; Willcox, 2020; Marneweck *et al.*, 2021). Moreover, their body parts are also used as traditional medicine (Sodhi *et*

*al.*, 2004; Nijman, 2010).

Due to lack of economic opportunities, the illegal trade of small carnivore species has increased within the local communities (Challender and MacMillan, 2014). Felidae includes the largest proportion of the threatened small carnivores among the nine families which threatened by the biological resource use (Palazy *et al.*, 2011; Nijman *et al.*, 2019b). The illegal trade due to desire to own exotic pets is also one of the leading threats to numerous small carnivores (Siriwat and Nijman, 2018; Siriwat *et al.*, 2019).

#### Change in land use pattern

Land use change is combination of IUCN threat categories such as aquaculture and agriculture, commercial and residential development, modification of natural system, service corridors and transportation. It has been reported that 91% of threatened small carnivores is affected due to land use change. Change in land use pattern for agriculture was identified as leading threat that affected 85% of threatened small carnivore species. Mostly, industrial agriculture and large scale of agricultural activities has contributed to this threat (Marneweck *et al.*, 2021). In Southeast Asia, South America and Africa, the expansion of palm oil industry is predicted to overlap with the habitat of threatened small carnivores (Fitzherbert *et al.*, 2008).

Development of commercial and residential is reported to cause threats to 47% of threatened small carnivores. The Eupleridae species are indigenous to Madagascar and are of great concern as they are facing threat due to deforestation. The worldwide growth of human population leads to the deforestation and conversion of habitat for commercial and residential development (Seto *et al.*, 2011). On the other hand, some small carnivore species adapt themselves in urban environment (Bateman and Fleming, 2012). Transport and service corridors are reported to impact 42% of threatened small terrestrial carnivores while modification of natural system causes threat to 28% of small carnivores.

Land use changes due to anthropogenic activities create several problems to threatened small carnivores through different ways. It leads to the isolation in population by reducing the connection and gene flow (Riley *et al.*, 2006; Crooks *et al.*, 2011; Gerber *et al.*, 2012; Poessel *et al.*, 2014). It also reduces the availability of spaces used in their needs (for example, to cover themselves from hunting) (Cantú-Salazar *et al.*, 2009; Gálvez *et al.*, 2013). Moreover,

**Table 1.** IUCN threat categories and sub-categories with the percentage (%) of affected threatened small carnivores (Source: Marneweck *et al.*, 2021).

IUCN Red List Threat	% of threatened small carnivores affected
<b>Biological resource use</b>	96%
Hunting & trapping terrestrial animals (intentional & unintentional)	91%
Gathering terrestrial plants (intentional & unintentional)	15%
Logging & wood harvesting (intentional & unintentional)	64%
Fishing & harvesting aquatic resources (intentional & unintentional)	15%
<b>Agriculture &amp; aquaculture</b>	85%
Annual & perennial non-timber crops	76%
Wood & pulp plantations	45%
Livestock farming & ranching	40%
Marine & freshwater aquaculture	15%
<b>Transportation &amp; service corridors</b>	42%
Roads & railroads	42%
Utility & service lines	2%
Shipping lanes	2%
<b>Residential &amp; commercial development</b>	47%
Housing & urban areas	43%
Commercial & industrial areas	19%
Tourism & recreation areas	13%
<b>Invasive and other problematic species, genes &amp; diseases</b>	43%
Invasive non-native/alien species/diseases	36%
Problematic native species/diseases	13%
Introduced genetic material	2%
Problematic species/diseases of unknown origin	2%
Viral/prion-induced diseases	13%
Diseases of unknown cause	0
<b>Natural system modifications</b>	28%
Fire & fire suppression	13%
Dams & water management/use	17%
Other ecosystem modifications	8%
<b>Energy production &amp; mining</b>	21%
Oil & gas drilling 4% Mining & quarrying	15%
Renewable energy 8%	21%
<b>Pollution</b>	21%
Domestic & urban waste water	15%
Industrial & military effluents	17%
Agricultural & forestry effluents	17%
Garbage & solid waste	9%
Air-borne pollutants	0
Excess energy	4%
<b>Human intrusions &amp; disturbance</b>	13%
Recreational activities	8%
War, civil unrest & military exercises	6%
Work & other activities	4%
<b>Climate change &amp; severe weather</b>	13%
Habitat shifting & alteration	9%
Droughts 2% Temperature extremes	0
Storms & flooding	2%
Other impacts	2%
<b>Geological events</b>	2%
Earthquakes/tsunamis	2%
Avalanches/landslides	2%
<b>Other</b>	0

change in land use pattern decreases the population of prey species that increases human-carnivore conflict (Treves and Karanth, 2003; Wolf and Ripple, 2016; Carvalho *et al.*, 2018; Planillo *et al.*, 2018). The development of roads increases the chances of access for poaching and hunting of small carnivores and their prey (Wilkie *et al.*, 2000; Espinosa *et al.*, 2018; Duporge *et al.*, 2020). It is a matter of great concern that the countries, which harbour a rich population of small carnivore species, are contributing to illegal hunting and trade (Clements *et al.*, 2014).

### Invasive species and diseases

Invasive species and diseases were reported as a threat to 43% of threatened small carnivores. It has been predicted that the invasive species are introduced intentionally or accidentally by human in many ecosystem (Kolar and Lodge, 2001). Invasive species can negatively impact threatened small carnivores in various ways. They create threat to small carnivore species through direct competition for predation or resources (Ritchie *et al.*, 2014; Vanak *et al.*, 2014; Farris *et al.*, 2017a; Farris *et al.*, 2017b). In some cases, the hybridization between invasive species and closely related native species may also lead to the introgression of non-native genes or loss of genetic variability in populations of threatened small carnivores (Kelly *et al.*, 1999). For example, in Bale Highlands, the endangered canid Ethiopian wolves (*Canis simensis*) have been reported to hybridize with domestic dogs that threatened the genetic integrity of the wolves which persists in different isolated, small sub populations (Gottelli *et al.*, 1994; Marino and Sillero-Zubiri, 2011).

Invasive species can also act as an intermediate host and introduce novel pathogens in the environment (Beltrán-Beck *et al.*, 2012; Sepúlveda *et al.*, 2014; Sutor *et al.*, 2014). The epizootics of the viruses of canine distemper and rabies in wildlife have been reported to be mediated by the invasive species (Alexander and Appel, 1994; Holmala and Kauhala, 2006). Moreover, rabies and canine distemper viruses are identified as significant threats to carnivore species. The outbreak of these diseases can facilitate the extinction of many threatened small carnivores species (Thorne and Williams, 1988; López *et al.*, 2009).

### Energy production

Energy production is reported to threaten 38% of small carnivores. Combustion of fossil fuel, develop-

ment of road and other activity have negative impact on terrestrial wildlife leading to the fragmentation of habitat and multi-source pollution (Monson *et al.*, 2000; Sawyer *et al.*, 2017).

Mining can also affect the aquatic small carnivores through habitat destruction, river sedimentation and pollution. For example, in gold mining, mercury is frequently used to recover the trace amount of gold and this mercury finally accumulates in the environment (Laperche *et al.*, 2014; Mason *et al.*, 2019). In aquatic ecosystem, the biomagnification of mercury in food chains is deleterious to small carnivore species (for example, North American river otters) (Crowley *et al.*, 2018). The river fragmentation and changing flooding pattern due to construction of hydroelectric dam, particularly in South America and Asia, have threatened semi aquatic carnivores such as otters (Lutrinae) by destructing habitats and changing the availability of prey species (Santos *et al.*, 2008).

### Conclusion

The assessments of IUCN red list globally increase the public awareness, scientific knowledge, funding and resources and action for the conservation of listed species (Betts *et al.*, 2020). Recent researches have suggested that Madagascar and Southeast Asia are the important regions to focus on the conservation of the native carnivores based on their population status (Farris *et al.*, 2017a; Farris *et al.*, 2017b; Willcox, 2020). There is an urgent need to investigate the proper ways to minimize the primary local threats of small carnivores. Though the threats of large and small carnivores are similar but fewer IUCN assessments have been done for small carnivores as compared to large carnivores. Small carnivores need more frequent monitoring as the two major threats (biological resource use and land use change) are increasing globally (Bell *et al.*, 2004; Willcox, 2020). Many regulatory policies exist in some regions of the world but the enforcement is yet lacking (Yi-Ming *et al.*, 2000; Nijman *et al.*, 2019a). In this context, research and conservation attention are necessary to reduce the threats so that the current declination of small carnivores can be slowed down or reversed. Conservationist should take proper steps to aware the public about the ecological roles and services of small carnivores and encourage them for conservation.

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