In defense of the world’s most reviled vertebrate animals: part 2: mammals (bats, hyenas, mice, rats, and skunks)

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Introduction

It appears that just as we humans express both our love for, and hatred against, certain groups within our species, our closest animal relatives, the mammals, also receive very selective admiration and detestation. Mammals such as those included in the ‘charismatic megafauna’ (big and attractive as shown in Figure 1) and the cute & cuddly species (Figure 2) make ideal aids for enlisting conservation support. In parallel, as noted in this paper, certain species of mammals are passionately hated and are often the subjects of extermination campaigns. These hated species are major concerns, and their intrusions into the artificial habitats of people provoke negative sentiments against the world of wildlife from which they originate. We humans wage war against our enemies and our impulse is to remove the objectionable species not just from our urbanized world, but everywhere. However, the most offensive nuisance mammals are superlative competitors and survivors and attempts to eliminate them require such extensive measures that, inevitably, many other species are endangered. What is needed is to find ways of living with these pests that minimize their harmful effects and a key first step is to learn to understand and respect their needs. Towards this goal, this review presents both the negative and positive aspects of our most detested mammalian pests emphasizing that, on balance, their benefits to humans exceed their harm.

Small (2019) explored how the most reviled species of invertebrate animals significantly but irrationally prejudice the public against wildlife and mitigate efforts to rehabilitate and conserve biodiversity. Part 1 of this paper (Small 2020) similarly carried out the same exercise for the most reviled species of ‘lower vertebrates’ (fish, frogs & toads, snakes, and birds). This follow-up review conducts a similar analysis of the most reviled mammals, which we humans arrogantly consider to be the ‘highest’ group of animals because we are the predominant member. Burgin et al. (2018) list 6400 species of living mammals which represent less than 10% of recognized vertebrate species and less than 0.5% of all animal species. Nevertheless, mammals overwhelmingly dominate conservation initiatives. By a considerable margin, the public supports conservation and rehabilitation of certain ‘charismatic’ mammals much more than any other species (Table 1). As with the previous examination of non-mammal vertebrates (Small 2019), the goal is to generate understanding of the economic values and useful roles of the world’s most disliked mammals in order to minimize the disrespect for biodiversity that they generate. The most despised mammals include bats, hyenas, mice, rats, and skunks (Figure 3). Notably, most of these disreputable mammals are no larger than a housecat whereas the most respected mammals are usually huge. Size is one of the characteristics that strongly determines whether a species is liked or disliked by humans (Small 2011, 2012) and even though most mammals are relatively small they are at least as vital to the welfare of the world as the giants.

In relation to their relatively small number of species, mammals nevertheless play disproportionately large economic roles in human existence. Domesticated mammals, and in some regions wild mammals, provide food and hides. Livestock mammals furnish most of the world’s meat, milk, leather, and wool (as noted by Thornton 2019, there are currently 1.5 billion cows, 1 billion sheep, and 1 billion pigs in the world). Some species are important beasts of burden for riding, hauling, and ploughing. The dung and urine of livestock provide an agricultural fertilizer that is superior to today’s synthetic versions. Dogs and cats have become the world’s major pets, and dogs are also invaluable working assistants. (Unfortunately most of the approximately 1 billion dogs [Atitwa 2018] and about 600,000 cats [Migiro 2018] in the world are ‘free-range’ or feral,
causing enormous ecological problems.) Recreational hunting is primarily for mammals and birds. Rats and mice are the principal vertebrates employed in medical research and scientific studies. (As pointed out later, on a world basis about 100 million mice and a smaller but substantial number of rats may be sacrificed annually in laboratories for experiments.)

In nature, mammals are also often disproportionately important – as members of food chains and food webs, as grazers, and as predators. Mammals are often keystone species – critical for maintaining services and functions associated with sustaining a balanced ecosystem. On the negative side, some invasive mammals cause extensive damage to ecosystems and biodiversity.

Figure 1. Examples of charismatic megafauna mammals that strongly attract conservation support (all photos are public domain). Credits: (a) Elephant: Hung Lê from Pixabay. (b) Orca: Clker-Free-Vector-Images from Pixabay. (c) Giant Panda: Dušan Smetana from Pixabay. (d) Giraffe: PublicDomainPictures from Pixabay. (e) Tiger: George Desipris.

Figure 2. Examples of cute & cuddly mammals that strongly attract conservation support. Credits: (a) Meerkat: Public domain photo by Skeeze from Pixabay. (b) Koala: Public domain photo by Skeeze from Pixabay. (c) Harp Seal (baby whitecoat phase): Photo by Lysogeny (CC BY SA 4.0). (d) Ring-tailed Lemurs: Photo by Alexandra (CC BY SA 3.0). (e) Long-tailed Chinchilla: Photo by Matteo De Stefano/MUSE (CC BY SA 3.0). (f) Red Panda: Public domain photo by Mathias Appel.
The attention that we humans pay to mammals is also highly disproportionate to their relatively small number compared to other animals. The International Union for the Conservation of Nature (IUCN) is the world’s oldest and largest global environmental network that aims to help the world find pragmatic solutions to our most pressing environment and development challenges by supporting scientific research (https://www."

**Figure 3.** The most vilified mammals (bats, hyenas, mice, rats, and skunks). Painting by Jessica Hsiung.

**Table 1.** The most charismatic animals (‘deemed charismatic, mainly because they were regarded as beautiful, impressive, or endangered’) as determined and ordered by Albert et al. (2018). All except the Shark and the Crocodile are mammals.

|   |   |   |   |
|---|---|---|---|
| 1. | Tiger | 6. | Panda |
| 2. | Lion | 7. | Cheetah |
| 3. | Elephant | 8. | Polar Bear |
| 4. | Giraffe | 9. | Wolf |
| 5. | Leopard | 10. | Gorilla |
| 11. | Chimpanzee | 12. | Zebra |
| 13. | Hippo | 14. | Shark |
| 15. | Crocodile | 16. | Dolphin |
| 17. | Rhinoceros | 18. | Bear |
| 19. | Koala | 20. | Blue Whale |

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The IUCN organizes ‘Specialist Groups’ which disband and reform every 4 years (https://www.iucn.org/commissions/ssc-groups; e.g. Shark Specialist Group, Duck Specialist Group). An analysis of the specialist groups devoted to animals shows that mammals are the most studied species (Table 2).

Despite the useful roles described above, some mammals are decidedly harmful to humans. Some rodents destroy crops growing in fields and stored in buildings – and also ruin property. Several mammals transmit deadly infectious diseases. A few wild carnivorous mammals prey on domestic animals and occasionally on people. A few, most notably skunks, are simply repellent to human olfactory senses, while others, particularly hyenas, seem to represent the worst of human character defects. The species examined here are reputedly the worst of the worst.

Bats

Bats make up the mammalian order Chiroptera, with over 1300 species (Taylor and Tuttle 2018; examples are shown in Figure 4). The traditional taxonomic division into two sub-orders, the Megachiroptera (the Old World fruit bats or flying foxes, shown in Figure 5, which are exclusively herbivores) and the more numerous and diverse Microchiroptera, has been losing support because of recent genetic studies. Bats occur throughout the world except the Antarctic. There are twice as many species in the Old World compared to the New World, but an especially diverse range of bats occurs in South America. Unlike other mammals, bats are capable of true (self-powered) flight, not just gliding. The wings are folds of skin stretched between elongated finger bones and various parts of the body. Some species like the Bumblebee Bat (Craseonycteris thonglongyai) are small, weighing as little as 1.5 g, others exceed 1.5 kg and have a wingspan as large as 1.7 m. The smaller bats (‘Microbats’) usually roost in caves or other similar protected areas, while many large bats (‘Megabats’) often overnight in the open. Bats are mostly nocturnal, usually spending days in caves, trees, or other refuges. Most bats are rather drab, reflecting their usual active period during nights. However, the colouration of a few is interesting, such as the all-white Honduran White Bat (Figure 6). In cold seasons, bats may hibernate in dens, especially caves. While at rest, they hang upside-down. Some species are solitary, others are social, sometimes congregating in the millions. Some bats eat fruits, but about 70% are insectivorous (insect eaters), and some species are large enough to hunt fish, frogs, lizards, birds, and mammals – even other bats. True ‘vampire bats’ include only three species, ranging from Central to South America (occasionally in Mexico), which feed entirely on blood (they are the only mammals that do so). Bats are hunted by some animals, especially birds of prey and snakes. There are numerous scientific books on bats (e.g. Hill and Smith 1984; Altringham 2011; Adams and Pedersen 2013; Fenton and Simmons 2015; Voigt and Kingston 2016; Taylor and Tuttle 2018), which have proven to be appealing to scientists and amateurs, if not to most of the public.

Compared to other mammals, flying is the most notable adaptation of bats, but echolocation (sonar radar) is also an extraordinary talent. Many bats produce ultrasonic sounds (which humans can’t hear) and interpret their reflections in order to locate objects, either to avoid them in flight or to hunt prey while flying in the dark. Meat-eating bats tend to use echolocation to hunt their prey, but fruit eaters do not need this adaptation. (Several marine mammals and a few terrestrial insect-eating mammals have also evolved echolocation, but the bats are the experts in this regard.) There are no blind bats (contrary to the expression ‘as blind as a bat’), but this idea is so entrenched that a bat is called a ‘blind mouse’ in some languages (murciélago in Spanish, slijepi miš in Bosnian). However, some bats that are night activity specialists have relatively poor vision.

Harmful aspects

Bats carry several deadly viruses such as Ebola, different kinds of coronavirus (such as SARS, MERS, and possibly COVID-19), henipavirus, and astrovirus, which can

| Vertebrates       | Number of groups | Invertebrates | Number of groups |
|-------------------|------------------|---------------|------------------|
| Mammals           | 35               | Insects       | 4                |
| Birds             | 16               | Other arthropods | 3            |
| Reptiles & Amphibians | 12           | Coral         | 1                |
| Fish              | 10               | Molluscs      | 1                |
| Total             | 73               | Total         | 9                |

Table 2. Number of International Union for the Conservation of Nature Specialist groups (based on Table 1 in Cowie et al. 2017).
cause lethal infections in other mammals. Bats appear to be a continuing source of new viruses infecting humans (Wong et al. 2007). Besides rabies, none of the other viruses seem to produce any symptoms in bats (the diseases are said to be 'subclinical') which appear to be extraordinarily resistant and, accordingly, are efficient vectors of many diseases (Klimpel and Melhorn 2013; Wang and Cowled 2015). It has been speculated that the high heat produced by bats while flying somehow immunizes them against most of the effects of viruses and may even stimulate the viruses to become more virulent (Gross 2020). While bats are known to carry over 200 viruses the extent to which they are responsible for particular outbreaks is in need of study (Moratelli and Calisher 2015), especially with respect to COVID-19 (Tuttle 2020).
In the United States and Canada, the most recently documented cases of rabies have been attributed to bat rabies viruses (Dato et al. 2016). Bat transmission of rabies virus to humans occurs only in the Americas and involves hematophagous [blood-eating], frugivorous [fruit-eating] and insectivorous [insect-eating] bat groups (Beltz 2018). Most bat species do not carry the rabies virus. Bat bites in humans are rare and rabies in humans from such bites is extremely rare.
Flying bats can easily carry deadly viruses long distances. Many bats, including fruit-eating bats, discard less-digestible portions of their food along with infective agents which can be ingested by other animals, spreading diseases (Jennings 2019). Fruits chewed by bats can be harvested and eaten by people, infecting them. Indeed consuming any of a variety of food items contaminated by saliva, feces or urine of bats can infect livestock and people (Schneeberger and Voigt 2016).

An outbreak of Nipah virus, which causes symptoms such as fatal encephalitis (brain inflammation) was traced to harvested juice from Date Palm contaminated by bats (Hunt 2020).

Horseshoe Bats are so named for their large horseshoe-shaped nose-leaf, which acts like a parabolic reflector, helping focus echolocation. Severe acute respiratory syndrome coronavirus-like viruses have long been known to occur in Horseshoe Bats (Woo, Lau, and Yuen 2006). Zhou et al. (2020) found that the genome of COVID-19 was 96% identical to that of virus carried by Horseshoe Bats (identified as Rhinolophus affinis) in China. It has been speculated that the COVID-19 pandemic can be traced back to the consumption of Horseshoe Bats in China, in so-called ‘wet markets’ where close contact between humans and food animals has resulted in the transmission of many microbes from animals to humans (Gross 2020). (A wet market sells perishable goods such as food and flowers; particularly outside of the Western World, wet markets often sell living animals for food.)

The three species of true vampire bats (which are mostly confined to tropical and subtropical regions of the New World) are the only exclusively blood-feeding mammals and have captured the imagination of many people. The concept of vampires can be traced back to Eastern European Middle Ages legends of a corpse returning to life and sucking blood from the neck of human victims (Figure 7). The vampire bat was named for the legend rather than the reverse.

False vampire bats are any of several Old World bat genera: Megaderma, Cardioderma, and Macroderma (family Megadermatidae) and the New World genera Vampyrum and Chrotopterus (family Phyllostomidae). It used to be believed that these large bats fed on blood, like true vampire bats, but in fact they prey mostly on small vertebrates.

True vampire bats are New World species which feed mainly on the blood of cattle, horses and wild mammals, but rarely bite humans. They extract relatively small quantities of blood but expose livestock to secondary infections, parasites and the transmission of viral-borne diseases such as rabies. The Common Vampire Bat (Figure 8) became a serious pest when Europeans introduced mammalian livestock into the New World Tropics. In Latin America, paralytic rabies transmitted by vampire bats (almost completely the Common Vampire Bat) is a major cause of mortality in cattle. The Common Vampire Bat is thought to be responsible for the death of about 100,000 domestic cattle annually in South and Central America (Altringham 2011).
Bats widely employ human structures such as buildings and bridges as den sites, and they are usually unwelcome. Bat excrement in attics can pose serious health risks to home owners, including diseases such as histoplasmosis (a fungal infection which can be acquired by inhaling spores) and the introduction of ticks and fleas. Professional removal may be necessary.
Collisions with birds, ‘bird strike’, are a well-known hazard to airborne aircraft. Although aircraft have been damaged by large populations of bats (Figure 9), this is quite a rare occurrence (Hill and Smith 1984).

**Beneficial aspects**

Textbox 1. Importance of bats

Bats are unexpectedly critical to the ecosystem. Bats are often considered ‘keystone species’ that are essential to some tropical and desert ecosystems. Without bats’ pollination and seed-dispersing services, local ecosystems could gradually collapse as plants fail to provide food and cover for wildlife species near the base of the food chain. Bats are also critical to the ecosystem through their pest control services. Throughout the United States, scientists estimate, bats are worth more than $3.7 billion a year in reduced crop damage and pesticide use. And that, of course, means fewer pesticides enter the ecosystem.

– Weebly.com (2015)

The most important positive contribution of bats is their enormous consumption of insect pests, particularly benefitting agriculture (Boyles et al. 2011; Riccucci and Benedetto 2014; Taylor et al. 2018) (Textbox 1). Even small bats can consume thousands of insects in a night, often amounting to half their body weight (Taylor and Tuttle 2018). Some species of fruit-eating bats can damage crops, but this pales by comparison with the enormous pest-control contributions that bats make to agriculture.

Guano is accumulated bat dung deposited in and near caves housing bats and is an invaluable fertilizer for plants because it is very high in nitrogen. (Bat guano is a source of saltpetre – sodium nitrate – once employed in the production of gunpowder and other explosives.) Some bats are pollinators, indispensable for hundreds of species of tropical plants. Plants that rely on nectar- or pollen-eating bats for pollination usually open their flowers at night. Notably, bats pollinate agave plants (Agave species) from which tequila is made; the Durian (Durio species), a stinky but popular fruit of Asia; and the African Baobab (Adansonia digitata), a charismatic tree with an enormously wide trunk. Fruit-eating bats distribute seeds. Despite the negative perception of bats by many, they have some potential for ecotourism (Pennisi, Holland, and Stein 2004).

Bats are widely consumed by people in Asia, the Pacific Rim, and Africa, and to a lesser extent in Central and South America (Mildenstein, Tanshi, and Racey 2016). Eating bats is rare in Western culture, in part because most temperate region bats are relatively small. To a much lesser extent, bats are also sometimes
hunted for their perceived medicinal values. Food use of the large-bodied fruit bats of the Old World tropics is especially common. Consumption of bats is contrary to Jewish and Islamic dietary laws. In West Africa, sale of bat bushmeat is sometimes discouraged because of the danger of disease transmission.

Anticoagulants from the Common Vampire Bat (*Desmodus rotundatus*), especially an anti-clotting agent called ‘Draculin’ or ‘Desmoteplase’, might have potential for treating patients with blood-clotting problems (Taylor and Tuttle 2018).

**Conservation aspects**

Bats have an unfortunate image problem that has resulted in their persecution. Since the dawn of humanity, people have been frightened of bats. Their nocturnal nature predisposed them to be feared since many people are scared of the dark — and indeed most creatures of the night, especially those, like bats, that are mostly unseen and often unheard because of their silent flight. In many cultures bats are viewed as bad omens and symbols of fear and death and they are often portrayed as the companions of witches *(Figure 10)* and vampires *(Figure 7)* who are traditionally believed to be able to transform themselves into bats. In many cultures, bats figure prominently in folklore and are often associated with evil, bad luck and death. Demons are often shown with bat-like wings. In Greek mythology, bats were associated with the Underworld and in Mayan culture the bat was a god of death. There are various persistent myths about bats including the notion that they attack the hair of humans. Another misconception is that they are dirty but, in fact, bats are very clean animals and groom themselves and their young much as cats do.

Occasionally, bats are depicted in a positive way. In the ancient kingdom of Macedonia bats were considered to bring good luck, a belief that persists today in the Gypsy world. Similarly, in Poland and some Arabic cultures, bats are occasionally viewed as harbingers of good luck. In China, bats are sometimes interpreted as symbols of longevity and happiness. Bats are also sometimes used as heraldic emblems. The well-known comic-book and movie character ‘Batman’ is a superhero who fights rogues and baddies on behalf of society. Three U.S. states have an ‘official state bat’: Texas and Oklahoma have named the Mexican Free-Tailed Bat their state bat, and Virginia has dubbed the Virginia Big-Eared Bat as their state bat.

*Figure 10.* Creepy Halloween vintage (public domain) postcards featuring witches associating with bats. (a) Circulated in 1917. (b) Circulated in 1910.
‘Zoonotic transfer’ of infectious agents may occur directly to humans from a primary source such as bats, or through a secondary food animal source infected by the primary source. There is believed to be evidence that the current outbreak of COVID-19 can be traced to the Huanan Seafood Market in the city of Wuhan, capital of the Hubei province of China. There, numerous wild animals such as bats, marmots, venomous snakes and deer are on sale. It has been hypothesized that the novel coronavirus from bats infected unсанected animals and subsequently spread to humans. Critically endangered Malayan Pangolins (Manis javanica) were shown to harbour the virus and pangolins in general have been accused of being intermediate carriers of the novel coronavirus between bats and humans (Gross 2020). As previous experience has demonstrated, once suspected of being the source of a disease, the response often has been to systematically eliminate the animals considered guilty, regardless of how threatened the species are in nature. Bats are not really to blame for zoonotic diseases such as COVID-19 – humans are (Walsh and Cotovio 2020). The responsible approach is to reduce or eliminate intensive harvest and marketing of diminishing wild animal species from nature where alternative food sources are available. Regardless of campaigns to eliminate bats suspected of posing an immediate disease threat to people, the use of bats as food represents a survival risk for the rarer bat species (Mickleburgh, Waylen, and Racey 2009; Mildenstein, Tanshi, and Racey 2016).

Textbox 2. Alarmist reports about virus-carrying bats endanger conservation

The recent upsurge in bat-borne virus research has attracted substantial news coverage worldwide. A systematic review of virological literature revealed that bats were described as a major concern for public health in half of all studies (51%), and that their key role in delivering ecosystem services was disregarded in almost all studies (96%). Although research on zoonoses is of the utmost importance, biased framings of bats can undermine decades of conservation efforts. We urge researchers and science communicators to consider the conservation impacts of how research findings are presented to the public carefully, and, whenever possible, to highlight the ecological significance of bats, their dire conservation situation and their importance for human well-being.

− López-Baucells, Rocha, and Fernández-Llamazares (2018)

There is a well-established body of evidence indicating that people seldom protect, and often despise, or even kill, animals they fear. This makes bats exceptionally vulnerable. Throughout history, they have been objects of fear and hostility across many cultures, arguably due to their nocturnal and elusive behaviour. Also, biased media coverage has framed bats as exceptionally dangerous virus reservoirs, generating frightening headlines worldwide, that are jeopardizing decades of conservation progress.

− Tuttle (2017)

The potential of bats to transmit diseases represents a significant source of danger to humans, but current reporting tends to be alarmist, endangering conservation efforts (Textbox 2). Responsible reporting is particularly important in regard to rabies transmission by bats (Lu et al. 2016, 2017). Bats do pose dangers to humans, but humans are far more dangerous to bats.

Bats in North America are the victims of white-nose syndrome, a skin disease caused by the fungus Pseudogymnoascus destructans. ‘White-nose syndrome is the most devastating wildlife disease of mammals in recorded history’ (Bure and Moore 2019). The fungus grows about the muzzles and wings of bats while they hibernate. The emerging disease was first discovered in New York state in 2006, initially spread over eastern North America, and is currently expanding in North America (Hoyt et al. 2020). The fungus was introduced to North America from Europe, where its potential for expansion is undetermined (but it does seem that many Old World bats are resistant). White-nose syndrome has killed millions of bats in North America, wiping out most of the bats of some species in some regions. Three endangered species and one threatened species have been affected by the disease. People visiting bat caves may pick up the fungus on their clothes, and spread it.

There is evidence that bat fatalities occur at wind turbines because of ‘barotrauma’ – lung tissue damage (embolism) caused by rapid air-pressure reduction near moving turbine blades (Baerwald et al. 2008). ‘Collisions with wind turbines and white-nose syndrome are now the leading causes of reported multiple mortality events in bats’ (O’Shea et al. 2016).

About two dozen bat species have been evaluated as Critically Endangered (the highest level of threat defined by the International Union for the Conservation of Nature), about 50 as Endangered, 100 Vulnerable and 80 as Near Threatened, but more than half have not yet been evaluated (Taylor and Tuttle 2018).

Despite the dislike of many for bats, there are substantial numbers of people and organizations involved in bat conservation, at least in Western nations (Figure 11). ‘Bat gates’ which keep people out while allowing bats to enter and leave freely are now often installed at the entrance of caves housing large numbers of bats (Tobin and Chambers 2017). Disturbance of sleeping bats by people can be a substantial threat to them, as mothers may abandon their young, and rousing hibernating bats forces them to burn energy that they may need to survive winter. In addition to preserving natural roosting sites, there are efforts to promote bat welfare by providing artificial roosts (Figure 12).
Numerous small rodents are known as mice, but by far the most prominent is the common House Mouse, *Mus musculus*. This is sometimes called the ‘Field Mouse’ although many other species also have this name, especially any of the other approximately 40 species of the genus *Mus*. The House Mouse originated in the grasslands of Asia (northern India according to Boursot et al.)
and has spread around the world. It may have a more extensive range than any other mammal except *Homo sapiens* (MacKay and Specialist Group 2010). This species has become intimately associated with people (Boursot et al. 1993), negatively as a pest, and usefully as a domesticated pet and much more importantly as the laboratory mouse, serving as an experimental animal in biology, medicine, industry, and education.

The evolution and classification of the House Mouse has been extensively studied (Fox et al. 2007; Macholán et al. 2012). Its considerable degree of variation is indicated by Hardouin et al. (2015): ‘the more widely distributed populations are grouped into three different subspecies: *Mus musculus* in Eastern Europe, Central and North East Asia, *Mus musculus domesticus* in Northern Africa and Western Europe, and *Mus musculus castaneus* in South East Asia. These last two subspecies have further expanded in modern times to the Americas, Australia and Oceania. In addition, *Mus musculus molossinus*, a hybrid between *M. m. musculus* and *M. m. castaneus* found in Japan, is often considered as a subspecies on its own. Closer to the centre of the distribution, *Mus musculus gentilulus* has been identified in the eastern part of the Arabian peninsula on the basis of its mitochondrial DNA lineage while from the same type of data it has been shown that certain populations considered as *M. m. castaneus* in Iran, Pakistan and Afghanistan should probably be considered as belonging to further sub-specific groups. Moreover, another completely independent lineage has recently been identified on this basis in Nepal.’

Adult House Mice usually have bodies 6.5–10 cm long, with tails 5–10 cm long, and they generally weigh less than 20 g (range: about 12–30 g). Wild forms are usually dark (grey, light brown, or black) while domesticated mice are available in a variety of colours. House Mice breed prolifically, often reaching sexual maturity at 35 days, and bearing up to 10 litters of 4–7 in a year. Wild House Mice usually die within a year, but domesticated mice can live for 2 or more years (rarely as long as 6 years). A baby mouse is called a ‘pinky’, a male is a ‘buck’, and a female is a ‘doe’.

The ecology of House Mice has been extensively studied (Berry 1970). They thrive in and near buildings, in open fields, and in agricultural lands. Indeed, human-associated mice are much more successful than they are in wild areas remote from people. A House Mouse can squeeze through a hole as small as 1 cm in diameter, and so it easily enters homes. Mice often migrate from outdoor locations into buildings with the onset of cold weather in late fall, in search of warmth, food, and shelter. (Other species of mice, often termed ‘field mice’, often also behave similarly.) House Mice are quick runners (up to 13 km per hour), good climbers, jumpers, and swimmers. Mice prefer to be active at night, and mostly consume plant matter although they are omnivorous. Mice tend to nibble, eating small but frequent meals that can amount to as much as 20% of their body weight daily, and as a result they pass 50 or more fecal pellets per day (Witmer and Jojola 2006). Although mice are rarely observed in buildings, the droppings give away their presence. Mice obtain much of their water from their food, and can live on limited availability of water because of their ability to concentrate their urine.

**Harmful aspects**

Indoors, House Mice feed on food left unprotected by humans (Figure 13), degrading and contaminating domestic, agricultural, and commercial edible materials along with their packaging. Feces deposited by mice in buildings are a potential source of disease and also cause psychological stress. Mouse odour, especially from the urine of male mice, is remarkably persistent (Kwak et al. 2016). The teeth of mice grow continuously, facilitating gnawing and damaging wood, textiles, and insulation. Of particular concern, mice chewing on electrical wires represent a fire risk to buildings. Mice similarly damage communication wires, resulting in widespread shutdowns of computer-based systems. Mice are more common than rats, and cause significantly more damage to indoor property. Outdoors, mice damage many field crops especially grains and legumes, and also consume and contaminate livestock feed at animal production facilities. Occasionally in some regions, mice reach plague proportions, numbers sometimes exceeding 200,000 per hectare (Singleton and Redhead 1990).

House Mice and the fleas and other parasites that they carry transmit several diseases to humans, livestock, and pets, although other rodents are often more significant carriers. Mice can be sources of human diseases, such as leptospirosis, cryptosporidiosis, salmonellosis, streptobacillosis, murine typhus, rickettsial pox, and tularemia. However, unlike rats, they are not major carriers of the plague or of hemorrhagic fevers like hantavirus (Phifer-Rixey and Nachman 2015). For homeowners, a particular concern is that mouse feces can contain *Salmonella* bacteria causing food poisoning. Generally, the House Mouse is not an important source of infectious diseases affecting humans (Blackwell 1981).
Rodent control with toxins (especially rodenticides, designed to be consumed, but also fumigants and repellents; note Figure 14) is widely practiced, with unintended harm to innocent species. Most rodenticides sold over the counter are anticoagulants, which kill by interfering with normal blood clotting, causing the animals to die from internal bleeding. Anticoagulants are less effective against mice than against Norway Rats, and House Mice have evolved resistance against anticoagulants (Prescott et al. 2018). Mice baits are usually poisoned seeds or grains, and when discarded they are a threat to wild animals consuming them.

**Beneficial aspects**

The House Mouse is the world’s most frequently used vertebrate laboratory animal, due in large part to low cost, ease of maintenance and handling, and high reproductive rate (Berry 1981). In Britain (which compiles the best national statistics on animal usage) in 2018 about 1 million of 1.8 million experimental vertebrate animals were mice (Understanding Animal Research 2019). (Dogs, cats, horses, and primates have special protection under U.K. law, and can only be used experimentally with special justification.) Because of opposition to animal experimentation, most countries and organizations are reluctant to report accurate numbers of laboratory animals employed. Estimates of world annual usage of all vertebrate animals tend to range up to over 100 million vertebrates. However, if one were to extrapolate world usage just for mice, about 100 million experimental mice may be sacrificed annually.

Many standardized inbred and mutant strains are used in medical research (Figure 15), and genetically engineered strains are being produced to study and potentially cure inherited diseases in humans. The inevitable harm and pain inflicted on mice have been argued to be morally justified by the benefits to people (e.g. Baertschi and Gyger 2011). Scientific and medical experimentation on animals (especially mammals) is subject to national guidelines governing their welfare. The Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC; https://www.aalas.org/), is a private, non-profit organization promoting humane treatment of animals employed in science. People for the Ethical Treatment of Animals (PETA; https://www.peta.org/) is the largest animal rights organization in the world, and promotes the abandonment of animal usage. Ethical treatment of animals and ethical treatment of biodiversity are different areas but both require consideration of appropriate relationships between people and the rest of the living world.

‘Fancy mice’ (Figure 16), bred for docility and attractive colours, have been employed as pets for centuries, and most laboratory mice strains arose from fancy mice (Royer 2015). Domesticated mice termed ‘feeder mice’ are often sacrificed as a food source for carnivorous pets, especially snakes. Local animal cruelty laws may forbid feeding live mice (or other rodents) to snakes, and many but by no means all suppliers furnish only dead and frozen mice.

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**Figure 13.** Mice damaging food. Photo (public domain) from pxhere.
It seems strange to worry about the disappearance of animals many people consider pests. Nevertheless, dozens of mouse subspecies are going extinct around the world. For example, the Pacific pocket mouse is sitting on some of the most desirable coastal real estate in California. Fortunately, this little guy is protected by conservation regulations strong enough to deter developers from pursuing building projects in coastal lands worth millions of dollars, causing projects to be put on hold or completely shut down to insure the health and safety of its habitat.

– Thornton (2013)

Rodents are a hard sell when it comes to conservation. In most human cultures, rodents are generally viewed as vermin . . . Admittedly, rodents are in fact often pests, being guilty of damaging crops, pilfering stored grains, invading households, and spreading zoonoses . . . As a group, rodents face the same suite of threats to their welfare and existence as do other organisms. Paramount are habitat destruction, over-exploitation by humans, and disease. A new threat of unknown but potentially major influence is rapid global warming. Additionally, rodent conservation is hampered by indifference and complacency. The former is the result of a conservation focus on larger, more charismatic and generally familiar species, as well as residual negative attitudes towards rodents. The latter stems from the view that rodents are abundant, have high reproductive rates, widespread distributions, and are adaptable. Therefore, they can take care of themselves, or so it is thought.

– Lidicker (2007)
Mice are such an ubiquitous pest that it is odd to consider that some unique wild kinds are in danger of extinction (Textbox 3; Figure 17). Nevertheless, conservation of rodents, which make up 40% of all mammal species, is a difficult undertaking (Textbox 4).

Conservation of mice is complicated by distinctly ambivalent attitudes towards them. Of course, the harm that they do as pests and their potential to carry diseases generate hostility. Moreover, some people seem to be born with, or develop early in their lives,
a pathological fear of mice, a psychological condition termed musophobia (murophobia is fear of rats and mice; Figure 18). Fear of mice tends to be associated with fear of rats. Animal phobias tend to be considerably more common in women than in men (see discussions in the sections dealing with frogs and toads in Small 2020, and spiders in Small 2019).

In a more favourable vein, mice have been associated with respected religious and mythological figures (Powell 1929; Festing and Lovell 1981) (Figure 19), and have often been treated kindly in literature for children (Figure 20), notably in Beatrix Potter’s books (Figure 21). The conflict between mice and cats has been a favourite theme in stories for young people, most memorably between the comic characters ‘Tom’ (the cat) and ‘Jerry’ (the mouse) (note Figure 22). ‘Micky Mouse’ and ‘Mighty Mouse’ are familiar, heroic cartoon characters.

In some regions of the world, invasive House Mice have seriously endangered native wild species. Introduced House Mice are a particular threat to the native flora and fauna of islands, where the biota has not adapted to them, especially seabird nestlings (Cuthbert and Hilton 2004; Wanless et al. 2007; Angel, Wanless, and Cooper 2009). Mice have been eliminated from some islands, but they are harder to remove than rats (MacKay, Russell, and Murphy 2007).

**Hyenas**

Living hyenas (occasionally spelled hyaenas) include four species constituting the family Hyaenidae. Within the hyena family, the Brown Hyena is genetically most related to the Striped Hyena. The Aardwolf is not a wolf, and is considered to be a ‘hyena’ although its lifestyle is divergent. Despite their dog-like appearance, hyenas are more closely related to cats (Smith and Holekamp 2019). Hyenas are among the leading carnivores of Africa (Figure 23).

The Spotted Hyena (*Crocuta crocuta*; Figure 24) is the largest living hyena species. It is also known as Laughing Hyena, and indeed is the hyena that ‘laughs’ (Brottman 2012). The females on average are about 10% larger, and much more aggressive than the males, dominate them, and lead the clans (Watts and Holekamp 2007). The biggest specimens weigh over 70 kg and can be almost 1 m tall at the shoulder. The species is widespread but fragmented over sub-Saharan Africa, especially East and southern Africa. It was once common in Eurasia. Spotted Hyenas are the most social of hyenas, occurring in groups sometimes exceeding 100, and they are the most successful and frequent of the large African carnivores. Although they scavenge, at least half of their food is obtained by hunting, contrary to the depiction in the popular and influential Disney film *The Lion King*. Indeed, Spotted Hyenas compete fairly successfully against the African
Lion (Kruuk 1972). Spotted Hyenas have powerfully muscled jaws (possibly the strongest of any living mammal) with enlarged premolars enabling them to shear and crush even the largest bones. Their highly acidic stomachs facilitate digestion of bones, horns, and teeth that competing carnivores cannot use. The same is true for Striped and Brown Hyenas (Smith and Holekamp 2019). ’By virtue of their size and abundance, Spotted Hyenas are among the most significant predators on the African Savannah. In terms of tonnage of meat consumed, they are, perhaps, the most significant terrestrial carnivore on the planet’ (Glickman 1995). Spotted Hyenas are keystone predators in many African ecosystems, i.e. they have a predominant influence on the balance of species (Trinkela 2009). In much of Africa where Lions are not present, they are the apex predator.

The Striped Hyena (Hyaena hyaena, also known as the Barbary Hyena; Figure 25) is the smallest ‘hyena’ species (if one excludes the Aardwolf), adults averaging about 35 kg, but sometimes weighing a much as 55 kg. Striped Hyenas are indigenous to North and East Africa, the Middle East, the Caucasus, Central Asia, and the Indian subcontinent. They rarely form small packs, but mated pairs cooperate to raise their cubs. The species is mostly a nocturnal scavenger. Like skunks, when threatened they spray a noxious liquid from their anal glands.

The Brown Hyena (Parahyaena brunnea, Figure 26; it is also called Strandwolf, a reference to the frequency of the species in the Strand of the Western Cape of South Africa) is the rarest species (Eaton 1976), occurring only in southernmost Africa (Namibia, Botswana, Zimbabwe, Mozambique, and South Africa). It is...

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**Figure 18.** Musophobia (fear of mice), shown in a children’s book illustration (1898, public domain) titled ‘Three blind mice’. Credit: New York Public Library Digital Collections.
adapted to desert and semi-desert areas and open woodland savannahs, and survives near urban areas by scavenging. Indeed, Brown Hyenas are mostly scavengers. Adults weigh about 40 kg, the males slightly larger than the females. Like wolves, they live in small clans made up of a mated pair and their offspring.

The Aardwolf (*Proteles cristata*; Figure 27) looks like a small hyena, usually weighing 7–10 kg and having a height at the shoulder of 40–50 cm. The name ‘Aardwolf’ means earth-wolf in Afrikaans. The Aardwolf has been placed in its own sub-family, *Protelinae*, the other three species in sub-family *Hyaeninae*. Unlike their hyena relatives, they do not kill or scavenge large animals although they have sometimes been accused of eating corpses. The cheek teeth of Aardwolves are specialized for eating harvester termites, especially of the genus *Trinervitermes*. Unlike Aardvarks which dig into termite mounds, Aardwolves lick termites off the ground with their long sticky tongues, and can consume up to 250,000 termites in a night. Aardwolves are found in two regions: Southern Africa, and in East and Northeast Africa. They are restricted to

![Figure 19. Lord Ganesha, elephant-headed Hindu deity, mounted on his giant mouse (also often said to be a rat). Subduing the mouse by riding it symbolizes control over the rodent's destructive tendencies. Bazaar art (public domain) from India, 1910.](image-url)
Figure 20. Anthropomorphic illustrations (public domain) in a children’s book. Source: Coloma, Moreton, and Vyse (1914).

Figure 21. Examples of Beatrix Potter’s illustrations (public domain) for children’s books.

Figure 22. Early twentieth-century postcard (public domain) showing cat dining with mice. The French artist, Maurice Boulanger, was known for cute and funny anthropomorphic cats.
these regions where their food – termites of the family Hodotermitidae – occur. Like the Striped Hyena, threatened Aardwolves can spray a noxious liquid from their anal glands. Also like Striped Hyenas, they are mostly nocturnal, and live as monogamous pairs along with their young.

In prehistoric times, there were many species of hyenas the largest of which was the Giant Short-faced Hyena (*Pachycrocuta breviostris*; Figure 28), some individuals reaching over 1 m at the shoulder and weighing well over 100 kg (Turner and Antón 1996). The species arose about 3 million years ago, spread across Eurasia and Africa, and became extinct about 400,000 years ago.

![Figure 23. The dominant large predators of Africa. Artwork by M. Antón in Turner and Antón (2006) (CC BY 4.0).](image)

**Figure 23.** The dominant large predators of Africa. Artwork by M. Antón in Turner and Antón (2006) (CC BY 4.0).

**Figure 24.** Spotted Hyena (*Crocuta crocuta*). Photo by Charles J. Sharp (CC BY SA 4.0).

**Harmful aspects**

During periods of extreme stress (war, famine, disease) there has been extensive predation on weakened and unprotected people by hyenas (Gade 2006). Today, ‘Spotted hyenas and humans often come into conflict where they coexist in the landscape. Usually the conflicts involve hyena predation on livestock and retaliatory killings by humans; however, direct attacks on humans by rabid or otherwise healthy hyenas do occur’ (Baynes-Rock 2013). Hyenas significantly attack livestock in Africa but protective measures are usually effective (Gade 2006). In parts of Africa, Spotted Hyenas have adapted to infiltrating cities, scavenging garbage,
preying on feral dogs and cats, eating human corpses, and posing a potential danger to children and homeless people (Gade 2006). Hyenas can also vector diseases of humans and livestock, but this is not considered a notable danger.

**Beneficial aspects**

Like most carnivores, hyenas play important roles in regulating the balance of their prey in relation to other animals in ecosystems. Carnivores usually catch weaker prey (especially very young, old, or sick animals) which
tends to leave the strongest and fittest individuals. Like other scavengers, hyenas also contribute to the recycling of energy in ecosystems, and to the prevention of accumulating corpses that can contribute to diseases. Hyenas are capable of consuming carrion in advanced decomposition because of their resistant immune

Figure 27. Aardwolf (Proteles cristata). Photo by Greg Hume (CC BY SA 3.0).

Figure 28. Drawing of restoration of the extinct Giant Short-faced Hyena (Pachycrocuta brevirostris) by Mariomassone (CC BY SA 4.0), in comparison to a human (added by B. Brookes).
system and very strong digestive system, so they can survive the presence of infectious agents like anthrax that could be deadly to other species. Referring to Spotted Hyenas in the Horn of Africa, Gade (2006) stated that they are ‘tolerated as efficient sanitation units’ for their roles in removing garbage and carrion from towns, notably reducing rodents, flies, and bad odours.

Hyenas are attractions in zoos (but see Textbox 5). Rarely, they have been kept as pets. In ancient Egypt, it appears that hyenas were artificially fattened as food (Zeuner 1963). Under Islamic law, the meat of hyenas is considered halal (acceptable for consumption), and in areas of North Africa, the Middle East, Iran, and Pakistan, hyena meat has become popular (Tubei 2019).

Conservation aspects

The International Union for Conservation of Nature currently assesses the Spotted Hyena and Aardwolf as ‘Least Concern’, although Spotted Hyenas have become locally extinct in parts of Africa. Habitat loss and widespread hunting have downgraded the assessments of the Striped and Brown Hyenas to ‘Near-threatened’. Humans and Lions cause most adult hyena mortality (Smith and Holekamp 2019). Spotted Hyenas are the largest of the hyenas, and when harvested for trophies hunters seek the largest, which will usually be the dominant breeding alpha females, thereby removing some of the superior genes and leadership of the clan.

The Striped Hyena (Figure 29) is at risk. ‘In some parts of its global distribution range, striped hyenas are considered as critically endangered ... the striped hyena is already extinct in many localities ... Populations are generally declining throughout their geographical range due to persecution, poisoning, and hunting for meat or medicinal purposes’ (Alam, Khan, and Pathak 2015).

The Brown Hyena is particularly at risk. ‘Despite its listing as Near Threatened, Brown Hyenas continue to be persecuted, often considered as problem animals by farmers or killed for trophy hunting. Incidental and often deliberate poisoning, shooting, and trapping of these animals all hamper the survival of this ecologically important species’ (Westbury et al. 2018).

Hyenas, particularly the Spotted Hyena, are mostly viewed negatively in Western culture, where they are considered to be dangerous, vicious, ugly, cowardly, and treacherous (Gould 1981; Glickman 1995). They are invariably depicted in a bad light in movies and cartoons, often as evil, deceitful bullies. Hyenas are also viewed negatively to a considerable extent in African tradition – often characterized as dull-witted despite it being known that they are cunning and dangerous

Figure 29. Striped Hyena (Hyaena hyaena, at left) and Spotted Hyena (Crocuta crocuta, at right), the two species that are least threatened at present. Lithograph (public domain image) designed by Friedrich Specht (1839–1909) in 1878 and printed by Leipziger Schulbilderverlag von F. E. Wachsmuth, Leipzig.
predators (Crandall 2002). In North African folklore the ‘werehyena’ was equivalent to a werewolf. In Middle Eastern literature and folklore, Striped Hyenas were often viewed as symbols of treachery and stupidity. The extensive historical and modern vilification of hyenas makes it extremely difficult to enact conservation measures for them (Textbox 5).

Textbox 5. Hyena conservation is penalized by their bad reputation

Spotted hyenas, or their immediate relatives, the brown and striped hyenas, are rarely found in zoological parks … this serious miscarriage of biological justice can be traced to the poor public reputation of the hyena. There are no ‘save-the-hyenas’ committees, and their persistent public relations problems could have very serious consequences for the preservation of hyena habitats and the long-term prospects for these species.

– Glickman (1995)

Hyenas inspire horror in people … in people’s minds, hyenas are inexorably linked with garbage cans, corpses, feces, bad smells, and hideous cackles. Indeed, in places hyenas subsist on the refuse of human society, and that side of their behaviour is, of course, most often noticed.

– Kruuk (1972)

We have always imagined the hyena to be involved with dead bodies, and, as a result, we have convinced ourselves that hyenas are vile, horrible creatures. In mythology and magic, they have been associated with putrefaction and the macabre, with waste and disease. The hyena is the totem animal of the outcast and the taboo, lurking in wastelands, laughing and scavenging. We think about hyenas this way because it is easy to do so, and because we need to have our villains, even in the animal world. But these imagined creatures, almost universally feared and reviled, are a product of human culture, not of nature.

– Brottman (2012)

An illustration of the bad light in which hyenas have been shown is the story of ‘The Beast of Gévaudan’, described as a man-eating animal which terrorized the former province of Gévaudan, France, allegedly killing hundreds of people between 1764 and 1767. It is not possible today to determine how much of the story is true, and what was the actual cause of the killings at the time, but one popular theory was that a hyena was responsible – perhaps one that had escaped from a zoo (Figure 30).

By analogy with humans, scavengers are interpreted as cowards who would rather steal meals from more successful predators than hunt or kill their own prey. Scavengers are also often associated with gluttony, uncleanness, and disease. While the scavenger stereotype is inaccurate for Spotted Hyenas, it is at least somewhat applicable to Striped and Brown Hyenas. As discussed for vultures (Small 2020), although scavengers are not admired by humans, they play indispensable roles in ecosystem functioning.

For over a thousand years, records indicate great concern about the role of hyenas as graverobbers of human corpses. Hyenas are able to locate buried bodies and dig them up and, in areas where hyenas are indigenous, care is often taken to prevent them from accessing dead bodies. In Moslem areas of Africa and the Middle East, walls are often built around cemeteries. In times of war, epidemics, and famine, consumption of bodies by hyenas has been widespread (Gade 2006). Consuming dead bodies is one of the natural ecological roles of hyenas, but when they do so in graveyards they greatly offend humans, and make it extremely difficult to sympathize with their welfare.

Spotted Hyenas are often disturbingly noisy, sometimes emitting bloodcurdling howls or, more often, maniacal laughs or demented giggles which can seem remarkably human-like. Although these sounds seem sinister and distressful to many, it should be noted that Spotted Hyenas have a large repertoire of calls that serve for communication among the numerous members of the clan.

Still another odd feature of hyenas is their stubby hind legs, which seem disproportionately short, and gives their bodies a curious sloping appearance. However, while the resulting gait seems awkwardly lumbering, it appears to increase energy efficiency, allowing the animals to lope easily. Unfortunately for hyenas, the movements makes them appear as if they are skulking, further adding to their reputation as deceitful. As pointed out by Glickman (1995), ‘Bears also have short hindlegs and [this] has not prevented them from being adopted as positive cultural icons in the form of children’s toys’.

‘Sexual mimicry’ is one sex mimicking the opposite sex in behaviour, appearance, or chemical signalling. It is frequent in invertebrate species, but rare in vertebrates. An extreme form of sexual mimicry occurs in Spotted Hyenas. Female Spotted Hyenas are notorious for having a ‘pseudopenis’ – a clitoris that is large, elongated, erectile and looks like the male penis when erect. In place of a separate vagina and urethra, the pseudopenis contains a single urogenital canal used to urinate, have sex, and deliver babies – a unique anatomy among female mammals. (In addition, the outer labia are fused and filled with tissue, taking the form of a ‘pseudoscrotum’ resembling the male’s scrotum.) This odd anatomy led to the false interpretation, persistent to this day, that Spotted Hyenas are hermaphrodites. The possible adaptive advantages to Spotted Hyenas are unclear (Gould 1981; Muller and Wrangham 2002), but it is certainly disadvantageous to their reputation, contributing to their image as extremely deviant.
Hyenas have often been accused of smelling bad, but since they often feed on decaying carcases this might be inevitable. Like many other animals, hyenas also sometimes roll in smelly materials for social interaction motives. Additionally, hyenas produce pungent anal gland secretions called ‘hyena butter’ which they employ to mark their territories.

Hyenas have been hunted for body parts employed in traditional medicine (Frembgen 1998), of doubtful efficacy that, unfortunately, is paralleled by similar persecution of many other animals. Hyenas have also been hunted for sport (Figure 31), but rarely, because they are not considered suitable for attractive trophies.

In modern times, hyenas are particularly attracted to road-kill with the result that they themselves become traffic victims (Brottman 2012). In areas of war, many Striped Hyenas have been killed by land mines (Brottman 2012).

It is ironic that hyenas are viewed as much less worthy of conservation than their distant cousins, the iconic, charismatic big cats of Africa, with which they compete (Figure 32). Lions, especially well-maned specimens, are frequently depicted at rest in noble poses, while hyenas are typically shown looking quite vicious (Figure 33). In fact, Lions are at least as savage as hyenas, and just as willing to scavenge, but are fortunate in being far more appealing to the esthetic senses of humans.

Rats

Although many species (mostly rodents) have ‘rat’ in their name, ‘true rats’ are members of the genus Rattus. Musser and Carleton (2005) recognized 66 species in the genus. Rattus is the largest genus of mammals (Feng and Himsworth 2014), and is arguably among the most complex and least understood of all mammalian genera (Pagès et al. 2010). True rats are native to southeast Asia, Australia, and nearby islands. Most true rats live in forests or near water, often constructing nests or burrows. Many species live in groups. In nature, rats feed on plants (especially seeds), insects, and sometimes other small animals. Male rats are termed bucks, virgin females are does, pregnant and mother females are dams, infants are kittens or pups, and a group of rats is a mischief.

Some rats, the so-called ‘common rats’, have become associated with humans, and indeed are considered to be the world’s most successful mammals, with the
Figure 31. Old French trade card (public domain) showing Striped Hyena being hunted in North Africa.

Figure 32. Competition of hyenas and African big cats. (a) Brown Hyena stealing a Springbok from Cheetahs, in South Africa. Photo by Derek Keats (CC BY 2.0). (b) Museum diorama showing Spotted Hyenas attempting to rob Lions of their killed Zebra. Credit (public domain photo): Bruce Emmerling, Pixabay.com.
House Mouse in second place. Several books have been written detailing the historical and economic associations of rats and humans (Twigg 1975; Hendrickson 1983; Hodgson 1997; Barnett 2001; Sullivan 2004; Langton 2006). Common rats are omnivorous, have a very high reproductive rate, are extremely adaptable, and these characteristics assist them to colonize new locations and habitats made available by humans. In terms of their importance to humans, the most significant species are the Black Rat and the Brown Rat (Figure 34), discussed in detail here. Several other species are also noteworthy pests. The Asian Black Rat (R. tanezumi), like the Black and Brown Rats, has colonized urban ecosystems globally for centuries. Another invasive species, the Pacific or Polynesian Rat (R. exulans), is limited to tropical Asia-Pacific areas (Invasive Species Specialist Group 2014a; Kosoy et al. 2015). It is a major agricultural and environmental pest in parts of Southeast Asia and the Pacific (Invasive Species Specialist Group 2014a). The Himalayan Field Rat (R. nitidus) and Turkestan Rat (R. turkestanicus) are pests in southern and central Asia.

The word ‘commensal’ (a noun and an adjective) is used in a general sense to refer to relationships in which one species benefits without harming or helping its host. An often cited example is Remora fish attaching to sharks, the former benefitting by eating scraps from the latter’s kills, while not significantly harming the sharks. A second sense of ‘commensal’ is simply an intimate relationship between two species, such as between the rats discussed here and humans. Common rats are frequently called commensals. Since the first meaning is based on no harm occurring to either species, while the second meaning is based on considerable harm to one of the species (humans): the word ‘commensal’ is problematic.

The Brown Rat (R. norvegicus; Figure 35), has also been called Barn Rat, Common Rat, Gray Rat, Hanover Rat, House Rat, Norway Rat (the most frequent alternative name), Norwegian Rat, Parisian Rat, Sewer Rat, Street Rat, Water Rat, and Wharf Rat. (When humans have so many names for just one species, it is a clear indication of its importance.) The Brown Rat is believed to have originated in northern China. ‘Norway rats (Rattus norvegicus) possess the most extensive geographic range of any terrestrial mammal . . . Wherever they have been introduced, their extraordinary capacity for adaptation and procreation distinguish them as one of, if not the most, successful of vertebrate invasive species’ (Porter et al. 2015). The species is brown or grey, up to 28 cm long excluding the tail which is slightly shorter. Wild rats weigh 140–500 g while some domesticated strains range up to 1 kg.

The Black Rat (R. rattus; Figure 36) has also been called Blue Rat, European House Rat, Gray Rat, Old English Rat, Roof Rat, and Ship Rat. It is a native of the Indian sub-continent. The species may be grey-
brown on the back with either a similarly coloured or creamy-white belly, or it may be black all over. It is slender, and has large hairless ears. The animal usually weighs 120–160 g, occasionally over 200 g. There are genetically distinctive forms of Black Rat, which are sometimes recognized as different species (Musser and Carleton 2005; Robins et al. 2007; Pagès et al. 2010).
The Black Rat is lighter and has a shorter head–body length (excluding tail) than the Brown Rat. Its tail is much longer than its head–body length and is uniformly coloured. The tail of the Brown Rat is clearly shorter than its head–body length, and it has a pale underside. The upper side of the hind foot of the Black rat is usually dark, whereas it is always completely pale in the Brown Rat. The Black Rat is a very agile and frequent climber, rarely burrows, nests mainly in trees and shrubs and swims infrequently. The Brown Rat burrows extensively, nests underground and is a strong swimmer. It also climbs much less frequently. On continents and large islands (such as the U.K.) the Brown Rat is more closely associated with humans and it is dominant over other introduced rats. However, on oceanic islands (such as New Zealand) where it is free-living in forests and wetlands, Black Rats are dominant. Black Rats are also most abundant in coastal areas and in the tropics while Norway Rats prefer temperate climates. Although Black and Brown Rats inhabit both rural and urban areas, Black Rats are more successful in the former, Brown Rats in the latter. As feral (i.e. free-living outside of its native area) species, Black and Brown Rats rarely live for as long as 1 year although under human care they can live for several years (very rarely 6 years).

**Harmful aspects**

**Textbox 6. The dangers from rats**

The presence of urban Norway and black rats (*Rattus norvegicus* and *Rattus rattus*) is an important and growing issue in cities globally due to their associated health and economic impacts. For example, rats pose a risk to public health as they are the source of a variety of zoonotic pathogens (disease-causing microbes transmissible from rats to people, e.g. *Leptospira interrogans*) responsible for significant human morbidity and mortality. Infestations can also serve as a chronic stressor, impacting both the mental and physical health of residents. Rats also damage urban infrastructure (due to chewing and burrowing activities) and contaminate foodstuffs. Finally, infestations can result in substantial economic losses, both directly (i.e. costs associated with rat control), and indirectly (i.e. costs associated with mitigating and repairing rat-associated damage). Given rapid urbanization, these issues are likely to increase in future; 55% of the world’s population resides in cities, with a projected increase to 68% by 2050. Much of this growth will occur in developing regions where rat-associated risks are higher due to issues of inadequate housing, infrastructure, and sanitation.

Byers et al. (2019)

Rats are agile; capable of impressive jumping, climbing, and swimming. They are intelligent, inquisitive, courageous, adapt rapidly to different situations, and breed prolifically. From a human viewpoint, they are talented – indeed dangerous competitors (Textbox 6). Very extensive efforts have been made to eliminate rats from many locations, but rarely with complete success (Figure 37).

Most rat species are of limited concern in their indigenous areas, but will take advantage of crops grown locally. Some rats are agricultural pests, especially of grain crops, and they consume and contaminate considerable stored foods by depositing saliva, urine, and feces on them. ‘The primary economic impact of *R. rattus* relates to agricultural and horticultural damage. It is capable of destroying up to 30% of crops annually [see Figure 38]. Of the 60 or more species in the genus *Rattus*, *R. rattus* is likely to be the most damaging to agricultural crops globally’ (Invasive Species Specialist Group 2013). The Brown Rat is also a major pest of both rural and urban areas (Invasive Species Specialist Group 2014b).

Rats are serious vectors of infections such as typhus, salmonella, Lyme disease, leptospirosis, hantavirus, and bubonic plague (Himsworth et al. 2013; Kosoy et al. 2015; Strand and Lundkvist 2019), and they transfer diseases to wildlife, livestock, and pets as well as humans. The Black Rat is generally credited with having carried fleas that vectored the bacterium *Yersinia pestis* which caused the devastating Black Death in Europe (1346–1353), but there is evidence that other disease carriers were responsible (Dean et al. 2018). Nevertheless, it is disquieting that both Black and Brown Rats are capable of transmitting *Yersinia pestis*, which is commonly present in rat populations of Africa, southeast Asia and South America. Bacterial infections can spread from rats to humans via rat bites, contact with the animal’s urine, and by fleas. Rats are also an important source of bacteria resistant to antimicrobial medicines which, accordingly, make humans more susceptible. Brown Rats are the primary reservoir of Seoul virus, which causes a hemorrhagic fever in humans.

In houses, rats cause fires and electrical interruptions by gnawing electrical wires. By cutting cables, rats interfere with communications. Using their constantly growing rodent teeth, they can even burst metal water pipes. Rats also cause structural damage to premises and ruin household contents by chewing. Outdoors, their burrowing impairs sewers, damages the banks of irrigation canals and levees, undermines building foundations and slabs, causes settling in roads and railroad track beds, and even endangers dams.

Rats threatened by humans or pets defend themselves by biting and rats sometimes attack sleeping people, especially very young children. Reports of mutilation
of babies by rats receive sensational media coverage, reminiscent of how rare shark attacks on people generate morbid interest.

In cities, rat control relies heavily on the use of poisons (Parsons et al. 2017) which are potentially harmful to humans and biodiversity. Unfortunately, resistance to rodenticides has become substantial (Buckle 2013; Prescott et al. 2018). The term ‘super rat’ has been applied to rats that have become immune to conventional anticoagulant poisons.

Starting in the early 2000s, car manufacturers began using soy-based materials for insulation for wiring in cars, to reduce dependency on petroleum and to save money. This led to complaints that rodents, mainly rats, were being attracted to consume the insulation and so to damage the cars. In recent years, a half-dozen class-action lawsuits were filed against auto manufacturers. However, the evidence isn’t conclusive and to date judges have sided with the companies (Brulliard 2020).

**Beneficial aspects**

Rats have been employed for entertainment for centuries, often in circuses in which they were trained to conduct acrobatic acts (Hedrich 2006). More cruelly, rat-baiting contests in which dogs killed large numbers...
were widespread in Europe and North America until the nineteenth century. Some strains of Brown Rats (often called ‘fancy rats’) have been bred to be raised as pets (Figure 39). The Brown Rat is also the principal laboratory rat (Modlinska and Pisula 2020). Wild and Black Rats are also occasionally employed in research, but not infrequently scientific papers from Asia have incorrectly identified their research subject as the Black Rat (Hulin and Quinn 2006). About 90% of vertebrate animals employed in laboratory procedures are mice and rats. After mice, the rat is the most common laboratory animal sacrificed in biomedical research and testing. Several strains of Brown Rats have been bred specifically for medical research into human diseases (Figure 40). Carbone (2004) estimated that in the United States alone, 80,000,000 mice and rats (collectively) were used for experimentation in 2001. The concern in this review is primarily about conservation of the world’s biota, not moral aspects of animal welfare. Nevertheless, physically harming enormous numbers of animals to benefit humans is an issue that, even when judged to be necessary and ethical, should be re-examined
regularly in the hope of reducing or even eliminating the practice. For a sympathetic guide to the care of lab animals, see Liss et al. (2015).

Numerous mammals, birds and reptiles are predators of rats and for many they are an important staple. In addition, rats are a significant source of nutrition for people in many Third-World nations, where they are hunted and consumed widely. In times of famine in Europe, rats were widely employed as food (Hedrich 2006). Nevertheless, some religions (notably Judaism and Islam) forbid the consumption of rat meat, and in most of the Western World rats are not considered a socially acceptable food. Rat fur is employed in garments to a small degree, although so-called rat fur is likely to be from Nutria (Myocastor coypus) or some other rodent. Although rats are generally harmful to plants, sometimes they serve as distributors of seeds so that the plants can establish in new areas.

Conservation aspects

Textbox 7. Rat threat to seabirds

The current crisis of global biodiversity loss and species extinctions requires the urgent implementation of long-term conservation actions. Among birds, colonial breeding seabirds are most threatened. Indeed, out of the 346 species of seabirds in the world, 28% are listed as threatened and 10% as Near-Threatened. Seabirds are threatened by a combination of interlinked factors, most notably competition with the fishing industry, climate change, degradation of breeding sites, and egg/chick predation by introduced species. On oceanic islands and archipelagos the most serious threat to colonial seabirds is often the introduction of non-native species. Invasive rodents have probably had the largest impact on seabird populations and occur on over 90% of all islands worldwide. Seabird breeding colonies are particularly vulnerable to rats because most species nest on the ground or in burrows, and chicks are poorly adapted to escape from predators. Rats have been observed to prey on seabird eggs, chicks, and adults, and are estimated to be directly or indirectly responsible for 42% of bird extinctions on islands.

– Sarmento et al. (2014)

As pointed out in the treatment of the House Mouse, it is difficult to find support for rodent conservation in general, despite rodents making up 40% of all mammal species. The generally unsavoury reputation of rats makes it hard to sympathize with numerous other rodent species that are not significantly harmful to people, especially the many species with ‘rat’ in their name.

In their native habitats rats serve useful ecological roles, but when introduced in foreign locations they can devastate wildlife by competing for the same resources, introducing diseases, and simply killing native species. Rats introduced around the world by seagoing vessels have been extremely harmful to biodiversity. Over 80% of the world’s oceanic islands have been invaded by rats, which have devastated some of the endemic species (Russell, Towns, and Clout 2008). Indeed, they can greatly degrade and modify island ecosystems (Banks and Hughes 2012). ‘Removing invasive rats from Islands is a powerful conservation tool’ (Howald et al. 2010). Rats have been especially harmful to birds on islands (Textbox 7) where they have preyed on eggs and contributed to seabird extinction and endangerment (Jones et al. 2008). Invasive rats are not only harmful to animals but also to native plants which they reduce by eating seeds and seedlings. Ironically, foreign rats particularly endanger the survival of their rodent relatives when they invade their indigenous areas. While certain species of Rattus are a threat to biodiversity, The IUCN Red List of Threatened Species shows that several other species of the genus are threatened, and two have become extinct (https://www.iucnredlist.org/search?query=rattus&searchType=species; Figure 41).

If there ever was an animal with a reputation in desperate need of rehabilitation it is the rat. The word rat is often used as a slang pejorative indicating an unscrupulous, despicable, contemptible character, a liar, double-crosser, or hateful person. Among criminals, a rat is a person who betrays fellow criminals by providing information to the police (less kindly expressed: the lowest form of human being – a backstabbing snitch). Strikebreakers are sometimes called rats. Another informal meaning is a person who deserts his party, side, or cause. ‘To smell a rat’ is to suspect something is wrong in a particular situation. The expression ‘rats’ is an exclamation of disappointment, disgust, or disbelief.

Rat stories are also often rather negative in tone. ‘The Pied Piper of Hamelin’ is an ancient, well-known tale featuring a rat-catcher who, after being refused payment for leading away a town’s rats using enchanted music, leads away the town’s children (Figure 42). Cartoon and movie depictions of rats are also usually uncomplimentary, especially compared to mice, which are often shown in attractive poses. Nevertheless, rats are sometimes shown sympathetically (Figure 43).

Murophobia is fear of rats and mice (musophobia is fear of mice). Fear of rats tends to be associated with fear of mice. Animal phobias tend to be considerably more common in women than in men (see discussion in the sections dealing with mice; and for frogs and snakes in Small 2020). Phobic fears of classes of animals are not only harmful to people with such fears, they also harm the target organisms by reducing sympathy for their survival.
Despite the very negative regard for rats by most people, they are respected or considered useful in some places. The Karni Mata Temple in Rajasthan, India, also known as the ‘Temple of Rats’, is a Hindu shrine dedicated to worship of up to 25,000 Black Rats that are maintained there (Figure 44). The Chinese Zodiac is based on 12 animals, which are sequentially associated with a Chinese calendar, the first year of which is the rat. 2020 is a year of the rat. Clearly, the culture in which one is born has a determining effect on attitudes towards particular animals. As discussed in Small (2019), once prejudices against particular species are acquired they are extremely difficult to modify: the most efficient way of doing so is to educate the young
about their admirable qualities. As noted in Figure 45, children are quite capable of establishing respectful, indeed even loving relationships with rats.

**Skunks**

Numerous plants and animals produce chemicals that attract (e.g. sex hormones often cause animals of one sex to seek the opposite sex; floral odours draw in pollinators). Conversely, many species produce repellent chemicals for self-defence. A few have perfected the ability to project a harmful liquid to protect themselves. For example, the hundreds of species of bombardier beetles eject a hot noxious chemical spray from the tip of their abdomen, which can kill attacking insects. Spitting cobras (mostly species of *Naja*), true to their name, project toxic chemicals into the eyes of creatures that threaten them. The most well-known animal that launches noxious repellent chemicals is the skunk. The awful odour associated with skunks is primarily responsible for their demonization by humans (Miller 2015).

There are 10 living species of skunks, placed in three genera: *Conopatus* (hog-nosed skunks, four species); *Mephitis* (the hooded and striped skunks, two species); and *Spilogale* (spotted skunks, four species). These are indigenous to the Americas, from Canada through central South America.

Related to skunks (and sometimes also called skunks) are two species of the genus *Mydaus*, known as stink badgers (optionally hyphenated as stink-badgers), which are found in Indonesia and the Philippines. The stink badgers resemble the American skunks, and also have the ability to spray extremely potent anal secretions, but before resorting to spraying they often first feign death. The most obvious external difference between stink badgers and skunks is that the former have short, pointed tails while skunks have bushy tails. The Palawan Stink Badger (*M. marchei*) reportedly can spray noxious liquid up to a metre, while the Sunda Stink Badger (*M. javanensis*) (Figure 46) is limited to about 15 cm. As noted later, the North American skunks have longer ranges.

Skunks and stink badgers constitute the mammal family Mephitidae. Skunks were previously considered to be in the weasel family (Mustelidae, which includes weasels, otters, badgers, and others) but DNA research indicated that they warrant separate recognition, and as a result they were placed in the Mephitidae (Dragoo and Honeycutt 1997).

Most skunks are the size of house cats. The species vary in total length (including tails) from about 40 to 95 cm. The smallest, the spotted skunks, may be only 0.5 kg in weight, while the largest, the hog-nosed skunks, may weigh over 8 kg. Their short legs do not allow skunks to run away rapidly from predators, and they move at a deliberate waddle-like walk, slow trot, or clumsy gallop. Skunks seem placid, sluggish, and unconcerned about predators, which is understandable given their formidable defence system. Most skunks are black and white; so are numerous other mammals, including Giant Pandas, Killer Whales, Zebras, and hundreds more – a phenomenon which may have several explanations (Daly 2017).

The claws of a skunk’s forefeet are long, curved, and sharp (Figure 47), well-adapted to digging, and skunks often unearth soil-dwelling creatures. While they sometimes excavate their own tunnels, skunks generally den in burrows of other animals, rock crevices, brush piles, or spaces under buildings. Skunks occur in agricultural areas, deserts, grasslands, open fields,
rocky or mountainous areas, and woodlands. They are primarily insectivores, but they eat a variety of other invertebrates such as spiders, crustaceans, and molluscs, vertebrates smaller than themselves such as toads, frogs, lizards, snakes, mice, chipmunks, rabbits, and eggs of birds and turtles, as well as fruits, nuts, roots, and leaves. Skunks are opportunistic feeders, strongly attracted to edible garbage, carrion, and food left for wild birds and pets by humans. They are adept at stealing honey from beehives as well as eating the bees. Skunks are nocturnal and during the winter they may rest periodically or enter a phase of lethargic sleep (torpor) without falling into a complete state of hibernation (skunks do not hibernate). For many skunks, sex must be rough to induce ovulation; male skunks may bite the female on the back of her neck, often drawing blood. A male skunk is called a buck, the female a doe and the baby a kit or kitten. A group of skunks is called a surfeit or a huddle, but most skunks (especially the males) are solitary.

The Striped Skunk (*Mephitis mephitis*; Figure 48a) is by far the most common species in North America (Fergus 2010). It occurs in all 48 contiguous states, southern Canada, and northern Mexico, from sea
level to timberline. The fur characteristically has a white strip that starts at the forehead and splits into a V shape along the skunk’s back. However, other patterns also occur (Verts 1967; Rosatte et al. 2010), and as in other skunk species, albino mutants arise. The Hooded Skunk (Mephitis macroura; Figure 48b) is similar to the striped skunk, but has longer and softer fur, and a longer tail. Some Hooded Skunks have a single, solid white stripe down their back from their forehead to the tip of their tail, some have two thin white stripes running down the side of the body from shoulder to stomach, and some have a combination of these two patterns. Both species stomp with their front feet to warn
animals they consider threatening before spraying; sometimes they try to spray fast-approaching cars and are killed. The spotted skunks (*Spilogale* species; Figure 49) do not actually have ‘spots’ on their back, but this appearance is due to a series of interrupted white lines. These
are the smallest members of the skunk family and the only ones that can climb trees (Figure), which they do frequently to hunt or avoid predators.

The hog-nosed skunks (Conepatus species; Figure 50) have elongated snouts which serve to extract bugs and grubs from the ground. These superb diggers have long, specialized claws and powerful forearms which they employ to dig dens and climb up rocky slopes. Hog-nosed skunks occur in the U.S., Mexico, and Central and South America.

Skunks are infamous for their ability to protect themselves from predators by projecting a foul-smelling thick oily liquid from their musk glands, one on either side of the end of the rectum, just inside the anus (the glands are correctly referred to as rectal glands, but are usually termed anal glands). These scent glands have nozzle-like ducts ending in nipples which protrude through the anus and can be aimed. The anal glands are operated by muscular action, and baby skunks as young as a week after birth may have some ability to expel smelly liquid. The irritating spray contains sulphur

Figure 48. Skunks of the genus Mephitis. (a) Striped Skunk (M. mephitis), from Audubon and Bachman (1851), plate XLII. (b) Hooded Skunk (M. macroura), from Audubon and Bachman (1854), plate CIi. These paintings are in the public domain.

Figure 49. Some spotted skunks (Spilogale species). (a) Eastern Spotted Skunk (S. putorius). This species occurs from southern Manitoba and Ontario in Canada through the eastern U.S. to northeastern Mexico. Public domain painting from Nelson (1918). (b) Island Spotted Skunk (S. gracilis amphiala), endemic to the two largest California Channel Islands, Santa Cruz and Santa Rosa. Photo by Brian Kentosh (released into the public domain).
compounds — thiols — sometimes called mercaptans. (The simplest thiol is hydrogen sulphide, H₂S, the sulphur analogue of water, H₂O.) Thiols, which are responsible for the offensive long-lasting stench, have a rotten egg or garlic smell. Thiols in raw onions cause people to cry, and thiols are added to natural gas supplied to homes, so that a leak will have a noticeable odour. Skunk thiols are responsible for their nauseating smell. Skunks can target accurately up to 3 m, less accurately up to 6 m, and the highly persistent spray can cause temporary blindness and nausea. Skunk spray can be detected by humans at concentrations as low as 10 parts per billion, a level that may occur by wind transport over 5 km away from the release point. All of the species have fur with warning colouration, most often bold white stripes, streaks or spots over black, which they have from birth (some are all-black, some have brown instead of black areas, and a few are all-white). Skunks are usually shy and reclusive, avoiding confrontation. They will first attempt to ward off attackers by hissing, foot-stamping, or other threat postures, because their store of noxious liquid (typically about 15 cc) is sufficient only for five or six uses, and regenerating the supply may take more than a week. Very few animals feast on skunk meat, although skunks are sometimes killed by dogs, foxes, coyotes, bobcats, and mountain lions. However, Great Horned Owls, which have a dull sense of smell and razor sharp talons, frequently prey on skunks. Skunks have been shown to be more fearful of Horned Owl shrieks than calls from mammalian predators (Fisher and Stankovich 2018).

**Harmful aspects**

Skunks are a significant vector of the rabies virus, one of the most lethal of infectious diseases. It has been estimated that about 20% of reported cases in animals in the U.S. and Canada are due to skunks (Rosatte et al. 2010). Often over 20,000 people die annually from rabies, over 95% in Africa and Asia. However, in developed countries rabies in humans and domesticated animals is rare, due to surveillance and vaccination programmes. Vaccines to treat humans are available but need to be employed promptly following potential infection. Globally, dogs are overwhelmingly the principal source of infection of humans, but in the Americas bats are the most common source. Rodents are very rarely infected, and non-mammalian species are immune (some birds can be temporarily weakened). Rabies virus is transmitted by direct contact, such as a bite, or by contact with mucosal surfaces of an infected animal. Many wild New World mammals, including bats, foxes, raccoons, and skunks, are reservoirs of infection in the Americas, posing a danger to domestic mammals including cats, dogs, and livestock. In some parts of the world, culling (i.e. killing) of species is carried out when it is discovered that the risk of rabies has increased. In the New World, for most potential carriers, provision of vaccines in targeted food ('bait') is considered the most efficient way of controlling the risk, and this has been applied to skunks (Rosatte et al. 2009; Mainguy et al. 2012). Different host species often are infected by particular viral strains (a species may have a characteristic viral strain, or several strains, and a given viral strain may occur in more than one species). In the U.S., skunk rabies has the broadest geographical distribution of all terrestrial (i.e. excluding bats) rabies virus strains (Brown et al. 2014). Because of the difficulty of creating combinations of vaccines that will immunize skunks against all virus strains, trap-vaccinate-release programmes are also employed, although they are more costly and labour-intensive (Jojola, Robinson, and Vercauteren 2007; Wohlers et al. 2018). Skunks suffer from an unwarranted reputation as being rabies ‘carriers’ that transmit but do not succumb to the virus.

**Figure 50.** Some hog-nosed skunks (*Conepatus* species). (a) The American Hog-nosed Skunk (*C. leuconotus*) from Central and North America. This large skunk grows to 85 cm in length. Painting (public domain) from Nelson (1918). (b) Molina’s Hog-nosed Skunk (*C. chinga*) from Western South America. This specimen is brown with white stripes, but most animals are black with white stripes. Painting (public domain) from Jardine (1843), plate 13.
(such ‘subclinical’ tolerance actually occurs in bats, as noted earlier); in fact, skunks die, like almost all other infected mammals, once symptoms occur.

Skunks are common in suburban areas, where they often raid garbage containers and annoy homeowners (Rosatte et al. 2010). They often establish their homes in crawl spaces under porches, and in barns, garages, sheds, junk cars, and woodpiles. They also search for rodents in such places. Sometimes skunks become trapped in window wells. Discovering that a skunk family has moved onto one’s property can be disturbing. Skunks also dig holes in lawns, golf courses, and gardens to capture insect grubs. They occasionally kill poultry (Figure 51) and eat their eggs. Unfortunately for skunks, European colonizers of the New World confused the European Polecat (Mustela putorius) with skunks and indeed employed the word polecat to label skunks. They also confused the considerable reputation of European Polecats for destroying game and poultry with the behaviour of skunks (Miller 2015). Although most wild animals that skunks consume are not admired by humans, skunks will eat eggs of wild ground-nesting birds, upland game birds, and waterfowl, sometimes resulting in bird enthusiasts and hunters lobbying for skunk control and removal (Larivière and Messier 1998). Skunks may also damage beehives when they try to feed on bees or obtain honey (Storer and Vansell 1935). Skunks occasionally consume vegetables and grains from gardens and commercial crops. However, ‘An economic evaluation of the feeding habits of skunks shows that only 5% of the diet is made up of items that are economically valuable to people’ (Knight 1994).

Irritating skunk odour is regularly generated in neighbourhoods from skunk encounters with other animals, and especially when a skunk is run over on roadways. The relatively poor vision of skunks and their slow movements make them vulnerable to vehicle collisions.

Dogs and skunks rarely co-exist peacefully (Figure 52). Dogs are often sprayed, causing them and their owners considerable annoyance. Occasionally, people are also sprayed, but skunk scent gets on humans most often from sprayed dogs. Regardless of the advice offered below, when skunks spray humans it is a good idea to seek expert medical advice, and when they spray dogs it is also advisable to consult a veterinarian. Contrary to folklore, bathing in tomato sauce or juice to remove the stench is not recommended because it merely masks the skunk smell, without eliminating it. The odour eventually may become less evident to the victim simply because of olfactory fatigue (Wood 1999). If sprayed in the eyes, immediately flush with cool water (there are commercial eyewash products made specifically for dogs). Dogs can be treated with a mixture of 1 L of 3% hydrogen peroxide, 80 mL of baking soda and 5 mL of liquid soap (a quart of 3% hydrogen peroxide, a quarter cup of baking soda and a teaspoon or two of liquid detergent). The mix should be made in a large, open container, and used while it is still bubbling. Wear rubber gloves and lather the mixture on, leaving it for 30 minutes, and then rinse thoroughly with tap water. The mix should not be stored because the oxygen build-up could blow off the top of the container, and it might bleach the dog’s fur (Cosier 2006). Commercial mixtures are also often available from veterinarians, but

Figure 51. The common Striped Skunk (Mephitis mephitis) viewed in early times as a serious poultry killer. (a) Source (public domain): Doughty (1832). (b) Source (public domain): Bryson (1911).
their clinics are usually closed at night when dogs are sprayed. If an odour lingers after washing clothes exposed to the spray, a dash of ammonia can be added to the wash cycle. To get rid of the odour on non-living objects, use dilute chlorine bleach, ammonia, or vinegar, after conducting a spot test. Although skunk odour can last for weeks it will eventually, naturally disappear. Although the smell of skunks is highly objectionable, being sprayed by skunks almost never leaves lasting damage.

**Beneficial aspects**

Skunks are highly beneficial to farmers, gardeners, and landowners because they feed on large numbers of agricultural and garden pests. They help control pests such as rodents (especially mice and rats), moles, rabbits (occasionally), insects (notably beetles, crickets, grasshoppers, wasps, and a variety of grubs), and other harmful animals such as snails (Kelker 1937; Lantz 1917). Without the pest-control services of skunks, health problems from mice and rats would increase. Although skunks damage lawns by digging up grubs, they benefit lawns by reducing grubs and other insect pests, as well as moles.

In North America, skunks were once widely trapped for the fur trade (Figure 53). Skunks which are shot or caught in leg traps are likely to discharge their musk and may contaminate their fur, so that trappers preferred to catch the animals in box traps and drown them, or kill them with a paralysing blow. Trappers sometimes ate young skunks, and found the meat reasonably palatable. For much of the twentieth century skunks were farmed for their pelts, with selective breeding for tameness and dark coats. The much more marketable names ‘Alaska sable’ and ‘American sable’ were substituted for skunk by furriers during the late nineteenth century. On a global basis, about 80% of fur (all species collectively) is produced from captive animals today, and skunk fur is insignificant.

During the nineteenth century, farmers sometimes tamed Striped Skunks and maintained them in barns to kill rodents, much like domesticated cats.

‘Skunk oil’ is a viscous preparation made as a rendered by-product of killed skunks. It is obtained by slowly heating the fat from a skunk. This use of the phrase skunk oil does not refer to the foul-smelling musk oil of the two anal glands, although many publications and some scientists refer to the anal gland liquid as skunk oil. Neither of these skunk oils are the same as cannabis (marijuana) oil, which is a third meaning of the phrase skunk oil. Skunk oil (rendered fat) was employed in indigenous North American medicine and occasionally is still used in folk medicine, although its efficacy has not been verified. This kind of skunk oil is also used as a hunting lure (some preparations are odorous, others not).

Skunks are sometimes kept as pets (Hume 1958), especially the Striped Skunk *Mephitis mephitis*, which is relatively social. The species generally lives no longer than 3 years in the wild but can reach 15 years in captivity. Wild skunks are sometimes adopted, especially as babies, but this usually represents a violation of local wildlife regulations. Breeds have been selected that are relatively tame and have various fur patterning and colouration (popular categories include albino, apricot, blonde, champagne, chocolate chip, chocolate swirl, cream, lavender, smoke, and violet). In the U.S., skunks cannot be kept as pets in many states. The scent
Figure 53. A skunk fur coat. Source (public domain): Schmid and Schmid (1902).
glands of skunks are often surgically removed, but there is controversy in some jurisdictions about the ethics and legality of this. Skunks have been imported to England as pets and there have been allegations that this has resulted in some escapees becoming feral. Skunks are high-maintenance pets requiring a major commitment. They can be kept responsibly as pets but are unsuitable except for a small minority of enthusiasts (Dragoo 2009; Cipriani 2011) (note Figure 54).

Conservation aspects

Skunks are vilified primarily because of their smell (e.g. Figure 55). A colloquial French Canadian phrase for skunk, enfant du diable, means ‘child of the devil’. The word skunk is rarely used as a compliment, and does not serve to improve the image of skunks for conservation purposes. Pejorative meanings related to skunk include: skunk – a contemptible ill-mannered person; to skunk – to deprive by cheating; skunked – being overwhelmingly defeated; drunk as a skunk – highly inebriated and stinking of alcohol. ‘Skunked beer’ has been exposed to too much light, which transforms certain components to skunky-smelling compounds. Several plant species have “skunk” in their English names, reflecting their bad odour. Examples of ‘skunky’ plants include Skunk Cabbage (Symlocarpus foetidus), Skunk Currant (Ribes glandulosum), and Skunk Sumac (Rhus trilobata). Cannabis sativa often has a distinctly skunky odour and in the U.S. the word ‘skunk’ is often employed to designate certain strains of marijuana with an especially skunky smell. In Great Britain, the word skunk often designates premium quality, indoor-grown cannabis. Because of the derogatory nature of the word, its use for medicinal forms of cannabis is sometimes not appreciated (Potter and Chatwin 2012).

The curious phrase ‘skunk works’, unlike most uses of the word skunk, is employed in a respectable sense. The phrase was first employed by the aeronautics industry having originated from cartoonist Al Capp’s comic strip Li’l Abner, where the ‘skonk works’ was a secret laboratory that operated a backwoods still. ‘When an established firm aspires to experiment in a radical direction, management gurus recommend opening a skunk works – an organisational home for high-priority and original-thinking projects. It is housed away from the organisation’s main operations, sometimes in secret or with organizational barriers. Typically, projects involve something of value to the future but are not directly connected to the present operational or service missions. Sometimes a skunk works has the approval of senior management and sometimes it does not’ (Greenstein 2016).
No species of the skunk family (*Mephitidae*) is currently evaluated as ‘endangered’, according to the International Union for Conservation of Nature. The Pygmy Spotted Skunk is listed as ‘vulnerable’ because of recent reductions in populations. Concern has been expressed about the Eastern Spotted Skunk, *Spilogale putorius* which has become rare in large parts of its distribution range (Gompper 2017; Eastern Spotted Skunk Cooperative Study Group 2018), particularly the subspecies, Plains Spotted Skunk (Dowler et al. 2017) (Figure 56).

**Figure 55.** ‘Reddy Fox’ is repelled by the prospect of being sprayed by ‘Jimmy the Skunk’ in a children’s story, *The Adventures of Jimmy the Skunk*. Public domain illustration by Harrison Cady, from Burgess (1918). T. W. Burgess (1874–1965), an American naturalist and conservationist, wrote over 100 children’s stories.
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Disclosure statement

No potential conflict of interest was reported by the author.

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