

Worldwide domestic cat invasions affect wildlife through hunting and gene pollution

Zijian Xu

School of Biological Science University of Reading, Reading, United Kingdom

Vm001322@student.reading.ac.uk

Abstract. The domestic cat is on the list of the 100 most dangerous invasive species of the world, they have invaded the worldwide environment and caused problems in multiple aspects. The invasion of cats has also been studied around the world. Domestic cats prey on small wild animals, affecting their populations. Relevant studies have been conducted in North America, Australia, islands around the world, and some countries in Asia and Europe, proving that a huge number of wild mammals, birds, amphibians, reptiles, and invertebrates are killed by domestic cats every year. At the other aspect, domestic cats can interbreed with certain wild cat species, such as Chinese Mountain cats leopard cats, and European wild cats, and these hybrid cats can produce fertile offspring. The invasion of domestic cats has also taken a toll on the genetic integrity of these feral cats. This article selects some research to analyze the affections that domestic cats have on wild animals and the ecological environment in terms of predation and genetic pollution, discusses certain widely used methods to control the domestic cat population, and the advantages and short backs of all strategies. It also analyzes the shortcomings and untouched aspects of existing research and proposes topics that require further research. Background knowledge and suggestions for research topics are provided for future research.

Keywords: Domestic cat, invasive species, predation, gene flow.

1. Introduction

Domestic cats (*Felis catus*) are generally believed to have been domesticated by humans from African wild cats (*Felis sylvestris lybica*) in ancient Egypt and expanded all over the world with humans[1]. Cats are one of the most popular pets worldwide, nowadays, the population of domestic cats has already grown to an estimated 600 million[2]. However, while being one of the top popular pets, domestic cats are also one of the worst invasive species at the same time. They have been listed in the top 100 invasive species of the world([3]. Because of human migration, domestic cat populations span the world and are found on all continents except Antarctica. As a result, the invasion problem of domestic cats has also affected all over the world. The negative impact of cat invasion can be separated into multiple aspects and the object that is being affected can be both wild animals and humans. Cats are predators, they hunt local small wild vertebrates and invertebrates and cause serious problems to the local wildlife population. Domestic cats also have the ability to breed with some wild felines like Chinese mountain cats and Asian leopard cats[4]. This hybrid behavior can cause pollution of the wild feline species gene pool, and cause affection on wild cat species gene integrity. Free arranging stray cats can also bring negative effects to humans, Cats can carry many diseases and can be infected by microorganisms such as fungi, bacteria,

and so on. Many of these can also be transmitted to humans. Domestic cats also have the ability to hurt humans from direct contact, which is attacking people. This research will collate and discuss some previous research on the impact of domestic cat invasion on the environment and humans, analyze the specific impacts of domestic cats in various aspects, whether there are solutions, and analyze which aspects of research are still lacking, to provide information for subsequent related research.

2. Domestic cat affection

2.1. Predation

Domestic cats prey on wild birds, reptiles, insects and mammals, and multiple studies in different regions have pointed out that domestic cats' predation on local wildlife has an impact on the population. These studies include Asia, Europe, North America, Australia and various islands. Research in these different regions will be analyzed, the conclusions and characteristics of each study will be compiled, and research gaps will be discussed, that is, research directions not covered by each continent, aiming to provide ideas and goals for subsequent research.

The ecosystems on islands are more fragile and extremely vulnerable to invasion of alien species[5]. According to 2008 International Union for Conservation of Nature (IUCN) records, invasion cats on islands affect 175 threatened vertebrate species, including 25 reptile species, 123 bird species, and 27 mammal species[6]. According to 2008 IUCN data[6], on a global scale, cats' invasion of islands around the world has led to the extinction of 33 (13.9%) of the bird, reptile, and mammal species in the world. The study is relatively comprehensive, involving a total of 120 islands around the world. And the research covers the impact of hunting by domestic cats on mammals, reptiles and birds. It clearly shows that the invasion of domestic cats has had a serious impact on the population of wild animals in island areas. The only drawback is that the study did not involve invertebrates. It is speculated that the reason may be that invertebrates are preyed on by domestic cats compared to vertebrates. less and less affected. In addition to islands, various continents have studied this predatory behavior cats have on wildlife.

A Chinese study estimated the rough number of wildlife killed by domestic cats each year. The number is estimated by using questionnaires. According to their conclusions, there are an estimated 161-4.95 billion invertebrates, 161-3.58 billion fish, 113-3820 million amphibians, 148-4310 million reptiles, 269-5520 million fish and 361- 9.80 billion mammals are killed by cats[7]. The study also stated that except for China, there is currently a lack of similar statistics on the number of animals that domestic cats killed in other parts of Asia, and there is a lack of research on the impact that predation behavior of domestic cat caused on the entire continent[7]. In addition, although this study shows that domestic cats prey on wild animals in large numbers, it cannot confirm that domestic cats pose a threat to wild animal populations' viability, and more research is still needed[7].

A study in the United States estimated that domestic cats kill approximately 1.3 to 4 billion wild birds and 6.3 to 22.3 billion wild mammals each year[8]. Another interesting result shows that unowned cats cause 89% of mammal mortality and approximately 69% of bird mortality [8]. This result suggests that the impact that unowned stray cats have on wildlife predation is greater than the impact caused by pet cats that are fed by humans. In addition, another country in the Americas, Canada, also conducted a study on the bird mortality preyed on by domestic cats. The results of the study showed that 100-350 million birds are killed every year[9]. The two studies in the Americas focus more on birds. The entire Canadian study focuses on the impact on birds, and the American study also devotes more space to studying the impact on birds. In addition, related studies in South America are lacking.

In Australia, cats have been linked to the extinction and decline of many local wild mammals. It is estimated that approximately 815 million cats are killed each year in natural habitats and 149 million in artificially modified habitats. kill. 180 million were killed by owned pet cats. The total is 1.144 billion[10]. Of these 1.144 billion individuals, at least 40% are native species, which means 459 million local mammals are killed by domestic cats each year[10]. The study also illustrates that although more research is needed and it will be challenging to study on the damage caused by stray cats on the viability of Australia's wild mammals, the results suggest that cat predation kills far more wild mammals than

the other key threat to wildlife, which is land clearing[10]. This study echoes studies in the United States that raise concerns about the differences in predation levels between owned and unowned cats. The study also admitted that these data can only prove that a large number of mammals are killed by domestic cats every year, but it does not prove that these killings of domestic cats will have an impact on the survival of wild animal populations. Follow-up research is needed to prove this. A little[10]. In addition, the study looked at the number of mammals that domestic cats killed each year in the continent range, but not birds, amphibians, reptiles or invertebrates. Research in these directions is also very important in Australia, a continent rich in rare wildlife.

But does this mean cats will eat more wildlife due to a lack of human feeding? Tokunoshima Island had an experiment on this question, and it suggested that human feeding of cats may lead to more predation of wild animals[11]. Free-arranging domestic cats can be divide into two categories, feral cats living in the forest and stray cats living in residential areas and dependent on humans[11]. However, data obtained through capture-recapture methods show that feral cats can also enter residential areas, and artificial food components can be found in their fecal samples. This means that there is no clear distinction between cats of these two classifications, both feral and stray cats are dependent on human feeding, and artificial food has been shown to be the main source of food for feral cats. On the other hand, the government of Tokunoshima Island has sterilized 2,797 stray cats, but the data obtained through the capture-recapture experimental method shows that the population of cats is still large, and the breeding is very successful, and it has not been effectively controlled. This result suggests that anthropogenic food sources drive overpredation in cats[11]. This result can prove that feeding stray cats that are not wild animals does not reduce the threat to wild animals but may lead to overpredation by cats. Therefore, it is very important to educate the public to stop feeding stray cats and limit the freedom of their own pet cats.

2.2. *Gene pollution*

Domestic cats have the ability to hybrid with multiple wild cat species, including the Chinese mountain cat[12], the leopard cat(pet bangle cat), and the European wild cat[13]. This unclear reproduction isolation is possibly due to the close interbreeding of these wildcat variants during evolution and migration[14]. Many artificial hybridizations aim to create new varieties of pet cats, however, arranging stray cats can also hybrid with wild species and cause gene pollution of wild cats. Few research clarified the occurrence of hybridization behavior between domestic cats and certain wild feline species.

In Europe, there are multiple research about European wild cats (*Felis silvestris*) being hybrid by domestic cats. This research shows that in Germany, Italy, Switzerland, and Portugal, European wild cat's gene is less affected by a domestic cat[13]. There are some possibilities to identify the gene of European wild cats and the genes of domestic cats[13]. However, in Hungary and Scotland, the situation is much worse[13, 15]. In Switzerland, the success hybrid rate between wild cats and domestic cats is around 6%, the high rate could reach 8%[13]. In this research, the model they designed also indicates that even though the wild cat might be more adapted to the environment and have more advantages in competition with domestic cats, gene introgression in wild cats will continue to become more and more serious in the future. Therefore, if hybridization cannot be stopped, the genes of European wild cats will be seriously contaminated and eventually become extinct[13]. Another research also demonstrates that in hybrid wild cat individuals, there are an average of 17% domestic cat genes, and those genes can be related to factors such as growth and aggressiveness[14]. means the hybridization will change wild cats' behavior and physiological characteristics.

Chinese mountain cats (*Felis biet*) are having similar problems to European wild cats. As a close relative of domestic cats, hybrids between Chinese mountain and domestic cats have also been observed many times. As the only wild cat in the Qinghai-Tibet Plateau, the desert cat's genetic integrity also receives special attention[12]. Through genetic research, it has been found that gene flow between Chinese mountain cat and domestic cats is very common, and these gene flows have occurred recently, probably dating back to the mid-20th century to the early 21st century[12]. This study also proved through population genome analysis that the Chinese mountain cat and other wild cat lineages such as

the Chinese wild cat (*Felis silvestris ornata*) should be classified as the same species, and their genetic relationship with domestic cats is also relatively close, so gene flow can occur[12]. With the increase of the domestic cat population in the Qinghai-Tibet Plateau, it is likely that Chinese mountain cats will face the same problem as European wild cats.

African wild cats, Asian wild cats and other wild cats, which are also subspecies of wild cats (*Felis silvestris*), also have the possibility of hybridizing with domestic cats and producing fertile offspring. In addition, a variety of other wild cats, including ocelots and servals, have also been proven to have the ability to hybridize with domestic cats due to the breeding of pet cat breeds. These wild cat populations may also be threatened by genetic introgression from domestic cats.

3. Discussion

Domestic cats have already caused environmental issues all over the world. Both prey and predators are being affected by domestic cats. Their predation of wild animals has not only caused the decline in prey's population but also increased the difficulties for local predators to find prey. The free-arranging domestic cats also caused gene flow with wild cat species and affected wild species' gene integrity. Therefore, action is needed globally on domestic cat invasions to reduce the damage caused by domestic cats and protect affected wildlife and ecosystems.

3.1. Control population

To reduce the harm caused by domestic cats to the environment, one of the most important points is to reduce the domestic cats population size, and control their further growth. Currently, there are two main methods used in most areas to control the population of non-pet stray cats, direct removal (euthanization) and TNR (trap, neuter, release)[16]. However, both methods have drawbacks. As research shows, euthanization is more efficient than TNR, removing over 50% of the cat population can control the population effectively, on the other hand, TNR requires neutering more than 75% of the cat population to reach the same result[16]. However, there are humanitarian issues with directly culling stray cats, and this method has been firmly opposed by many stray animal protection organizations[17]. The drawbacks of the TNR method are it costs more time, money, and manpower, and at the same time, it is less efficient[16].

3.2. Feeding

Cats are very popular pets. Many people love cats and provide help to stray cats. The phenomenon of feeding stray cats is very common. Some stray animal protection organizations will also add feeding to stray cats while performing TNR. They believe that feeding stray cats can reduce their hunting behavior, thereby reducing the harm to the environment[17]. However, the truth is totally opposite. The previous research on Tokunoshima Island has already proved that feeding stray cats does not reduce predation but will increase the cat population and lead to overhunting[11]. In addition, there is no guarantee that every cat that comes into contact with food when feeding has been neutered by TNR. If these unneutered cats are fed, their survival rate will be increased, giving them more chances to reproduce, thus leading to a growth of population size[17]. In order to control the population, relative organizations should instead appeal to the public to stop feeding stray cats.

3.3. Pet cat

Whether feral cats or stray cats are ultimately formed by domestic pet cats that were abandoned, lost, or the offspring of them. Pet cats also have the ability to hunt and kill wild animals, as mentioned in part Therefore, Controlling the freedom of pet cats is also important. By restricting pet cats from going outside, pet cats killing wild animals can be controlled, as well as the chances of pet cats getting lost and becoming stray cats. Neutering prevents pet cats from interbreeding with stray cats. A similar method had already been implemented by the village of Omaui in New Zealand, all households with cats must have their pet cats neutered, microchipped, and registered with the government. And no other cats should be kept after the death of their pet[18].

4. Conclusion

This paper discussed two aspects of domestic cats' invasion. Illustrated the impact that domestic cats brought, and discussed some research on this invasive species, listed their results and the aspects they haven't involved, and also some possible solutions to control the population of domestic cats. However, no strategies are perfect and each of them might have a different efficiency in different environments. At the same time, different regions are affected differently by domestic cats, so the suitability of each method varies. More research in different regions is needed to find the best methods for each special environment. Similarly, even though it is known that the invasion of domestic cats into the natural environment is already worldwide, the extent of the impact on all continents is still unknown. There is still a lack of a large amount of relevant research in some areas, especially some species-rich, and have precious ecological resources area such as southeast Asia, South America, and Africa. Even in areas where there are relevant studies, the research in many areas is insufficient and cannot confirm whether the invasion of domestic cats really affects the survival of local wildlife and how much impact it has. In addition, many endangered species are difficult to study and investigate even if they are threatened by domestic cats because they are rare in number and are rarely discovered by scientists. In addition, people's understanding of many species is currently still insufficient, which makes related research and protection work even more difficult. The genetic exchange between domestic cats and wild cats will cause the genomes of wild cats to be mixed with domestic cat genes, eliminating the negative effects of domestic cat genes. It will also eventually cause the genes of these wild cats to gradually disappear, leading to the extinction of the species and crossbreeding cats or domestic cats instead. But whether the extinction of these wild cats will have an impact on the ecological environment in which they live is also a question that lacks research. Could hybrid cats serve the same function as feral cats and could they replace their ecological niche? If the replacement of these wild cats will not cause serious damage to the environment, is it still necessary to protect the wild cat population? Regarding the affection that domestic cats have for the ecological environment, there are still many aspects and problems waiting to be solved. This paper hopefully can give some idea and background information for future research, shows some aspects that still haven't been studied, and a few questions that are still not solved about domestic cats' impact on wildlife. These topics will be useful and important for the further protection of wildlife from being threatened by domestic cats.

References

- [1] Serpell, J. 2013. Domestication and history of the cat. In D. Turner & P. Bateson (Eds.), *The Domestic Cat: The Biology of its Behaviour*. Cambridge: Cambridge University Press(pp. 83-100)
- [2] S. D. Gehrt, S. P. D. Riley, B. L. Cypher, 2010. *Urban Carnivores: Ecology, Conflict, and Conservation* (Johns Hopkins Univ. Press).
- [3] Lowe, S., Browne, M. & Boudjelas, S. 2000. 100 of the World's Worst Invasive Alien Species: a Selection from The Global Invasive Species Database (Invasive Species Specialist Group, International Union for Conservation of Nature)
- [4] Robbins, N. 2013. "Breeds of Domestic Cats: Bengal". *Domestic Cats: Their History, Breeds and Other Facts*. Scotts Valley, CA: CreateSpace Independent Publishing Platform. p. 115–119.
- [5] McCreless, E., Huff, D., Croll, D. et al. 2016. Past and estimated future impact of invasive alien mammals on insular threatened vertebrate populations. *Nat Commun* 7, 12488
- [6] Medina, F. M. et al. 2011. A global review of the impacts of invasive cats on island endangered vertebrates. *Global Change Biol.* 17, 3503–3510.
- [7] Yuhang Li et al., 2021. Estimates of wildlife killed by free-ranging cats in China, *Biological Conservation*, Volume 253, 2021, 108929, ISSN 0006-3207
- [8] Loss, S., Will, T. & Marra, P. 2013. The impact of free-ranging domestic cats on wildlife of the United States. *Nat Commun* 4, 1396.

- [9] Peter P Blancher, 2013. 'Estimated Number of Birds Killed by House Cats (*Felis catus*) in Canada' Avian Conservation Ecology 3; see also Anna M Calvert and others, 'A Synthesis of Human-Related Avian Mortality in Canada' (2013) 8 Avian Conservation Ecology 11.
- [10] Brett P. Murphy et al.2019. Introduced cats (*Felis catus*) eating a ontinental fauna: The number of mammals killed in Australia, Biological Conservation, Volume 237, Pages 28-40
- [11] Maeda, T., Nakashita, R., Shionosaki, K. et al. 2019. Predation on endangered species by human-subsidized domestic cats on Tokunoshima Island. Sci Rep 9, 16200.
- [12] Yu, He; et al. 2021. Genomic evidence for the Chinese mountain cat as a wildcat conspecific (*Felis silvestris bieti*) and its introgression to domestic cats. Science Advances. (26): eabg0221.
- [13] Claudio S. et al.2020. Projecting introgression from domestic cats into European wildcats in the Swiss Jura. Evolutionary Applications, 13 (8): 2101
- [14] Driscoll CA, et al.2009. The Taming of the cat. Genetic and archaeological findings hint that wildcats became housecats earlier--and in a different place--than previously thought. Sci Am. 300(6):68-75.
- [15] Senn, H. V., et al. 2019. Distinguishing the victim from the threat: SNP-based methods reveal the extent of introgressive hybridization between wildcats and domestic cats in Scotland and inform future in situ and ex situ management options for species restoration. Evolutionary Applications, 12(3), 399–414.
- [16] Andersen, Mark C.; et al.2004. Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats. Journal of the American Veterinary Medical Association. 225 (12) [2023-05-10].
- [17] Longcore, Travis et al. 2009. Critical Assessment of Claims Regarding Management of Feral Cats by Trap-Neuter-Return. Conservation Biology. 23 (4)
- [18] Kelly-Leigh-Cooper. 2018. Why a village in New Zealand is trying to ban all cats BBC News Chinese.