

New data on the bats (Mammalia: Chiroptera) of the Drinos Valley, Vjosa Wild River National Park Southern Albania

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Abstract. Albania's bat fauna is rich but still poorly studied and subject to numerous pressures. One immediate pressure includes the plans to build hydroelectric dams on the Vjosa River and its tributaries, recently classified as a national park. This study was part of an international movement to improve knowledge of both a taxonomic group and a geographical area that have not been studied extensively, to take them into account for conservation purposes. In June 2022, 15 passive bat acoustic sampling sites were set up in four distinct sectors along the Drinos and Suha Rivers, two tributaries of the Vjosa. The Drinos River was included within the national park boundaries in 2023. These recordings were analyzed using automatic identification software and manually verified. Our study identified 16 of the 32 species known to occur in Albania, of which four had fewer than 25 previous records in Albania: *Myotis bechsteinii*, *Myotis emarginatus*, *Myotis nattereri* and *Rhinolophus blasii*. Our results highlight a high level of activity observed at the sampling sites and the importance of alluvial and riparian hydroecosystems for bats. This study supports the need to take bats into account in the management plans and projects of the Vjosa Wild River National Park. It also produced 135 additional bat records for the country, adding to the 1243 national records.

Key words: Albania, bats, Drinos Valley, Vjosa Wild River National Park

Introduction

The Balkans are part of the Mediterranean biodiversity hotspot (Myers et al., 2000). The region is home to a wide variety of mammals, particularly bats, with 39 species recorded (Benda et al., 2003, 2019; Georgiakakis et al., 2023; Karapandža et al., 2014; Karapandža & Paunović, 2010; Pavlinić et al., 2010; Presetnik et al., 2014) amongst the 55 species known in Europe (Eurobats, 2025).

Albania is home to 32 species of bats (Sachanowicz & Ciechanowski, 2018; Théou & Bego, 2018). This richness is due to highly varied geographical features and a significant altitudinal gradient that results in varied climates and a wide diversity of landscapes (Borelli & Varela, 2001). The limestone geology also provides numerous natural cavities that are essential for several spe-

cies of bats. Furthermore, Albania's history contributes to this diversity. Traditional agriculture is still very much present, while the country's military past has left behind numerous structures (castles, blockhouses, tunnels, etc.) that are favorable to bats (Théou & Bego, 2018). The country also encompasses vast ecosystems, some of which have not been affected by land development projects.

This is particularly true of the Vjosa River and its tributaries, which form one of Europe's last remaining wild river hydroecosystems (Schiemer et al., 2020). This area was recently threatened by hydroelectric dam projects, and as a result, there was a significant mobilization of local people and the scientific community to protect this exceptional natural heritage (Puecker & Steger, 2023). In March 2023, the Albanian government classified

the Vjosa and four of its tributaries as the Vjosa Wild River National Park.

An international movement to improve scientific knowledge was launched ahead of the classification as part of the “Save the Blue Heart of Europe” campaign and is still ongoing. The aim was to promote the protection of the river and provide decision-makers with the knowledge they need to implement appropriate conservation policies. The present study is part of this initiative, with a focus on bats. Although the national diversity of bats is well documented (Benda et al., 2019; Sachanowicz et al., 2015; Sachanowicz & Ciechanowski, 2018; Théou & Bego, 2018), there are still significant knowledge gaps. The latest summary reports 1,243 data points at the national level (Benda et al., 2019), or an average of one data point per 28 km². Our study therefore, aims to contribute to improving knowledge of bats within the Vjosa Wild River National Park and surrounding area by: 1) describing the species present; 2) assessing the level of bat activity in the sampled hunting habitats.

Materials and methods

Acoustic sampling sites and sampling effort

In June 2022, a week-long field campaign was carried out by two of the authors (A. Olivier and M. Thibault) on the Drinos River and one of its tributaries, the Suha (Thibault & Olivier, 2022). Fifteen acoustic sampling sites were set up (Table 1). These were spread across four distinct sectors along a gradient starting from the lower valley of the Drinos River at an altitude of 150 meters and extending to the Suha River at an altitude of 250 meters (Fig. 1). Acoustic sampling targeted only the riparian hydroecosystem. Thirteen acoustic sampling sites were set up in the riverbed, either within the riparian forest, on the inner edge (at the interface between the riparian forest and the watercourse), or on the outer edge (at the interface between the riparian forest and the terrestrial environment) (Fig. 2). Two acoustic sampling sites were set up in the floodplain in hedgerows no more than 140 meters from the watercourse (Fig. 2).

Each sector had between three and five acoustic sampling sites. The recorders were installed between the evening of June 5, and the morning of June 9, when weather conditions for bat recording were favorable. The recordings lasted throughout the night, for a total recording time of 9225 minutes.

Equipment used for acoustic sampling

The study was conducted using passive ultrasonic listening. This method involves installing a device equipped with a microphone that records all ultrasonic sounds captured during the sampling period. The recorders used were Audio-moth 1.2.0 full-spectrum devices. Following the recommendation of the “VigieChiro - protocole Point Fixe” developed by the National Museum of Natural History of Paris, the sampling frequency was set at 250 kHz with a gain of 28.7 dB, no standby interval, and a recording time of 300 seconds per file. The devices were programmed to record sounds emitted at frequencies above 8 kHz. The microphones were positioned 1.8 meters above the ground. Recordings began half an hour before sunset and ended half an hour after sunrise. The recorded sounds were sequenced, compressed, and stored in WAV format on the recorder's memory cards.

Processing of recorded sequences

The raw ultrasonic sequences were processed using Kaleidoscope software (Wildlife Acoustics), which decompressed them and cut them into 5-second sound clips. The resulting files were then sent to the online portal “VigieChiro - protocole Point Fixe” set up by the National Museum of Natural History, Paris. The “Tadarida” algorithm was used to automatically identify the signals. This algorithm assigns each 5-second sequence to a species with an associated reliability index. Finally, the automatic identifications were manually verified using BatSound (Pettersson) software, which allows the sequences to be viewed as spectrograms. A sample of sequences for each species was verified to validate or invalidate the preliminary identifications provided by the “Tadarida” algorithm.

Qualitative analysis

A list of species was compiled based on the analysis of ultrasonic sequences. This analysis was carried out using the acoustic identification method for bats (Barataud, 1996, 2002, 2015; Russ, 2023). The criteria for ultrasonic identification of species are based on variations in frequency, duration, and power of the signal, as well as rhythm (Barataud, 2015; Obrist et al., 2004; Preatoni et al., 2005; Russo & Jones, 2002). The identification of *Myotis* remains the most problematic, as the

acoustic signals of these species are very similar. A large number of sequences cannot be identified

down to the species level, which is why some identifications stop at the group level (Table 2).

Table 1. Characteristics of the 15 acoustic sampling sites carried out.

Date	Acoustic sampling sites	Coord. X	Coord. Y	Start time	End time	Habitats
05/06/22	Viroi_26	20.12529	40.10512	19:30	05:45	Riparian forest
	Viroi_28	20.12491	40.10532	19:30	05:45	Riparian forest
	Viroi_29	20.12475	40.10487	19:30	05:45	Outer edge of riparian forest
06/06/22	Humelicë_28	20.08212	40.17275	19:30	05:45	Outer edge of riparian forest
	Humelicë_29	20.08250	40.17227	19:30	05:45	Riparian forest
07/06/22	Suhë_26	20.25897	40.06002	19:30	05:45	Inner edge of riparian forest
	Suhë_27	20.25807	40.06310	19:30	05:45	Outer edge of riparian forest
	Suhë_28	20.25636	40.05838	19:30	03:55	Inner edge of riparian forest
	Suhë_29	20.25842	40.06272	19:30	05:45	Riparian forest
	Suhë_30	20.25906	40.05991	19:30	04:10	Inner edge of riparian forest
08/06/22	Hormovë_26	20.08915	40.22625	19:30	05:45	Hedge along the main channel of the Drinos River
	Hormovë_27	20.08806	40.22893	19:30	05:45	Inner edge of riparian forest
	Hormovë_28	20.08820	40.22910	19:30	05:45	Riparian forest
	Hormovë_29	20.08817	40.22668	19:30	05:45	Hedge along the main channel of the Drinos River
	Hormovë_30	20.08762	40.22672	19:30	05:45	Inner edge of riparian forest

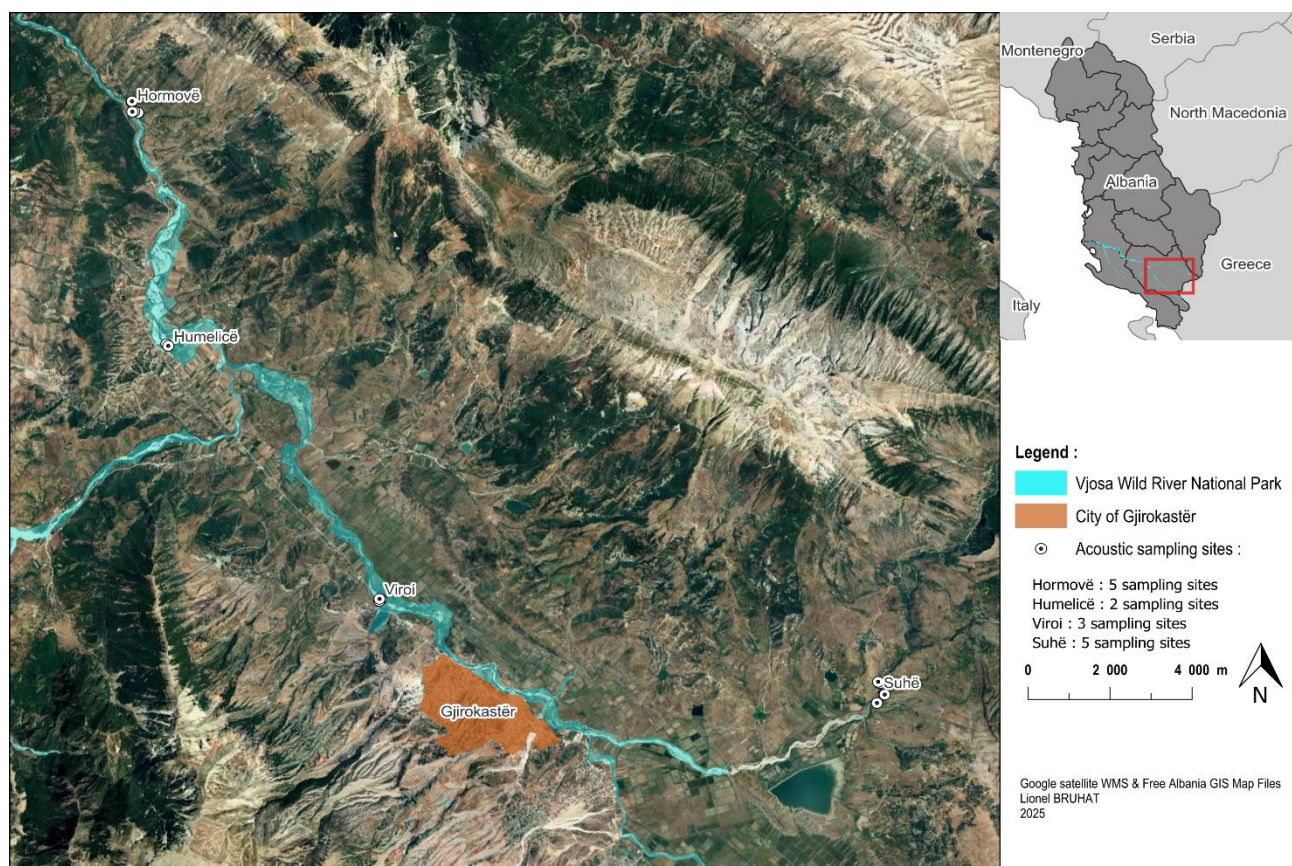


Fig. 1. Location of acoustic sampling sites.

**Hormovë****Humelicë****Suhë****Viroi****Fig. 2.** Photographic record of sampled habitats (© Anthony Olivier).**Table 2.** Taxa used to define ultrasonic activity levels.

Taxa used to define the level of ultrasonic activity	Included species
<i>Barbastella barbastellus</i>	-
<i>Hypsugo savii</i>	-
<i>Miniopterus schreibersii</i>	-
<i>Nyctalus lasiopterus</i>	-
<i>Pipistrellus kuhlii</i>	-
<i>Pipistrellus nathusii</i>	-
<i>Pipistrellus pipistrellus</i>	-
<i>Pipistrellus pygmaeus</i>	-
<i>Rhinolophus blasii</i>	-
<i>Rhinolophus euryale</i>	-
<i>Rhinolophus ferrumequinum</i>	-
<i>Rhinolophus hipposideros</i>	-
<i>Rhinolophus mehelyi</i>	-
<i>Tadarida teniotis</i>	-
Serotules group	<i>Eptesicus nilssonii</i> , <i>Eptesicus serotinus</i> , <i>Nyctalus leisleri</i> , <i>Nyctalus noctula</i> , <i>Vespertilio murinus</i>
<i>Pipistrellus</i> group	<i>Hypsugo savii</i> , <i>Miniopterus schreibersii</i> , <i>Pipistrellus kuhlii</i> , <i>Pipistrellus nathusii</i> , <i>Pipistrellus pipistrellus</i> , <i>Pipistrellus pygmaeus</i>
MyoLF group (Myotis Low frequencies group)	<i>Myotis myotis</i> , <i>Myotis blythii</i>
MyoHF group (Myotis High frequencies group)	<i>Myotis alcaethoe</i> , <i>Myotis bechsteinii</i> , <i>Myotis brandtii</i> , <i>Myotis capaccinii</i> , <i>Myotis daubentonii</i> , <i>Myotis davidii</i> , <i>Myotis emarginatus</i> , <i>Myotis nattereri</i>
<i>Plecotus</i> group	<i>Plecotus auritus</i> , <i>Plecotus austriacus</i> , <i>Plecotus macrobullaris</i> , <i>Plecotus kolombatovici</i>

Quantitative analysis and activity index

The Actichiro reference system (Haquart, 2013), based on the positive minute method, was used to assess the activity of bat species or groups of species. This reference system was constructed using activity values recorded in the French Mediterranean region in hunting habitats. A “positive” minute is a minute during which a bat species was encountered, regardless of whether it emitted ultrasound for 1 or 60 seconds. The Actichiro reference system makes it possible to assess and compare the intensity of activity of different species or groups of species based on the number of positive minutes recorded for each of them during a recording night. This method allows comparability between different studies/territories. The Actichiro reference system provides a table of activity values recorded in the French Mediterranean for each species or group of species. The activity level is defined based on threshold values set with reference quantiles: activity is considered “very low” if it is below the 2% quantile value; ‘low’ if it is between Q2% and Q25%; “medium” if it is between Q25% and Q75%; “high” if between Q75% and Q98%; “very high” if above Q98%. To obtain an activity level, the number of positive minutes obtained during each sampling night for a species or group of species is compared with the reference values.

In this study, activity levels were defined at the species or species group level (Table 2). This choice was based on the reliability of the “Tadarida” algorithm classification and the ease of ultrasonic identification. For example, it is difficult and time-consuming to identify *Myotis* species, so their activity level was limited to the species group level. Conversely, the activity level was determined at the species level for *Rhinolophus ferrumequinum* because these ultrasounds are reliably pre-identified by the algorithm and easily validated by the bioacoustician.

Results

Qualitative inventory

Biodiversity description and sampling effort

The 15 nights that were sampled enabled 16 species of bats and one additional group to be identified with certainty, while another species is probable (Table 3). This diversity corresponds to approximately 50% of Albanian chiropterofauna. The accumulation curve (Fig. 3) shows that the sampling effort deployed made it possible to describe a large part of the species presented during this period. After 12 nights of recordings, the curve tends towards the asymptote, while the associated confidence interval decreases.

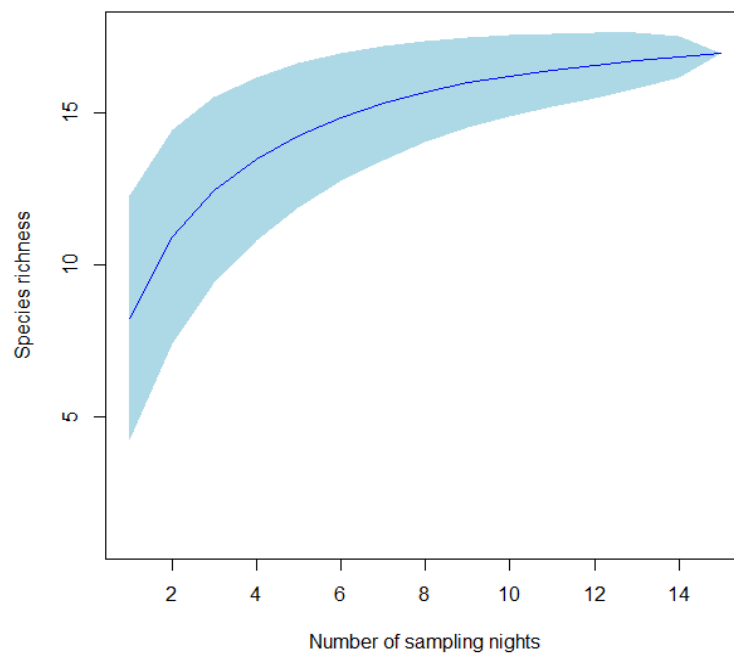


Fig. 3. Accumulation curve showing the variation in species richness (species identified with certainty) as a function of sampling effort. The 95% confidence interval is shown in light blue.

List of species

Sixteen species and one species group (*Plecotus* sp.) were identified with certainty (Table 3). In addition, one other species was probably identified: *Pipistrellus nathusii*. Other species may also have been encountered but could not be identified, either because current bioacoustic knowledge is insufficient to distinguish between them (as is the case here for certain ultrasonic sequences concerning *Rhinolophus hipposideros* and *Rhinolophus mehelyi*) or because the ultrasounds present were not

characteristic (as is the case between *Nyctalus lasiopterus* and *Tadarida teniotis*, and between *Myotis emarginatus* and *Myotis alcathoe*).

Among the species that have been confirmed, five are classified by the IUCN as vulnerable to extinction at the European level: *Miniopterus schreibersii*, *Myotis bechsteinii*, *Myotis blythii*, *Myotis capaccinii*, and *Rhinolophus blasii* (Table 3). In Europe, these species, except *Myotis bechsteinii*, have a Mediterranean affinity.

Table 3. List of species recorded during the study and status of each species. CR : Critically endangered; EN : Endangered; VU : Vulnerable; NT : Near threatened; LC : Least concern; DD : Data deficient; NE : Not evaluated.

Scientific name	Occurrence by sampling sites	Occurrence by sectors	Global Red List (2016)	European Red List (2023)
<i>Eptesicus serotinus</i>	4 / 15	3 / 4	LC	LC
<i>Hypsugo savii</i>	9 / 15	3 / 4	LC	LC
<i>Miniopterus schreibersii</i>	8 / 15	3 / 4	VU	VU
<i>Myotis bechsteinii</i>	1 / 15	1 / 4	NT	VU
<i>Myotis blythii</i>	3 / 15	3 / 4	LC	VU
<i>Myotis capaccinii</i>	3 / 15	3 / 4	VU	VU
<i>Myotis emarginatus</i>	10 / 15	4 / 4	LC	LC
<i>Myotis nattereri</i>	3 / 15	2 / 4	LC	LC
<i>Nyctalus leisleri</i>	14 / 15	4 / 4	LC	LC
<i>Pipistrellus kuhlii</i>	15 / 15	4 / 4	LC	LC
<i>Pipistrellus pipistrellus</i>	15 / 15	4 / 4	LC	LC
<i>Pipistrellus pygmaeus</i>	11 / 15	4 / 4	LC	LC
<i>Plecotus</i> sp.	3 / 15	1 / 4	-	-
<i>Rhinolophus blasii</i>	1 / 15	1 / 4	LC	VU
<i>Rhinolophus ferrumequinum</i>	13 / 15	4 / 4	LC	LC
<i>Rhinolophus hipposideros</i>	7 / 15	4 / 4	LC	LC
<i>Tadarida teniotis</i>	4 / 15	4 / 4	LC	LC
Unconfirmed identification				
<i>Pipistrellus nathusii</i>	1 / 15	1 / 4	LC	LC
<i>Myotis emarginatus</i> / <i>Myotis alcathoe</i>	1 / 15	1 / 4	-	-
<i>Myotis capaccinii</i> / <i>Myotis daubentonii</i>	4 / 15	4 / 4	-	-
<i>Myotis blythii</i> / <i>Myotis bechsteinii</i>	1 / 15	1 / 4	-	-
<i>Nyctalus lasiopterus</i> / <i>Tadarida teniotis</i>	1 / 15	1 / 4	-	-
<i>Rhinolophus hipposideros</i> / <i>mehelyi</i>	3 / 15	2 / 4	-	-

Notable species

Myotis bechsteinii

This forest bat species was positively identified at the "Hormovë_27" acoustic sampling site located in the riparian forest of the Drinos River, about ten meters away from the river course. One of the ultrasonic sequences includes social calls

known to be emitted in the immediate vicinity of the roost (Barataud, 2015). European populations of *Myotis bechsteinii* are considered to be in decline (Russo & Cistrone, 2023a). In Albania, the species is considered rather rare, with only 13 known locations in 2019, spread across the northern and southern regions of the country (Benda et al.,

2019). However, the species was already known to occur along the Vjosa (two locations) but had never been recorded along the Drinos.

Myotis emarginatus

This forest species was identified at 10 of the 15 acoustic sampling sites spread across all sectors. The ultrasonic sequences recorded correspond to hunting and transit behavior. Most of the sequences are characteristic of the species when it moves through foliage. European populations of *Myotis emarginatus* are considered to be non-threatened and increasing (Russo & Cistrone, 2023b). In Albania, however, the species is considered uncommon, with only 22 locations recorded in 2019 across the country. The species was already known to exist along the Drinos as a productive breeding colony. Around 60 individuals were recorded in Gjiro-kastër Castle, located just 3.5 kilometers from the Viroi sector (Benda et al., 2019).

Myotis nattereri

This bat was identified at 3 of the 15 acoustic sampling sites distributed across the Suhë and Hormovë sectors. These three acoustic sampling sites were located in riparian forests or on the forest edge. The recorded ultrasonic sequences correspond to hunting and transit behavior. *Myotis nattereri* is considered non-threatened in Europe, and its populations are assessed as increasing in several countries (Russo & Cistrone, 2023c). However, in Albania, the species is considered rather rare, with only 12 locations recorded (Benda et al., 2019). It was already known to occur at the confluence of the Vjosa and Drinos rivers (two locations) and in a cave in Goranxi, located about 1 kilometer from the Drinos River.

Rhinolophus blasii

This cave-dwelling bat was only encountered once, at the "Humelicë_28" acoustic sampling site located at the interface between the riparian forest and the Drinos River. The encounter was recorded at 2:30 a.m., during a transit phase. In Europe, its distribution area is limited to the Balkans and western Romania. The European population is considered fragmented and declining (Russo & Cistrone, 2023d). In Albania, the species is considered uncommon, with only 22 known locations in 2019, which are spread throughout the country, mainly at low and medium elevations (Benda et

al., 2019). *Rhinolophus blasii* was already identified near our study area. It has been observed roosting at the confluence of the Vjosa and Drinos Rivers (Benda et al., 2019) and has been encountered in a cave near the Drinos River southwest of Lake Doftisë (Sachanowicz & Ciechanowski, 2018).

Quantitative analysis

Total chiropterological activity and by taxon

The average chiropterological activity over all sampled nights was 334.5 ± 108.76 positive minutes. According to the Actichiro reference system, this corresponds to a "high" level of activity. At the local scale, the average chiropterological activity in each of the four sampled sectors is "high" and varies between 325.3 ± 103.6 and 346 ± 112.3 positive minutes, with no significant difference. Twelve of the 13 acoustic sampling sites located in riparian forests recorded a "high" level of activity, while the only two acoustic sampling sites located along hedges far from the watercourse recorded "moderate" levels of activity. The only acoustic sampling located in a riparian forest that recorded a "moderate" level of activity suffered from technical problems that stopped recording 1 hour and 50 minutes before the scheduled end time.

Chiropterological activity is largely dominated by *Pipistrellus kuhlii* and *Pipistrellus pipistrellus*, as well as by the "MyoHF group" (Fig. 4). These three taxa account for 87% of recorded activity. *Pipistrellus pygmaeus*, *Miniopterus schreibersii*, and the "Serotules group" account for most of the remaining chiropterological activity (10%).

According to the Actichiro reference system, bat activity during this period was "high" for a large number of taxa: *Rhinolophus ferrumequinum*, *Pipistrellus kuhlii*, *Pipistrellus pipistrellus*, *Miniopterus schreibersii*, as well as for the "MyoLF group," "Pipistrellus group," and "Serotules group" (Table 4). "Moderate" activity is recorded for *Rhinolophus hipposideros*, *Tadarida teniotis*, *Pipistrellus pygmaeus*, *Hypsugo savii*, and the "Plecotus group." The "MyoLF group," on the other hand, has "low" activity, while the activity of *Rhinolophus blasii* could not be classified due to a lack of references (Table 4).

Several taxa were detected at all listening stations: *Pipistrellus kuhlii*, *Pipistrellus pipistrellus*, the "MyoHF group", and the "Serotules group." *Rhinolophus ferrumequinum* has a significant spatial occurrence, as it was detected at 13 of the 15 stations (occurrence of 0.86). Conversely, *Rhinolophus*

blasii, *Tadarida teniotis*, the “MyoLF group,” and the “*Plecotus* group” have a low spatial occurrence of less than 0.26.

Phenology of chiropterological activity per night

The distribution of chiropterological activity during the night is not uniform (Fig. 5). An obvious peak is observed at the beginning of the night, between the first half hour and two and a half hours after sunset. For the rest of the night, activity remains at a high and constant level, with a slight peak before sunrise.

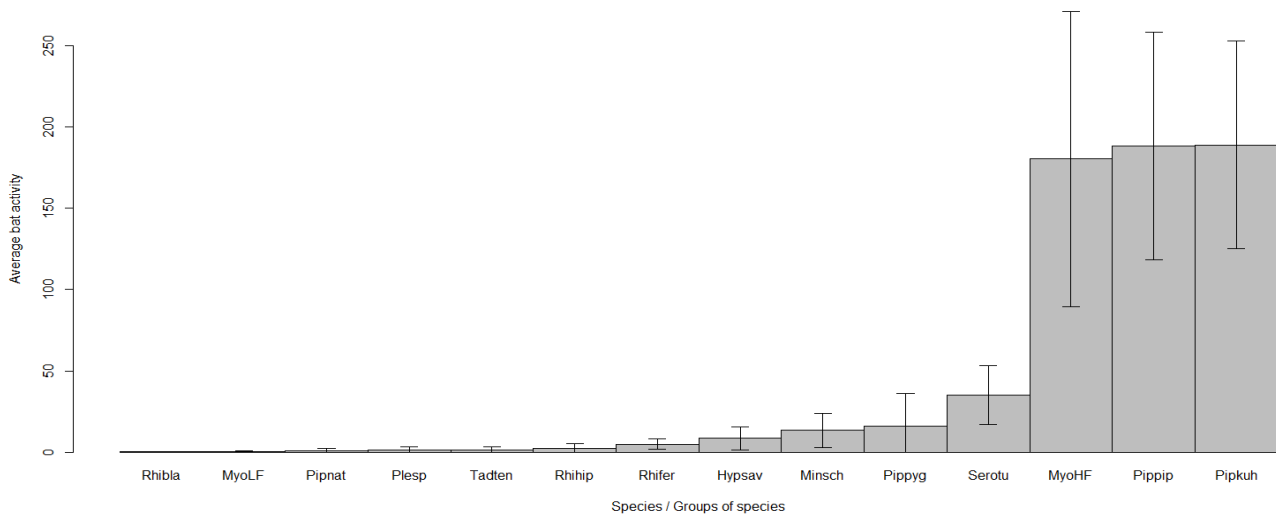


Fig. 4. Average activity per taxon and associated 95% confidence intervals.

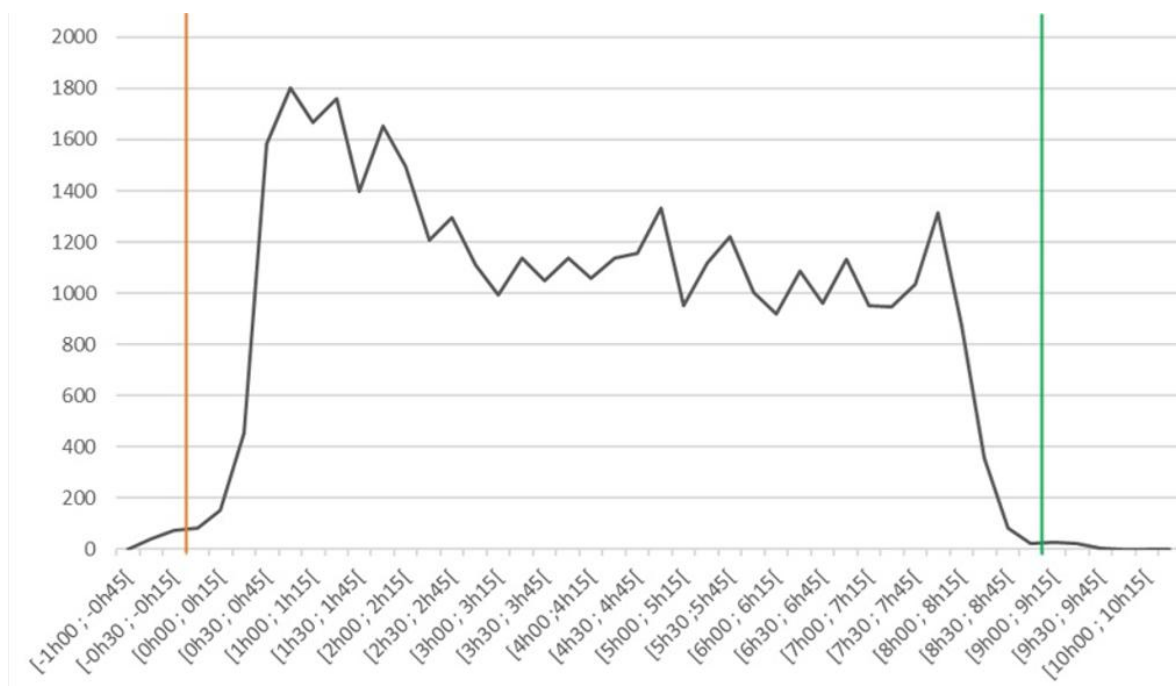


Fig. 5. Graphical representation of chiropterological activity during the night. Chiropterological activity (on the y-axis) corresponds to the sum of positive minutes recorded every quarter of an hour for all 15 nights analyzed. On the x-axis, time is represented by quarter hours starting from sunset, which corresponds to 00:00 a.m. and is symbolized by the vertical orange line. The vertical green line represents sunrise.

Table 4. Chiropterological activity per night by taxon according to the Actichiro reference system recorded in the Mediterranean biogeographic area (Haquart, 2013). For “*Pipistrellus* group”, activity level was produced according to the Actichiro reference system weighted by altitude in the Mediterranean biogeographical area. Rhipip: *Rhinolophus hipposideros*; Rhifer: *Rhinolophus ferrumequinum*; Rhibla: *Rhinolophus blasii*; Tadten: *Tadarida teniotis*; Pipkuh: *Pipistrellus kuhlii*; Pippip: *Pipistrellus pipistrellus*; Pippyg: *Pipistrellus pygmaeus*; Hypsav: *Hypsugo savii*; Minsch: *Miniopterus schreibersii*.

Sampling site	Rhipip	Rhifer	Rhibla	Tadten	Pipkuh	Pippip	Pippyg	Hypsav	Minsch	Pipistrellus group	MyoLF group	MyoHF group	Serotules group	Plecotus group	Total activity
Viroi 26	0	5	0	5	186	104	0	0	0	247	0	69	47	0	290
Viroi 28	0	2	0	0	181	60	0	15	0	214	0	63	23	0	244
Viroi 29	2	10	0	0	268	216	1	6	15	394	3	138	78	0	442
Humelicë28	5	22	1	12	131	152	3	0	0	222	0	139	5	15	300
Humelicë29	0	3	0	0	171	198	0	0	0	314	0	204	18	3	373
Suhë 26	1	5	0	0	396	201	4	2	66	437	0	461	35	0	487
Suhë 27	0	0	0	4	170	59	3	44	31	252	2	73	27	0	290
Suhë 28	1	7	0	0	94	125	3	9	7	187	0	127	7	0	231
Suhë 29	2	0	0	0	104	187	0	31	1	253	0	44	33	0	278
Suhë 30	0	5	0	0	397	236	8	0	38	422	0	426	12	0	444
Hormovë26	0	5	0	0	57	56	6	0	8	113	0	25	18	1	144
Hormovë27	5	1	0	0	194	472	43	0	15	476	0	392	32	0	486
Hormovë28	0	2	0	0	39	169	8	3	21	198	2	70	134	0	302
Hormovë29	1	2	0	1	98	134	17	9	0	207	0	26	29	0	233
Hormovë30	20	4	0	0	351	459	142	8	0	469	0	448	25	0	474
Mean value	2.5	4.9	0.7	1.5	189.1	188.5	15.9	8.5	13.5	293.7	0.5	180.3	34.9	1.3	334.5

Legend :

	Activity level “low.”
	Activity level “moderate.”
	Activity level “high.”
	Activity level “very high.”
	No activity or no reference to define the level of activity

Discussion

A notable specific diversity

The acoustic study identified just over 50% of bat species present in Albania, which corresponds to a high level of species diversity, as would be expected in Mediterranean riparian forests. It also produced 135 additional records for the country, adding to the 1,243 records published in 2019 (Benda et al., 2019), representing a contribution of nearly 10%.

The species recorded are diverse and include both specialist and generalist trophic species. As the sampled environments are at the interface between aquatic and terrestrial environments, forest hunting habitat species (*Myotis emarginatus*, *Myotis bechsteinii*, *Rhinolophus ferrumequinum*, etc.), aquatic habitat species (*Myotis capaccinii*), edge habitat species (*Pipistrellus* sp., *Myotis blythii*, etc.), and aerial habitat species (*Tadarida teniotis*, *Nyctalus leisleri*) were recorded. Among the species recorded, four are uncommon to rather rare in Albania, with fewer than 25 records according to the latest national summary: *Myotis bechsteinii*, *Myotis emarginatus*, *Myotis nattereri*, and *Rhinolophus blasii*. *Myotis capaccinii* were recorded with certainty or probability at numerous acoustic sampling sites, while its closely related species, *Myotis daubentonii*, was not recorded. These results are consistent with the literature, which reports spatial segregation between these two fishing bats, with *Myotis capaccinii* occurring at low elevation and *Myotis daubentonii* rare and confined to mountainous areas (Benda et al., 2019). However, *Myotis daubentonii* has already been recorded at an Elevation of 473 m in Albania, so it cannot be completely ruled out that some of our many unidentified contacts belong to this species. Some expected species were not detected, notably *Myotis myotis*, which is well known locally and appears to be fairly common in the country (Benda et al., 2019). *Myotis alcathoe*, although extremely rare in Albania with only one record, could potentially occur in our study area as it is known to occur at the confluence of the Vjosa and Drinos rivers (Niermann et al., 2007), only 7 kilometers from our listening stations of Hormovë. In the Humelicë sector, a recording may potentially be attributed to this species, but the poor quality of the signal did not allow a definitive identification. *Myotis davidii* and *Plecotus kolombatovici* could have been encountered. In fact, *Myotis davidii* has been captured

several times at the confluence of the Vjosa and Drinos rivers (Niermann et al., 2007; Sachanowicz & Ciechanowski, 2018), and *Plecotus kolombatovici* has been captured 7 kilometers from the Suhë sector (Benda et al., 2019). However, knowledge of the bioacoustics of these two species remains incomplete and, to our knowledge, does not have any discriminating acoustic characteristics. This is also the case for *Rhinolophus mehelyi*, which can not be distinguished acoustically from *Rhinolophus hipposideros* and *Rhinolophus euryale*.

Our results provide new information on the frequency and status of certain species. *Myotis emarginatus* is described as uncommon in Albania, with 22 known locations, while *Myotis nattereri* is considered rather rare, with 12 locations recorded (Benda et al., 2019). These results are challenged by our study. *Myotis emarginatus* was detected at 10 of the 15 acoustic sampling sites, while the occurrence of *Myotis nattereri* is not negligible, with 3 acoustic sampling sites. These two species are therefore probably more common in Albania than is currently known. This is likely explained by the fact that available records on Albanian chiroptero-fauna have been obtained mainly from surveys based on direct observation in roosts or during capture (10 of the 12 localities for *Myotis nattereri* and 20 of the 22 localities for *Myotis emarginatus*), which may lead to an underrepresentation of distinct species. This is the case, for example, with *Myotis nattereri*, which is difficult to observe in roosts as it prefers small crevices in trees or buildings.

Conversely, the very high occurrences recorded for *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros*, *Pipistrellus pipistrellus*, *Pipistrellus kuhlii*, *Nyctalus leisleri*, *Hypsugo savii*, and *Miniopterus schreibersii* support the conclusions of Benda et al. (2019), who consider these species to be common to very common.

High activity within riparian hydroecosystems

Bat activity level was defined using the Actichiro reference system, which was developed based on a dataset collected in the French Mediterranean region. This choice was made because, to our knowledge, there is no reference system specific to Albania or the Balkans. Even though the biogeographical area is the same, we can nevertheless assume that the Actichiro reference framework may not be fully adapted to the local context.

High levels of activity recorded at almost all acoustic sampling sites demonstrate the importance of alluvial and riparian hydroecosystems for bat fauna. The only two acoustic sampling sites located outside the minor bed, along hedges bordering agricultural areas, recorded “moderate” activity, suggesting that in the Mediterranean context, bats tend to favor riparian and aquatic habitats, as has been observed during periods of summer drought (Amorim et al., 2018). The environment is highly attractive to a wide range of species, such as *Rhinolophus ferrumequinum*, *Pipistrellus pipistrellus*, *Pipistrellus kuhlii*, the “MyoHF group”, and the “*Serotules* group” show “high” to “very high” activity at almost all acoustic sampling sites. It was also observed that the level of chiropterological activity remains high throughout the night, which is a further indicator of its attractiveness to bats.

The strong attractiveness of alluvial and riparian hydroecosystems to chiropterofauna is well known (Mas et al., 2021). Indeed, linear environments such as hedges, tree lines, and riparian forests, even though they generally cover only a small part of the area, are known to be preferred movement corridors for many bat species (Dietz et al., 2013; Entwistle et al., 1996; Krull et al., 1991; Limpens & Kapteyn, 1991; Pinaud et al., 2018; Verboom & Huitema, 1997). Riparian forests are also ecotones where the presence of water mitigates the effects of summer drought and supports a large biomass of invertebrates with occasional emergence phenomena. They are therefore preferred hunting grounds for bats. This is particularly the case for old-growth riparian forests, where bat activity and hunting activity are recorded significantly higher than in young riparian forests (Buono et al., 2020). This can be partly explained by the fact that they have a more complex structure (more gaps, greater canopy height, etc.) and contain more dead wood. These senescent riparian forests also host more microhabitats than young riparian forests. The diversity of microhabitats and the presence of old trees with large diameters play a key role in providing shelter for bats (Regnery et al., 2013a,b).

Finally, it should be noted that the acoustic study was conducted over a short period of time, focusing on a single season, and that only one major habitat type was sampled. Additional surveys in other seasons and the implementation of

double sampling of riparian forests versus dry forests would undoubtedly make it possible to complete the list of species and better highlight the importance of the alluvial and riparian hydroecosystems of the Vjosa and Drinos rivers for bats compared to the surrounding terrestrial environments.

Conclusions

The study identified 16 species of bats and one group of species in the lower Drinos Valley and on the Suha River. Four of these are considered to be uncommon or rather rare in the country. Chiropterological activity is high at almost all acoustic sampling sites, which demonstrates the importance of the Vjosa Wild River National Park for chiropterofauna. Although our sampling is not robust, it suggests that during the summer months, bats tend to favor alluvial and riparian hydroecosystems over drier and probably less productive terrestrial environments. The protection and preservation of the wild character of the alluvial and riparian hydroecosystems of the Vjosa and Drinos rivers appear to be necessary for the maintenance of a rich bat fauna by providing ecological corridors, roosts, and high-quality foraging habitats. Depending on local conditions, measures to preserve the oldest alluvial woodlands, combined with the selective establishment of freely evolving wooded patches, should be considered in order to increase preferred foraging areas and roosts for bats.

The ecological continuity of riparian forests must also be taken into account. These forests appear to be severely fragmented and reduced in the study area; both of these habitat alterations are known to be a threat to the viability of bat populations (Quinn & Harrison, 1988). Discontinuity is detrimental to many species of bats, for example, for *Rhinolophus ferrumequinum*, which has little tolerance for gaps of more than 50 m (Pinaud et al., 2018). Furthermore, it has been shown that bat activity decreases significantly when the width of the riparian forest is less than 50 meters for the “*Pipistrellus* group” or 40 meters for the “*MyoLF* group” (Buono et al., 2020). It could be interesting to implement a conservation policy aimed at restoring the ecological continuity of riparian forests where possible.

Finally, it should be noted that the study is only based on bioacoustics, which is limited in the

identification at a species level in some cases. However, this method has not been frequently used in Albania, and deserves to be developed as it allows fairly easy detection of numerous species that are difficult to detect when using other survey methods and whose status is therefore likely to be poorly assessed.

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