

The Ways That the Geographical Environment Shapes the Morphological Features and Behavioral Habits of Wild Cats (*Felis Silvestris*) in Asia, Europe, and Africa.

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Abstract. This report aims to describe the physical traits and behavioral habits of the three convectional subspecies of the wild cats, namely Asian wild cats (*F. s. ornata*), African wild cats (*F. s. lybica*), and European wild cats (*Felis silvestris silvestris*) in terms of three major geographical factors, namely climate, landform, and water and food resources. The report is a literature review that refers to the research about wild cats' habits and appearances in the last 3 decades. The conclusion is that temperature is the most direct and important factor affecting the skeletons, fur color, thickness, and activity mode. In contrast, landforms may influence the place they choose as habitats and their way of hunting prey. Factors like food and water resources influence their way of hunting prey, but they are also the major cause of the difference in drought tolerance of the three types of wild cats.

Keywords: Wild Cats; Ecology; Bergman's Law; Geographical Impacts.

1. Introduction

Wild cats (*Felis silvestris*) are a highly adaptive species distributed in all kinds of global geographical environments, including cities, forests, deserts, mountainous regions, and so on, demonstrating an extraordinary capacity to thrive. They have a fluid and energy-conserving walking motion because of their digitigrade nature, which makes them walk by their soft toes, providing the stealth necessary for stalking prey and navigating terrains. Their fluffy and lithe bodies, which act like a spring, and their relatively short but powerful forelimbs and well-muscled hindlimbs connected by a rotatable and flexible spine, enable them to change their body's position quickly and easily. [1] However, physical and behavioral differences also exist among cat species. For example, wild cats that inhabit wide plains usually have a slimmer body and lighter fur cover than those in forest areas. [2] The existence of the apparently distinguishable phenotypes and behavioral habits among wild cats is mainly attributed to the multiple geographical conditions surrounding them. This review aims to describe the physical characteristics and behavioral habits of the three convectional subspecies of the wild cats, namely Asian wild cats (*F. s. ornata*), African wild cats (*F. s. lybica*), and European wild cats (*Felis silvestris silvestris*). Three major geographical factors: climate, landform, and water and food resources, will also be listed and explained.

2. Climate

The body structures of the wild cats are mainly a reflection of the environmental temperature. The distribution of the European wildcat extends from the Scottish Highlands to Eastern Europe, Southern Europe (such as the Iberian Peninsula, Italy), and Western Asia. Its appearance and behaviors show a distinct geographical gradient change. [3] One major feature of European wild cats is that their body shape varies greatly in different regions because of the temperature. European wild cats, especially those that live in high-altitude areas, such as the Norwegian forests, Siberian forests, the Scottish Highlands, and Scandinavia, suffer from low temperatures, so that they have larger bodies and more robust builds to reduce the proportion of heat loss from the body surface and preserve the body's core heat. [4] A larger body size also makes it easier to store fats to survive the winter when food resources are scarce. On the contrary, in warmer regions such as the coast of the Mediterranean Sea and the

Iberian Peninsula, the cats have a relatively smaller and more slender body shape, since the smaller body size increases the proportion of heat dissipation on the body surface, which helps to cool themselves down in the hot environment.

Unlike the European wildcat, which is adapted to forest environments, the Asian wildcat is mainly adapted to arid and semi-arid grasslands, deserts, desert grasslands, and mountainous areas. [5] The distribution range of wild cats extends from the eastern coast of the Caspian Sea eastward, passing through the countries of Central Asia, the northwest of China, all the way to the edge of the Qinghai-Tibet Plateau in western China. They have a medium-sized body shape, which is lean and sturdy. [6] Although not as thick and muscular as European wildcats, they have clear muscle lines and slender limbs suitable for long-distance hunting and ambushes rather than short-distance bursts in the forest. This conforms to Bergmann's rule, which says that in cold regions, the protruding parts of the body will shorten to reduce heat loss. Still, Asian wildcats prioritize adapting to the movement needs in open areas. Their face is relatively wider than that of the European wild cats, and their ears are large, and the tips often have short tufts of hair. [7] These features help collect more subtle sounds, such as the underground activities of rodents in the silent wilderness, and are also indispensable in dissipating heat.

The direct ancestors of modern domestic cats were the African wildcat. [8] They are mainly found in North Africa, the Arabian Peninsula, and the arid regions of southern Africa. The core features of the African wildcat are a physical structure that facilitates heat dissipation, water retention, and camouflage in open areas. African wild cats are of slim build and have the longest limbs among the three wild cats mentioned in the article. Their light and slender body structure reduces the heat production per unit volume of their body. At the same time, the long limbs enable the body to stay away from the hot ground during movement and facilitate heat dissipation during running. [9] Another most distinctive feature is that they have the largest and most pointed ears. The large ears increase the body surface area and are filled with blood vessels, which can effectively dissipate body heat like a radiator. [10] At the same time, they can also collect the tiniest sounds in the desert, such as the movement of some insects and snakes underground. Their tails are also the longest, helping maintain balance during high-speed running and jumping.

Their coat color and pattern are their camouflage in the environment. European cats have quite different fur characteristics owing to the other heat conditions. The thicker and light-colored fur is another feature of the European cats that survive in the low-temperature environment. [11] The long and bushy fur with a thick undercoat can effectively block the cold air and prevent heat loss from their body. The light gray or yellowish-gray fur provides better camouflage for cats in areas that are covered by snow. Some individuals change the color of their skin throughout the four seasons to help them restore more insulation energy in the winter and avoid sunstroke in the summer by the temperature enzyme in their skin and fur. [12] Conversely, European wild cats in warmer regions also have shorter and thinner fur than those in colder regions. [13] They do not need powerful insulation; the lighter and thinner fur, in fact, helps with heat dissipation better. Their fur is often darker since most live in forests and shrublands, and dark reddish-brown fur can easily blend in with vegetation and soil shadows.

The primary color of the Asian wild cats' fur is sandy yellow, light grayish yellow, or pale brownish yellow, which blends perfectly with the background colors of central Asia's vast deserts, Gobi, and grasslands. Their patch-like patterns, unlike the striped patterns of European wildcats, are more like the projections of rocks or the shadows of sparse shrubbery. The spots of Asian wildcats are more concealed in open areas than stripes. [14] Winter is frigid in some distribution areas, such as Mongolia and northwest China. Their fur becomes extremely thick and long, and the color may become grayer and whiter to adapt to the snowy environment and hide in the heavily snowed mountain land.

Fur provides perfect camouflage for the sandy terrain for African wildcats. The solid, sandy yellow, light brown, or grayish yellow fur is almost identical to the colors of the deserts in North Africa, the Sahel region, and the savannas. [15] The stripes or spots on their bodies are usually somewhat

discontinuous and faint, unlike those of European and African wildcats, which are more distinct. This helps them hide their outlines in the light and shadow effects of the hot sun, thus better blending into the environment. The fur color in their belly is lighter than on their back, which helps to reflect the radiant heat from the ground.

Their behavioral habits and energy management share similarities, but the temperature directly determines some tiny differences. The activity rhythm is greatly influenced by the season in colder regions. During the freezing and deep winter, they may reduce their outdoor activities to conserve energy, especially in snowy weather. [16] They tend to be active during the day with sufficient sunlight and a slightly higher temperature. The range of their territory can also be larger owing to the possible decrease in prey density during winter; they need a larger hunting range to obtain sufficient food. European wild cats in warm regions have diurnal or nocturnal instincts.[17] To avoid the heat during the day, they tend to be active in the cool early morning, dusk, and night. Their range is also more stable, since the food resources are relatively abundant throughout the year, and their home range size is more fixed. The behavioral habits of Asian wild cats share some common points with those of European wild cats. They both have strong diurnal and nocturnal characteristics. Specifically, the daytime temperature crests in desert and grassland areas while the nighttime temperature is trough. Therefore, they also mainly move around during dawn, dusk, and at night, when the temperature is suitable, and it is also the time when many rodents come out to move and forage. Additionally, in winter, they both come out to move and forage when the sunlight is the strongest and the temperature is the highest during the day. African wild cats have stricter nocturnal and hiding habits than the other two types of wild cats.

3. Landform

Landform varies across Europe's low and high-latitude areas, forming disparate decisions in choosing habitats for European wild cats. Wild cats depend highly on dense forests in cold regions, especially coniferous or mixed forests.[18] The forests provide shelters from wind and snow, as well as warmth (such as tree holes and crevices in rocks), and the snow layer under the forest is also shallower, facilitating movement and tracking of prey. However, in warm regions, they can adapt to more open habitats such as Mediterranean shrublands and rocky hillsides besides forests.[19] The vegetation types in these areas are different, so the hiding places are also more diverse, providing the cats with abundant options to set up habitats.

Asia wildcats highly depend on concealed places for habitat and to hunt prey. They will choose rock crevices, caves, abandoned burrows of marmots, or shrubbery close to a clean water source as nests and shelters to protect themselves from the scorching sun, extreme cold, dangerous predators, or dehydration.[20] However, they are physiologically highly adapted to dry conditions. They can extract water from food, with a strong ability to concentrate urine in the kidneys. However, they will not remain exposed in open and unsheltered areas for long periods.

Similarly, African wildcats rely heavily on tall grass and sparse shrubbery in the savanna and Sahel regions south of the Sahara. This vegetation provides perfect camouflage for them to ambush their main prey, such as rodents and birds, and also offers crucial temporary cover to evade large predators. However, in the more arid semi-desert areas, they exhibit adaptability to rocky outcrops, dry valleys, and steep erosive gullies. These rocky crevices and caves are shelters for them to survive in the intense heat during the day, providing necessary shade for maintaining body temperature and serving as safe nests for raising their offspring. Although they strongly seek these shelters in behavior to avoid prolonged exposure in open areas.

4. Water and Food Resources

Water and food resources are indispensable for European wild cats to live. Still, their dependence on water and primary prey significantly differs, directly leading to their different social habits. In the

northern forests, the main prey might be small rodents such as voles, lemmings, and some birds. They also have social habits with other cats since the food resources are rare, so they live as a group to maintain their life. In the warm Mediterranean region, the food menu might be more diverse, including rabbits, reptiles, and even large insects, the source of which is reasonably sufficient. Therefore, cats in this warmer region are solitary [21], meaning they always live and hunt alone except for breeding purposes. However, cold environments provide wild cats with ubiquitous melting water from snow, while those that live in warm environments may have obstacles in looking for drinkable water.

The primary food source of Asia wildcats is small rodents such as gerbils, kangaroo rats, and hamsters, which share the same habitat with them. [22] They also prey on birds, lizards, insects, etc. Their diet reflects opportunistic characteristics, eating whatever is available. Hunting usually involves lying still for a long time or approaching quietly before launching a fatal attack, fully taking advantage of their camouflage color. They typically rest during the day in abandoned caves, rocky crevices, thick bushes, or the old burrows of mongooses, only coming out to move and hunt on cool nights. Although they live in open areas, they cannot be exposed to the sun for long. Their survival is totally dependent on the availability of shelters. They choose to move in areas close to rock piles, canyons, or areas covered by vegetation, to hide from high temperatures and predators at any time.

African wild cats are solitary and opportunistic hunters; they are cautious and independent, eating whatever they hunt. [23] Apart from the mating season, they usually travel alone, but their reason is to reduce competition in a resource-scarce environment rather than having abundant food. The open environment means a high risk of being preyed upon by eagles and wolves, so they are vigilant, and their behavior is secretive. Although they don't often stay in trees like forest felines in Europe, they are also excellent climbers, able to climb trees to avoid danger or scout the environment. [24] The main food source is small rodents such as gerbils and mice, and they also prey on birds, lizards, insects such as locusts, etc. Their diet is extremely diverse, and they are typical opportunists, grabbing whatever they can find.

5. Conclusion

Geographical conditions shape wild cats' physical characteristics and behavioral habits in Europe, Asia, and Africa. The most direct and essential factor is temperature, which affects their skeletons, fur, and activity mode. Landforms may influence the places they choose as habitats and their way of hunting prey. Factors like food and water resources influence their way of hunting prey, but they are also the major cause of the difference in drought tolerance of the three types of wild cats.

The wild cat population is declining rapidly because of the destruction of their habitats, hybridization with domestic cats, and persecution from climate change. The impacts of climate change are multifaceted, including rising temperatures, altered precipitation patterns, rising sea levels, and the frequent occurrence of extreme weather events. These changes directly and indirectly pose threats to the survival of wildcats. Therefore, it is necessary to distinguish different cat species and know the geographical environments that each of them lives in to protect them better.

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