Study on the Auditory Characteristics of Eurasian lynx

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Abstract: Lynx is a mammal in the cat family, endangered in Korea and mostly living in areas near Baekdusan and Gaema Plateau. It adapted to live in cold regions and is able to move rapidly in the snow. Hair on the ends of its ears helps its hearing and plays a significant role in detecting the direction of sounds. Lynx is usually solitary, forming its own territory in the forest, and is one of the apex predators in the wild. It usually rests during the day and hunts wide range of animals at dusk or night. In this research paper, the characteristics of the lynx's auditory senses are investigated. Long hair on the top end of its ears is used to distinguish sounds made by the prey from noise from the wind by using the sound that goes through the earflaps, the wind, and the senses on the hair. This paper investigates this method.

Keywords: Eurasian Lynx; Hearing of Eurasian Lynx; Sensors of Eurasian Lynx

1. Introduction

A lynx, also known as 'Eurasian lynx,' is a mammal in the cat family, approximately 90 cm long with relatively short tail of 20 cm. It is a wild animal facing extinction in South Korea due to reckless poaching for its fur with exquisite and rare patterns. Its head is relatively large and its ears are triangular with a cluster of long dark hair on their ends. There are whiskers similar to those of the tiger's on its cheeks. It has four sturdy legs, wide feet for fast movements on snow, and strong claws for easier tree-climbing. Moreover, it can jump more than thrice its height using its long and strong hind legs. The pupils in contraction are short oval in shape and the iris is light yellow in color. The body hair is soft, dense, and long. Its colors are variations of sandy, beige, rose, and maroon, with spots of brown or black. These spots are distinct in the summer but not in the winter. It lacks a pair of premolar tooth on the upper jaw compared to other cats[1].

The lynx is nocturnal and spends the day hiding under rocks or in thick undergrowth. The main method of hunting is stalking, sneaking and jumping on prey, although they are also ambush predators when conditions are suitable. In winter certain snow conditions make this harder and the animal may be forced to switch to larger prey. Eurasian lynx hunt using both vision and hearing, and often climb onto high rocks or fallen trees to scan the surrounding area. A very powerful predator, these lynxes have successfully killed adult deer weighing to at least 150㎏[2].

The lynx's cries, which are rarely heard, have frequencies wide and evenly distributed from low to high frequency. The gestation time of the lynx is about 70 days and it gives birth to one to two kittens in the spring. A newborn kitten has its eyes closed, opening them 10 days after birth, and stays with the mother for a year. The lynx has life expectancy of about 11 years. The Canada Lynx , which is similar to this species but slightly smaller with longer hair, lives in Canada and Alaska. The Eurasian lynx lives in plains, forests, and sometimes deserts in areas such as Korea, Europe, Turkey, Iran, the Himalayas, the northeastern China, Siberia, Sakhalin, and Kamchatka. It has been designated and protected as a first class endangered wildlife in South Korea on 31st of May, 2012, and is found in areas near Baekdusan and Gaema Plateau in North Korea. It is known that a few still lives in the Taebaek mountain range of South Korea but it has not been verified. Today, it is still designated as an endangered wildlife by the Ministry of Environment and restoration of lynxes in Seoraksan is in progress.

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In this paper, the sense of hearing, which has a significant impact in the lynx's hunting and other behaviors, is investigated. Moreover, modeling of the auditory senses and their characteristics are examined. In the second part of this paper, the appearance and behavior of the lynx are explored. In the third part, the characteristics of modeling of the auditory senses are examined through conventional modeling methods for auditory senses of other animals in the cat family. Conclusion will follow in part 4.

2. Appearance and Behavioral Features of the Lynx

2.1 Characteristics of the Lynx's Appearance and Cries

The Eurasian lynx is the largest lynx species, ranging in length from 80 to 130 cm and standing about 60–75 cm at the shoulder. The tail measures 11 to 24.5 cm in length [2]. Males usually weigh from 18 to 30 kg and females weigh 8 to 21 kg [3][4]. Male lynxes from Siberia, where the species reaches the largest body size, can weigh up to 38 kg or reportedly even 45 kg [5]. It has powerful, relatively long legs, with large webbed and furred paws that act like snowshoes. It also possesses a short "bobbed" tail with an all-black tip, black tufts of hair on its ears, and a long grey-and-white ruff[5].

During the summer, the Eurasian lynx has a relatively short, reddish or brown coat, which tends to be more brightly colored in animals living at the southern end of its range. In winter, however, this is replaced by a much thicker coat of silky fur that varies from silver-grey to greyish-brown. The underparts of the animal, including the neck and chin, are white at all times of the year. The fur is almost always marked with black spots, although the number and pattern of these are highly variable. Some animals also possess dark brown stripes on the forehead and back. Although spots tend to be more numerous in animals from southern populations, Eurasian lynx with heavily spotted fur may exist close to others with plain fur [6].

Figure 1 is the waveform and spectrogram of a lynx's cry. In the spectrogram, the main cry's basic frequency and resonance characteristics can be verified, main frequencies used in conversations between lynxes can be inferred from the corresponding frequency, and hearing of the lynx can be analyzed.

Figure 2 is the waveform and spectrogram of a lynx's cry. The cry in this part is meant for intimidation, expressing a cry closer to a voiceless sound than a voiced sound and making sounds in a wide range up to 2.8 kHz. Assuming the principal part of the sound made is at 2.8 kHz, it can be predicted that the primarily used auditory senses can hear broader range than the frequencies of the cry. Moreover, other experimental results have established that the lynx can hear sounds with frequencies up to 70 kHz.

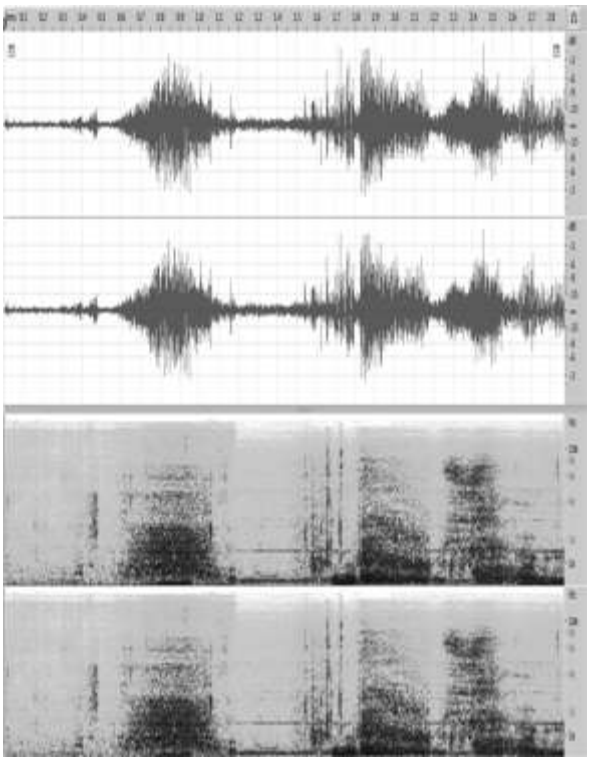

Fig. 1. Analysis Graph of a Lynx's Cry

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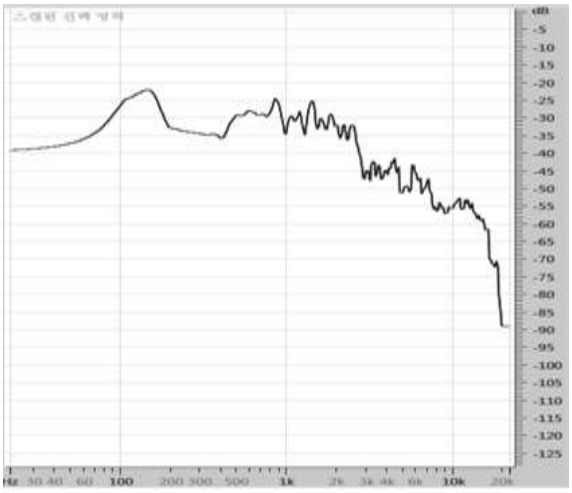

Fig. 2. Spectrum Analysis of a Lynx's Cry

Furthermore, the hairs on the end of the ears are about 48~54 mm long, dark brown in color with some white parts. The whiskers are white, thick, and sturdy. The skull is relatively short, with broadened upper cranium and reduced frontal area. Using the combination of senses on the hair on end of the ears with its hearing, the lynx exhibit exceptional hunting abilities.

2.2 Acoustical Analysis according to the Lynx's Behavioral Characteristics

The lynx is an enduring animal with four large and sturdy legs, which makes it easy for it to travel tens of kilometers. It can travel short distances rapidly, but becomes easily fatigued when covering long distances. It climbs trees well and jumps between trees to hide itself in the twigs. The lynx usually avoids water but may swim across wide rivers with relative ease when necessary. It roams around at dusk and dawn to look for food and is rarely active during the day. It spends most of the year near the location it has chosen, but may travel quite far to hunt when it has starved in hard winters or early springs. When it does, it may travel solitarily or in groups[1].

Looking into the acoustic characteristics of the lynx's movements, the four large and thick legs are hairy to support large area, which makes it suitable to make relatively small sounds from movements. Therefore, it has lower chance of being detected by the prey until it gets close enough. This makes the energy from movements be dispersed in large area, leading to reduced sound energy. Moreover, the lynx uses its hair on the ends of its ears and around its jaw to perceive and analyze sounds around it to decide whether it is a sound made by itself, the wind around its ears, or the prey's movements[2][3].

The lynx is nocturnal, so it uses combined hearing of the ears, hair on the ends of the ears, and hair around the jaw to hunt in the dark. By using its ears and the hair on their ends, it perceives the geographic features around it from the reflection of the sounds it made, locates the prey, and filters out other noises like the wind.

3. Modeling of Hearing through Ears of Other Cat

Previous studies have investigated the acoustic amplification phenomenon due to the shape of the earlobes and the tympanums of other species in the cat family by anatomical modeling of the auricle and the tympanum. Using these preceding research data, auditory characteristics of the lynx have been studied. The auricle of the lynx is 7~8 cm in width and 8~9 cm in length, which indicates that the first and second resonances occur at approximately 30 kHz, similar to other cats. Moreover, it can be inferred from the size of the torso and the head that it effectively amplifies and transmits sounds in the 50 kHz range[7].

A characteristic of the cries and other sounds made by the lynx gives additional estimations that the lynx can hear and perceive sounds up to 70 kHz. Furthermore, by using combined hearing from the ears and the hair on their ends, the sounds made by the objective can be distinguished from other noises like the wind.

Acoustic modeling of the sounds around the lynx's ear is as followed. The auricle of the lynx causes the wind to form a vortex which brings white noise into the earflap. Moreover, the hair on the end of the ear and around the jaw senses the effects of this vortex. The lynx hears by combining the sounds sensed by the ear with vibrations sensed by the hair on the ear and the jaw. If the sounds sensed by the hair and ear are identical, the sound would have been one made by itself or by the wind. Sound made by the prey, on the other hand, is sensed only by the ear. The lynx waits and hunts by analyzing the

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sounds made by the prey. These are the major features of the lynx's auditory senses.

4. Conclusion

In this research, characteristics of the auditory senses of the lynx have been studied. The auditory organs of the lynx function by combining the hearing from conventional ears with senses by the hair on the end of the ears. The noise of the vortex formed by wind around the ears has qualities of white noise and is recognized by the lynx. However, by combination of the two sensory organs, it filters out white noise of the wind and the wind made by its own movements to hunt effectively at night by detecting only the sounds made by the prey. Moreover, the hearing of the lynx was estimated by calculating the primary frequencies through modeling of the auricle and the tympanum.

The lynx survives and maintains its position as an apex predator in the jungle or the wild by using auditory senses in very wide range combined with senses of the hair on the ends of the ears. However, it needs protection as its population has drastically decreased due to overhunting for the beauty of its fur. The lynx, a wild animal with a distinct hearing ability, should be well protected.

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