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Vocal interaction between Eurasian Eagle-Owl *(Bubo bubo)* and canines (Carnivora, Canidae)

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Abstract We recorded vocal interaction in the natural environment of an Eurasian Eagle-Owl *(Bubo bubo)* with canines Gray Wolves *(Canis lupus)*, Red Foxes *(Vulpes vulpes)* and domestic dogs *(Canis familiaris)*. Vocalization was recorded using Olympus digital voice recorders. The calls of the male Eurasian Eagle-Owl were recorded by us in the frequency range of 200–420 Hz. The howl of a Gray Wolf was recorded in the frequency range from 300 to 1,100 Hz. Red Fox barking was recorded in the frequency range from 750 to 1,000 Hz. Barking of domestic dogs was recorded in the frequency range from 250 to 1,500 Hz. The vocalization of the Eurasian Eagle-Owl had an independent character inherent in the biology of the species. The Eurasian Eagle-Owl, with its cries, involuntarily provoked the entry of canines into joint vocal interaction, which can be explained by the high social activity of the latter. Co-vocalizations of the Eurasian Eagle-Owl and canines were noted in winter, spring and autumn, but mainly in spring (50%). The increased use of autonomous voice recorders, which record spontaneous vocalizations emitted by animals over long periods, will allow us to better document and study the importance of such interspecific interactions.

Keywords: *Bubo bubo, Canis lupus, Vulpes vulpes, Canis familiaris*, vocalization, predators

Összefoglalás Vokális kölcsönhatást vettünk fel az uhu *(Bubo bubo)* természetes élőhelyén szürke farkasokkal *(Canis lupus)*, vörös rókákkal *(Vulpes vulpes)* és kutyákkal *(Canis familiaris)*. A vokalizáció rögzítését Olympus digitalis hangfelvevővel végeztük. Az általunk felvett hím uhu hangok 200–400 Hz frekvencia között voltak. A szürke farkas üvöltése 300–1100 Hz közötti frekvenciatartományban, a vörös róka ugatása 750–1000 Hz közötti frekvenciatartományban, a kutya ugatása 250–1500 Hz közötti frekvenciatartományban lett felvéve. Az uhu vokalizációjának független jellege volt a faj biológiájából következően. Az uhu a kiáltásaival akaratlanul arra késztette a kutyaféléket, hogy közös vokális interakcióhoz csatlakozzanak, ami az utóbbiak magas szociális aktivitásával magyarázható. Az uhu és a kutyafélék együttes hangadása ősztől tavaszig, de leginkább tavasszal (50%) lett rögzítve. Az automatikus hangfelvevők növekvő használata, amelyek hosszú időszakon keresztül veszik fel az állatok spontán vokalizációját, lehetővé teszi számunkra, hogy jobban dokumentáljuk és tanulmányozzuk ezeknek a fajok közötti kölcsönhatásoknak a fontosságát.

Kulcsszavak: *Bubo bubo*, *Canis lupus*, *Vulpes vulpes*, *Canis familiaris*, vokalizáció, ragadozók

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Introduction

Acoustic communication plays an important role in the life of birds (Kumar 2003), including birds of prey (Catchpole & Slater 2008). Birds of prey use vocal signals for various purposes. The vocal activity of birds can change under the influence of habitat conditions: season, meteorological factors, and biotic connections. But the biological characteristics of the bird itself are of significant importance: sex, age, physiological state. The vocalization of birds of prey is more often aimed at attracting sexual partners or is a signal for conspecifics to protect the territory. Among conspecifics, males often give vocal signals in order to mark the boundaries of their territories. More often, interspecific co-vocalizations between owls are known in the literature (Mikkola & Mikkola 2022). Acoustic communication in nature can be recorded between different types of predators. Vocal interactions can also occur between birds and mammals (Caro 2005, Aubin & Mathevon 2020). This happens very rarely and needs special attention from scientists. The relationship between predatory owls (Strigidae) and mammals, in particular species from the canine family (Canidae), is of great interest, because representatives of these taxa are among the most actively vocalizing. Nevertheless, there are very few facts of joint voice interactions in literary sources. In particular, co-vocalizations between the Great Horned Owl *(Bubo virginianus)* and the Gray Wolf *(Canis lupus)* were noted in Yellowstone National Park (Domken *et al.* 2021). In addition, during the reproductive period of wolves in the Iberian Peninsula, V. Palacios and B. Marty-Domken noted territorial calls and aggressive behavior of the Tawny Owl *(Strix aluco)* towards researchers who imitated the vocalization of a predator (Domken *et al.* 2021).

A number of works are devoted to the study of the vocalization of a rare bird of prey – the Eurasian Eagle-Owl *(Bubo bubo)* (for simplicity referred to as Eagle Owl in the text (Penteriani 1999, 2001, 2002, Delgado & Penteriani 2007, Lapshin *et al.* 2018), but so far in the literature available to us no joint vocal activity of this large owl with mammals was noted. There is an opinion that when the cry of an owl or the howl of a wolf is heard in the forest, all other birds and animals calm down. This is well explained from the standpoint of the suppression of the activity of smaller competing species of owls. In most forests of Eurasia, these two species of predators can be at the top of the vocal hierarchy among birds and mammals, respectively. However, the existence of vocal relationships between these predators is unknown, so this is of undoubted relevance from the standpoint of competitive relationships.

Therefore, the purpose of this study was to characterize the joint vocal activity of the Eagle Owl with predatory mammals: Gray Wolf, Red Fox *(Vulpes vulpes)*, domestic dog *(Canis familiaris)* in Mordovia (Middle Volga region). The main objectives of this study were to describe the cases of co-vocalizations of animals and to assess the influence of situational parameters (temperature, wind strength, cloudiness and atmospheric pressure) on them. The latest data are of great importance for understanding and predicting the frequency of registration of such interspecies interactions. We predict that canines show a specific vocal reaction to the calls of the Eagle Owl.

Material and Methods

Study site

Voice activity of the animals was recorded year-round in various districts of the Republic of Mordovia (53º38' – 55º11'N and 42º11' – 46º45 'E) *(Figure 1)* in 2016–2023. The research covered the following districts: Bolshebereznikovsky, Chamzinsky, Dubensky, Atyashevsky,

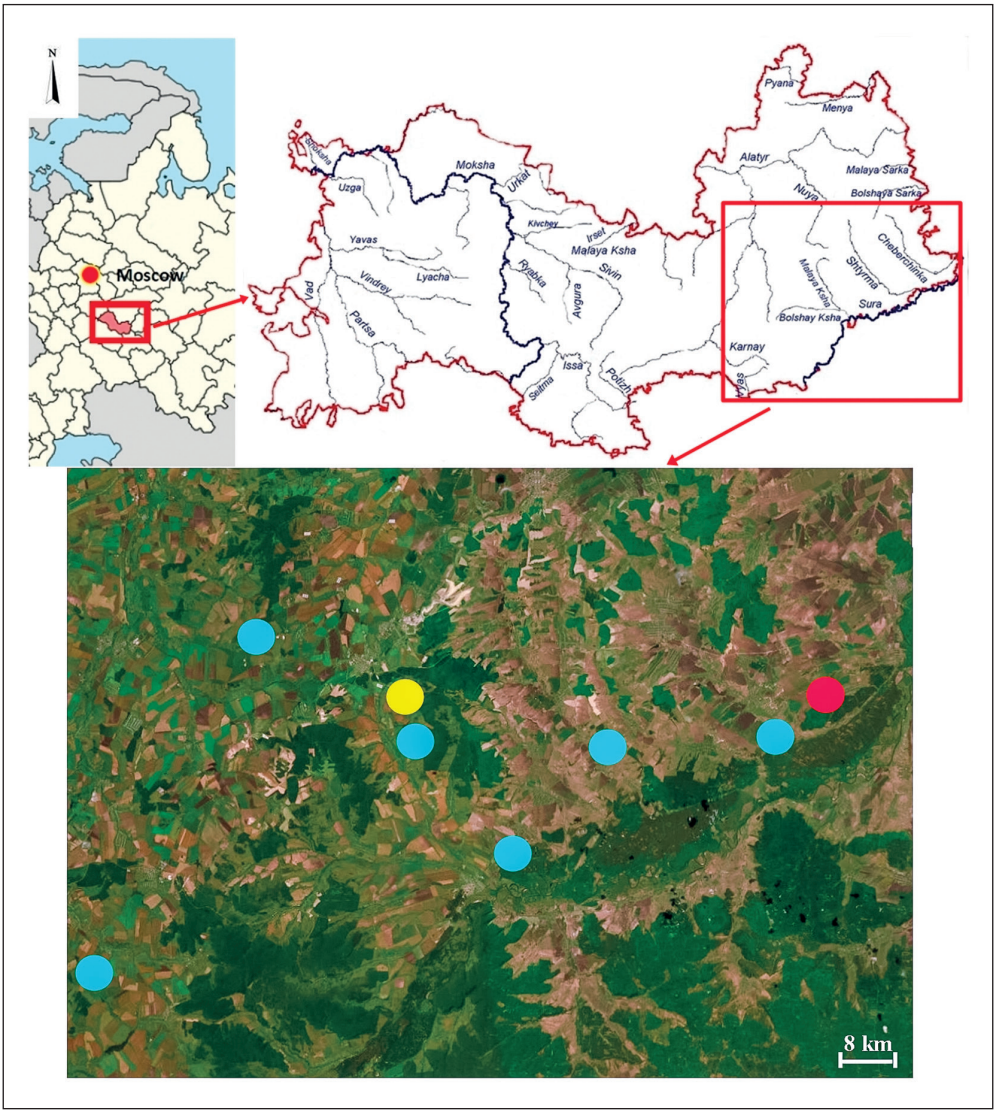

Figure 1. Map of the Republic of Mordovia with co-vocalizations registration points of Eagle Owl (red circle – with a Gray Wolf, yellow circle – with a Red Fox, blue circle – with a domestic dog)

1. ábra Mordvinföld térképe az uhuval történő közös hangadás felvételi pontjaival (piros kör – egy szürke farkassal, sárga kör – egy vörös rókával, kék kör – egy kutyával)

Table 1. Number of audio recordings containing the calls of different animal species
1. táblázat A felvételek száma, melyek a különböző állatfajok hangjait tartalmazzák

Species	Districts											
	Bolsheberezniko vsky	Chamzinsky	Dubensky	Atyashevsky	Ardatovsky	Kovylkinsky	Kadoshkinsky	Kochkurovsky	Ruzaevsky	Lyambirsky	Romodanovsky	Saransk
B. bubo	87	12	63	8	11	7	5	15	–	–	–	21
C. lupus	4	2	3	1	3	–	–	3	–	–	–	–
V. vulpes	6	4	2	2	2	1	1	3	2	1	1	1
C. familiaris	90	52	84	17	11	5	6	24	12	6	11	44
B. bubo and *C. lupus*	–	–	1	–	–	–	–	–	–	–	–	–
B. bubo and *V. vulpes*	–	1	–	–	–	–	–	–	–	–	–	–
B. bubo and *C. familiaris*	2	2	1	–	–	–	–	1	–	–	–	–

Ardatovsky, Kovylkinsky, Kadoshkinsky, Kochkurovsky, Ruzaevsky, Lyambirsky, Romodanovsky and suburbs of the city of Saransk *(Table 1)*. The distance between the research points ranged from 4 to 190 km. The climate of the region is continental with pronounced seasons throughout the year. The average annual air temperature varies from 3.5 to 4.0 °C. The average annual precipitation in the territory is 480 mm.

Data collection

The material for this article was the audio recordings of the vocalization of the animals obtained using Olympus VN-416PC, VN-406PC, VN-712PC autonomous recording units, as well as direct recordings on the ground. The sampling frequency of these voice recorders is 8–44.1 kHz. Bitrate 5–320 kbps. The recommended recording mode is WMA 5 kbps (mono), the recording level is high. The frequency range is from 70 to 19,000 Hz. Recording media: Internal flash memory – 4 GB + memory card up to 32 GB if needed. This technique of recording vocalization was developed and tested by us earlier on different animal species (Andreychev 2019, Andreychev *et al*. 2020, 2022). Voice recorders were placed in a camouflage device made from a sawn-off tree branch with a cavity inside for a recorder. Then they were placed on the edge of the forest, where Eagle Owls live. The distance between the recorders was at least 4 kilometers. This minimum distance for placing voice recorders was chosen because in our previous studies (Andreychev *et al.* 2017, Lapshin *et al.* 2018) it was proved that the vocalization of the Eagle Owl in the absence of wind extends to this distance from the calling Eagle Owl. If an Eagle Owl vocalize between the two recorders, its sound is recorded by both recorders. Moreover, on the voice recorder where the loud recording was received, it indicates the proximity of a

screaming bird. We used this circumstance when searching for nests. Voice recorders were installed in the daytime for 3–5 days. The maximum duration of continuous operation of voice recorders was about 140 hours. By the time the previous recording was finished, we would arrive and move the recorder to a different location. More than 10,000 h of audio recordings were processed each year. Most of them were made during the spring-summer period (more than 7,000 h/1 year).

Data analysis

Initially, the received audio recordings from voice recorders were converted in the Sony Sound Forge Audio Studio 7.0 (2003) program from WMA to WAV format and divided into short audio recordings of 70 hours each. The obtained audio records were processed with the use of the Avisoft-SASLab Pro 5.3.2-16 (2023) and Audacity 2.1.1 (2015) programs. With the help of these acoustic programs, it is possible to quickly identify animal calls.

The duration of individual periods of vocalization was determined. The possible influence on vocal activity of weather conditions (temperature (°C), wind speed (m/s) and direction of the wind, precipitation in the form of rain or snow, cloud cover (%), atmospheric pressure (mm Hg)) was revealed. To characterize the climatic conditions, we used data from a weather station Bolshie Berezniki (http://rp5.ru; http://nuipogoda.ru).

Data analysis was performed using MS Excel (Microsoft Corporation, Redmond, Washington, DA, USA). For proportions, 95% confidence interval (CI) was calculated using Quantitative Parasitology software, Qpweb version 1.0.15 (https://www2.univet.hu/qpweb/qp10/index.php).

Results

During the research period, 610 expeditions were carried out, 892 sound recordings were obtained and processed, with a total length of more than 82,000 hours. For all the time, 29 records were identified with co-vocalizations of the Eagle Owl with other animal species. Of these, 8 records (27.6%) of Eagle Owl calls with mammals *(Figure 2)* and 21 records of Eagle Owl calls with different species of birds (Ural Owl *Strix uralensis*, Tawny Owl, Long-eared Owl *Asio otus*, Tengmalm's Owl *Aegolius funereus*, Hooded Crow *Corvus cornix*, Common Raven *Corvus corax*, European Cuckoo *Cuculus canorus*, Common Crane *Grus grus*, European Nightjars *Caprimulgus europaeus*). Of the total number of co-vocalizations of the Eagle Owl, 6 records (20.7%) were registrations of the calls of the Eagle Owl with domestic dogs, 1 case each with a Gray Wolf and a Red Fox *(Figure 2)*. The frequency of registration of joint voice activity with domestic dogs can be explained by the fact that the nests of some pairs of Eagle Owls in the region were located in ravine-gully systems near settlements within about 1 km. Therefore, joint vocal interactions of the Eagle Owl and dogs are often noted. Even before the use of voice recorders, we often heard screaming owls at their characteristic pace against the background of barking dogs in the village. The frequency range of the calls of the male Eagle Owl is 200–420 Hz (328±34 Hz), the female is 400–550

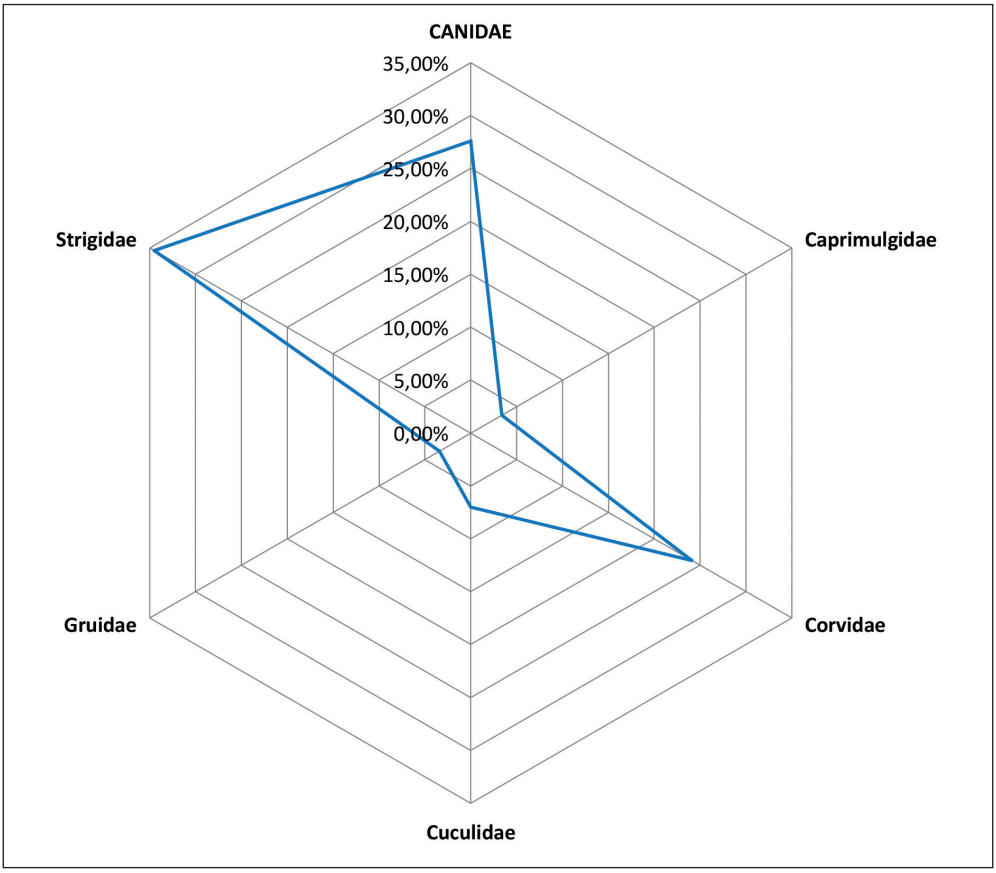

Figure 2. Ratio of co-vocalizations of Eagle Owl with other animals from different families of mammals and birds

2. ábra Az uhu együttes hangadásának aránya más állatokkal különböző emlős és madár családokból

Hz (455±18 Hz). The duration of the Eagle Owl's call is about 0.7 s, the frequency of calls usually varies with a frequency of 1 call in 5–10 s.

The vocal interaction between the Eagle Owl and the Gray Wolf was noted in the vicinity of the village Purkaevo (Dubensky district) October 17, 2016. Co-vocalizations was recorded from 23:56 to 23:59. The male Eagle Owl was the first to enter into joint vocal interaction, 20 seconds after the next call of the Eagle Owl, the Gray Wolf howled, which lasted 4 minutes. The howl of a Gray Wolf was recorded in the frequency range from 300 to 1,100 Hz *(Figure 3)*. The interval between continuous series of howls was 15 seconds. The Eagle Owl continued to scream against the background of the howl of the Gray Wolf. After the Gray Wolf stopped howling, the Eagle Owl continued to call for several minutes. Probably the Gray Wolf entered into acoustic interaction with the Eagle Owl under the influence of the latter on him as an irritant. Similarly, the Eagle Owl can be provoked to respond to the imitation of his calls by the accountant.

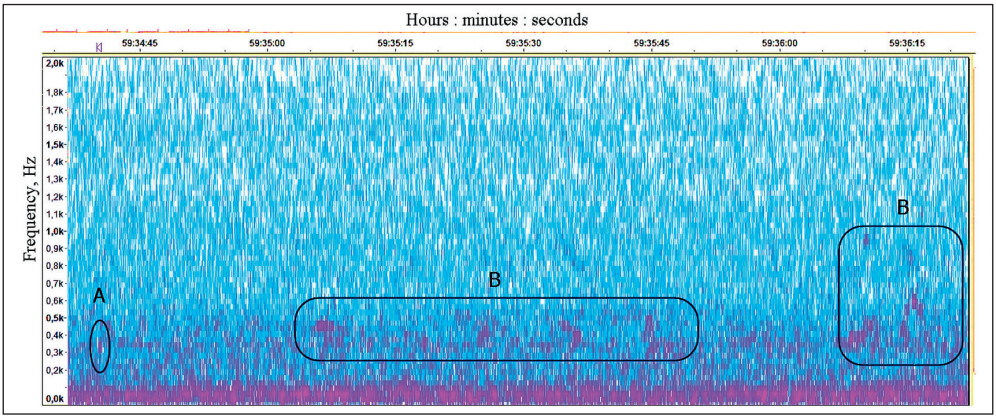

Figure 3. Spectrograms of the calls of the Eagle Owl (A) and Gray Wolf (B)
3. ábra Uhu (A) és szürke farkas (B) hangjainak spektrogramja

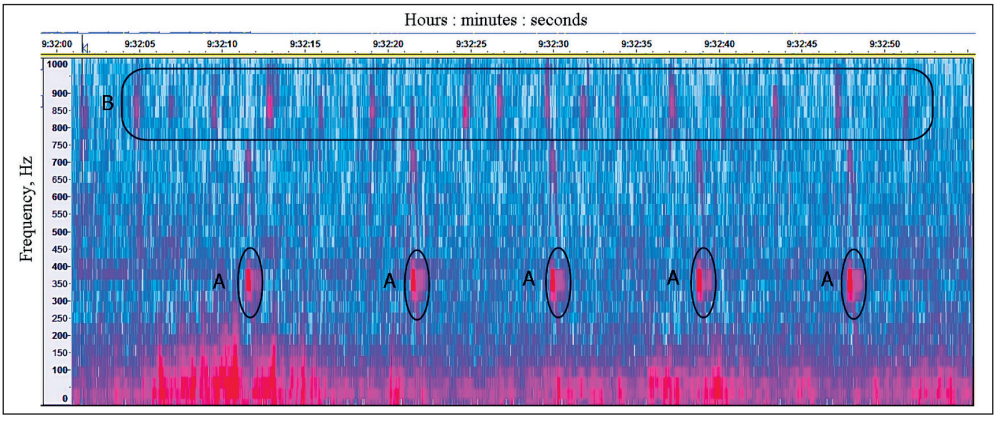

Figure 4. Spectrograms of the calls of the Eagle Owl (A) and Red Fox (B)
4. ábra Uhu (A) és vörös róka (B) hangjainak spektrogramja

Co-vocalizations of the Eagle Owl and Gray Wolf were observed in the temperature range from 0 to +3 °C. Joint calls were recorded at wind from 1 to 2 m/s, cloudiness from 10 to 20%, pressure from 764 to 766 mm Hg.

Joint calls of the Eagle Owl and Red Fox were noted in the vicinity of the village Ivanova Polyana (Chamzinsky district) March 3, 2020. Co-vocalizations were recorded from 19:49 to 19:52. This time interval indicates that the Red Fox was not at the hole during the barking. This is known from our previous studies using camera traps (Andreychev *et al.* 2015). The Red Fox and the Eagle Owl called simultaneously without interruption. Thirty-nine calls of Red Fox and twenty-six calls of Eagle Owl were recorded. Red Fox barking was recorded in the frequency range from 750 to 1,000 Hz *(Figure 4)*. Co-vocalizations were observed in the temperature range from +1 to +3 °C. Joint calls were recorded at wind from 1 to 3 m/s, cloudiness from 10 to 30%, pressure from 754 to 756 mm Hg.

Joint calls of an Eagle Owl and a domestic dog were noted in the vicinity of the village Bolshie Berezniki near the Bolshebereznikovsky boarding school for the elderly and

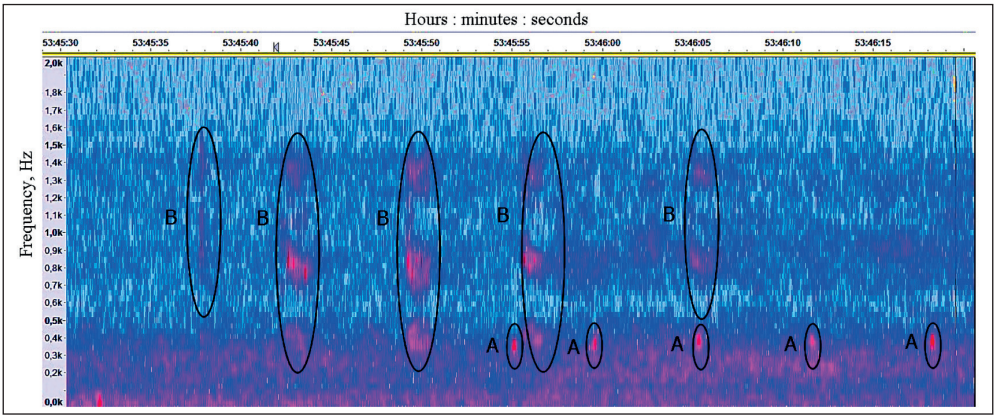

Figure 5. Spectrograms of the calls of the Eagle Owl (A) and domestic dog (B)
5. ábra Uhu (A) és kutya (B) hangjainak spektrogramja

disabled (Bolshebereznikovsky district), village Parakino (Bolshebereznikovsky district), village Picheury (Chamzinsky district), village Makolovo (Chamzinsky district), village Nikolaevka (Dubensky district), village Bulgakovo (Kochkurovsky district). We recorded dogs barking in the frequency range from 250 to 1,500 Hz *(Figure 5)*. Vocal interaction was recorded on January 18, 2018, February 3, 2020, March 4, 2020, March 10, 2022, March 16, 2022, and September 9, 2018. Eagle Owls and domestic dogs showed vocal activity together at 18:10, 20:05, 20:17, 21:02, 21:38, and 03:20. It should be noted that the voice activity of the Eagle Owl and dogs is independent. For example, when an Eagle Owl called during the barking of dogs, they did not stop barking when they heard it. Another situation was when the dogs barked in the village against the background of the calls of the Eagle Owl, which continued its vocalization. It seemed that each animal showed its vocal activity, not paying attention to other cries. Joint calls were observed at an average temperature of +2 ± 7.3 °C (CI = -18 ± 1 °C). Joint calls were recorded at an average wind strength of 1 ± 1.4 m/s (CI = 0–4 m/s), cloud cover of 20 ± 6.9% (CI = 10–30%), pressure of 754 ± 4.63 mm Hg (CI = 728–764 mm Hg).

Co-vocalizations of the Eagle Owl and canines were noted in winter, spring and autumn, but mainly in spring (50%). At the same time, the share of recordings with calls from the total number of recordings by season was taken into account. The predominance of co-vocalizations in the spring period is primarily due to the pre-incubation and incubation periods of the Eagle Owl. After comparing the intervals of values of environmental factors (temperature, pressure, cloudiness, wind strength) during the registration of co-vocalizations and all manifestations of factors during the years of research, it was revealed that duets of the Eagle Owl and canines are recorded in a certain tolerant range. In particular, in relation to the temperature factor, co-vocalizations was recorded of +3 ± 7.6 °C (CI = -18–+11 °C), while the range of annual temperatures varied from -26 to +34 °C. The atmospheric pressure factor during co-vocalizations were recorded of 756 ± 5.11 mm Hg (CI = 728–764 mm Hg), while the range of pressure fluctuations in the year varied from 714 to 783 mm Hg. The cloudiness factor during co-vocalizations were recorded of 20 ± 6.5% (CI

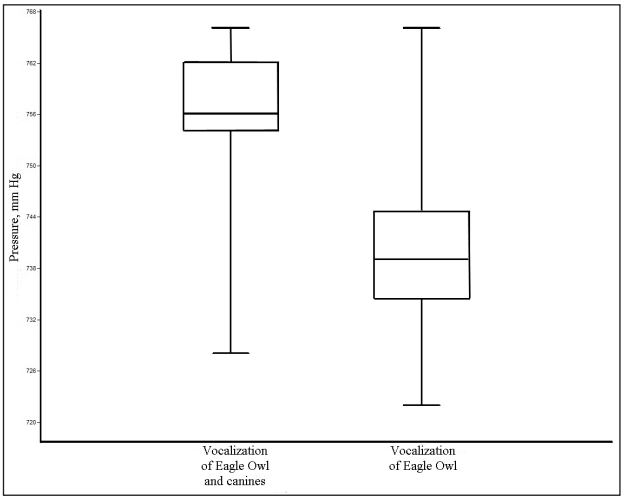

Figure 6. Ranges of atmospheric pressure in which vocalization was recorded for the Eagle Owl and canines and for the Eagle Owl alone

6. ábra A légnyomás tartománya, amelyben az uhu és a kutyafélék, illetve csak az uhu vokalizációja rögzítésre került

Note: 'strip on box' is the median, the boundaries of the box are 25–75% quantiles, whiskers – minimum and maximum values.

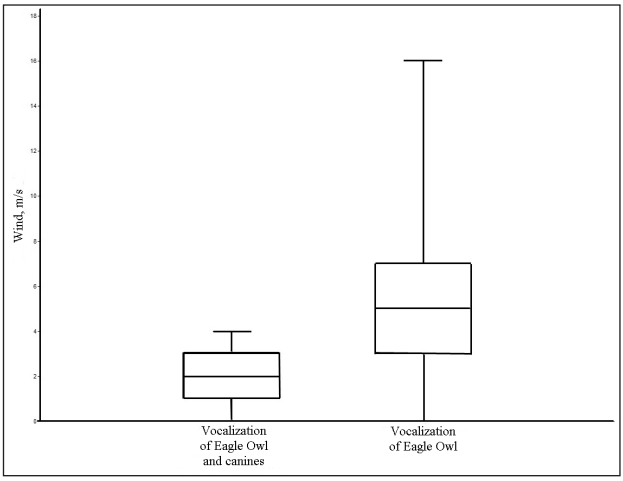

Figure 7. Ranges of wind speed in which vocalization was recorded for the Eagle Owl and canines and for the Eagle Owl alone

7. ábra A szélsebesség tartománya, amelyben az uhu és a kutyafélék, illetve csak az uhu vokalizációja rögzítésre került

Note: 'strip on box' is the median, the boundaries of the box are 25–75% quantiles, whiskers – minimum and maximum values

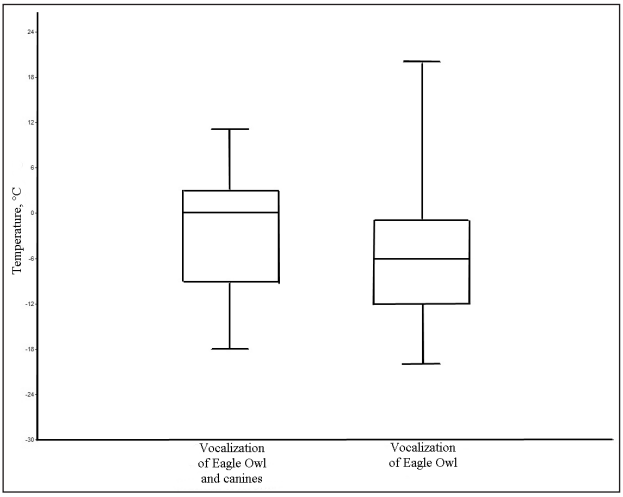

Figure 8. Ranges of temperature in which vocalization was recorded for the Eagle Owl and canines and for the Eagle Owl alone

8. ábra A hőmérséklet tartomány, amelyben az uhu és a kutyafélék, illetve csak az uhu vokalizációja rögzítésre került

Note: 'strip on box' is the median, the boundaries of the box are 25–75% quantiles, whiskers – minimum and maximum values.

= 10–30%), while the cloudiness varied from 0 of 100% throughout the year. The wind during co-vocalizations were recorded of 2 ± 1.1 m/s (CI = 0–4 m/s), while the wind varied from 0 of 17 m/s throughout the year. It should be noted the values of the parameters of meteorological conditions (atmospheric pressure *(Figure 6)*, wind *(Figure 7)* and temperature *(Figure 8)*), at which the co-vocalizations of the Eagle Owl with canines, and exclusively the vocalization of the Eagle Owl, was recorded. This may have practical implications for science in subsequent studies.

Discussion

In our work, we have received the answer of a Gray Wolf with a howl to the call of an Eagle Owl. It was like imitating the «hu-hu-hu» of an Eagle Owl. It is known that wolves respond to the howl of their conspecifics or the wailer on the hunt. They can also respond to other sources of sound, such as a horn (Palacios *et al.* 2017, Domken *et al.* 2021). This can be explained by the similar acoustic structure of all these sounds, namely, they are long and harmonic with a close frequency range. They use howling to communicate over long distances. In particular, wolves use vocalizations to transmit information about pack members, their location, or boundaries of spatial subunits (Harrington & Asa 2003, Palacios *et al.* 2007, Zaccaroni *et al.* 2012, Watson *et al.* 2018). The howl of wolves shows plasticity according to the situations (Theberge & Theberge 2022). According to the literature, the main frequency of Gray Wolf howling is usually in the range from 150 to 1,300 Hz in adults (Tooze *et al.* 1990, Feddersen-Petersen 2000, Zaccaroni *et al.* 2012, Root-Gutteridge *et al.* 2014, Sadhukhan *et al.* 2019).

The registration of the calls of the Eagle Owl and the wolf in the autumn period indicates that they cannot be attributed to reproductive vocalization. With regard to the Great Horned Owl and the Gray Wolf, the researchers recorded vocal interaction at the end of August, i.e. also not during the breeding season (Domken *et al.* 2021). They make the assumption that the wolves were young, because they are characterized by a high probability of responding to acoustic stimulation (Harrington & Mech 1979). Another important message is that wolves show the greatest vocal activity throughout the year in August, October, and July (Nowak *et al.* 2007). It is also known that during the day the maximum vocalization of wolves is recorded from 22:00 to 00:00 (Theuerkauf *et al.* 2003). This explains the time interval for recording the joint vocal activity of the wolf and the Eagle Owl in our work. For the Eagle Owl, on the contrary, the nighttime vocal activity is noticeably weaker than the evening one (Lapshin *et al.* 2018, Palacios *et al.* 2022), which indicates a discrepancy between the daily acoustic activity of the two species and explains the rarity of joint duets in nature. However, the wolf and the Eagle Owl are forced to interact in an acoustic signal environment, since their vocal activity can be timed to coincide with sunset and sunrise (Lapshin *et al.* 2018, Palacios *et al.* 2022). Thus, these two predators are quite active in terms of vocalization not only in relation to conspecifics, but also to other competitor species. This circumstance is decisive in the formation of a joint vocal repertoire between species.

Darden and Dabelsteen (2006) believe that Swift Fox *(Vulpes velox)* bark when threatened. This is in good agreement with our results on the co-vocalizations of the Red Fox and the Eagle Owl, since the Eagle Owl called often in the spring day, and the fox joined him. The calls of the Eagle Owl in this case can be considered provocative vocalization of the fox, because no response calls from another Red Fox were noted. These calls were directed precisely at the calls of an Eagle Owl. The fox probably perfectly heard the Eagle Owl, because it is known that the absolute hearing sensitivity of the Red Fox is one of the best among mammals and varies in the range from 51 Hz to 48 kHz (Isley & Gysel 1975, Malkemper *et al.* 2015). In its natural habitat, the fox made sounds with a lower frequency in the presence of Eagle Owl calls. In comparison, the frequency of the sounds of unselected Red Foxes 2 times higher (Mukhamedshina *et al.* 2019). The influence of Eagle Owl calls on the vocalizations of foxes and wolves is similar. For the Red Fox, as for the Gray Wolf, social contacts play an important role in their ecology (White & Harris 1994).

As for the entry of canines into joint vocal interaction with the Eagle Owl, this can be explained by their provocation by its calls. Canids are socially active animals, so they tend to interact not only with conspecifics, but also with other species. The frequency range of dog barking recorded by us is consistent with the data of Feddersen-Petersen (2000).

Thus, the joint vocal activity of the Eagle Owl and carnivorous mammals from the canine family has different reasons for its occurrence. The Eagle Owl is invulnerable to wild canines (Gray Wolf and Red Fox). Although they may be its competitors in the same territories, primarily for rodents and hares. Therefore, the vocalization of the Eagle Owl occurs mainly in spring and autumn in the traditional manner reported earlier (Lapshin *et al.* 2018), regardless of the presence and vocalization of wolves, and especially foxes. With regard to domestic dogs, the Eagle Owl does not pay any attention to their barking, which is actually confirmed by the greater frequency of joint vocal interactions. Our results serve as a starting point for further study of the relationship between the Eagle Owl and canines based on acoustic activity.

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