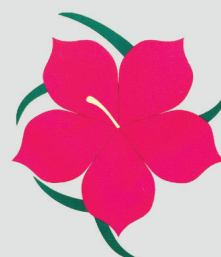


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ORIGINAL RESEARCH PAPER

MORTALITY OF BATS (CHIROPTERA) FROM WIND TURBINES IN MONTENEGRO

Čeda IVANOVIĆ¹ Jasminko MULAOMEROVIĆ²

¹ Prirodnački muzej Crne Gore, Trg Vojvode Bećir-bega Osmanagića br.16, 81000 Podgorica, Crna Gora, E-mail: cedaivanovic1967@gmail.com

² Centar za krš i speleologiju, Branilaca Sarajeva 30, 71000 Sarajevo, BiH, E-mail: jasminko@centarzakrs.ba

Key words:

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Ključne riječi:

vjetropark,
monitoring,
smrtni slučajevi slijepih
miševa,
Crna Gora.

SYNOPSIS

The first post-construction monitoring of the impact of the windfarm on bat fauna in Montenegro started in 2019 and was completed in 2022 in the area of the “Možura” windfarm. This research paper presents the results of that monitoring, i.e. the data of bat fatalities at the windfarm in Montenegro. During four years of research and monitoring in the area of the “Možura” windfarm, where there are 23 wind turbines, a total of ten carcasses of bats were noted; one carcass of *Myotis myotis*/*M. blythii* was recorded in 2019, three carcasses of bats *Pipistrellus pipistrellus*, *Pipistrellus kuhlii* and *Hypsugo savii* were recorded in 2021, and six carcasses of bats *Pipistrellus pipistrellus*, *Pipistrellus kuhlii* and *Eptesicus serotinus* were recorded in 2022.

SINOPSIS

SMRTNOST SLIJEPIH MIŠEVA (CHIROPTERA) OD VJETROTURBINA U CRNOJ GORI

Prvi postkonstrukcioni monitoring uticaja vjetroelektrana na faunu slijepih miševa u Crnoj Gori započet je 2019. godine, a završen 2022 godine na području vjetroparka „Možura“. U ovom radu su dati rezultati tog monitoringa tj. zabilježeni slučajevi stradalih slijepih miševa od vjetroelektrana u Crnoj Gori. Tokom četiri godine istraživanja/monitoringa na području vjetroparka „Možura“ koji ima ukupno 23 vjetroelektrane, registrovano je ukupno deset stradalih jedinki slijepih miševa: u 2019. godini je nađeno jedno truplo vrste *Myotis myotis*/*M. blythii*, 2021. godine tri stradala slijepa miša vrsta: *Pipistrellus pipistrellus*, *P. kuhlii* i *Hypsugo savii*, a 2022. godine stradalo je šest jedinki slijepih miševa vrsta: *Pipistrellus pipistrellus*, *P. kuhlii* i *Eptesicus serotinus*.

INTRODUCTION

For the last twenty years, a large number of windfarms have been built to use wind energy in Europe (WindEurope, 2024).

In each phase of building, windpower plants might have a greater or lesser impact on bats. One of the most negative impacts of windpower plants is the mortality of bats.

The mortality of bats in windfarms occurs due to direct collision with, or as a result of “barotrauma” (Arnett et al., 2008; Baerwald & Barclay, 2009; Cryan & Barclay, 2009; Grodsky et al., 2011).

The post-construction monitoring of bat fauna has

shown numerous fatalities of bats in many countries (Ahlen, 2003; Johnson et al., 2003; Kerns & Kerlinger, 2004; Arnett, 2005; Georgiakakis et al., 2012).

For this reason, the impact assessments of the construction and operation of wind power stations are mandatory, in order to avoid or minimise negative impacts on bats.

Montenegro, currently, has three windfarms: one on the Krnovo and the second on the Gvozd, northeast of Nikšić city and the third on Možura Hill, located north of Ulcinj city. This research paper presents the results of the four-year post-construction monitoring

of the bat fauna in the “Možura” windfarm, i.e. the recorded cases of bat deaths in that locality in

Montenegro.

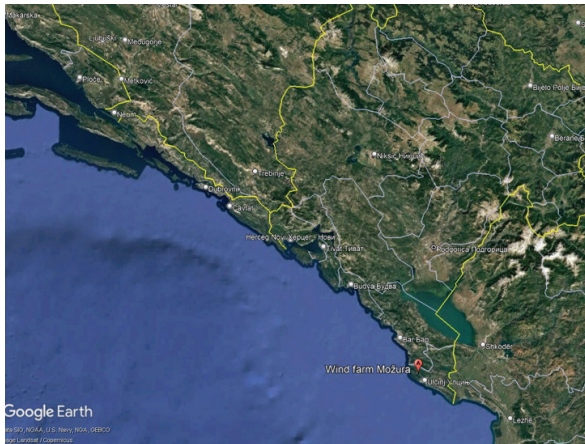


Figure 1: Location of the windfarm “Možura”.



Figure 2: The windfarm “Možura”.
Photo: Čeda Ivanović

SUBJECT AND RESEARCH METHODS

The “Možura” windfarm is located on the Možura hill (Figure 1), starting from the wind turbine number 1 (coordinates 41°59'16.8"N, 19°09'51.0"E, 420 m a.s.l.) to the wind turbine number 23 (coordinates 41°57'53.9"N, 19°14'35.2"E, 620 m a.s.l.). The individual power of the wind turbine is 2 MW, or 46 MW in total. The rotor diameter of the wind turbine is 121 m, and the pillar is 100 m high (Cigre, 2016) (Figure 2).

The relief of the Možura area is characterized by numerous sinkholes, karren fields and karstified depressions on limestone ridges extending in a northwest-southeast direction: Volujica (256 m a.s.l.) – Šasko brdo (106 m a.s.l.), Možura (589 m a.s.l.) – Briska gora (188 m a.s.l.), Marjan (398 m a.s.l.) – Bijela gora (327 m a.s.l.), and Mendre (162 m a.s.l.) – Pinješ (110 m a.s.l.), with intervening depressions and valleys: Kunje – Pelinkovići – Donja Klezna – Šasko Lake, Kruče – Bratica – Pistula and Valdanos – Ulcinj.

On the eastern side of Možura Hill, there are forests of the Hungarian oak (*Quercus frainetto*) and the Turkey oak (*Quercus cerris*), as well as pastures and areas of agricultural land. The northeastern slopes are covered by the Macedonian oak forests, sub-Mediterranean dry grasslands, and shrub vegetation, while the central part is dominated by the Macedonian oak forest. The southwestern side includes areas of pseudomaquis, true maquis, dense and impenetrable shrub vegetation, agricultural arable land, and meadows.

The methodology used to monitor bat mortality in the “Možura” windfarm was carried out according to

EUROBATS (Rodrigues et al., 2015). Research was conducted during the various periods each year from 2019 to 2022, respectively.

According to the methodology, the search process for dead bats started a half hour after sunrise to minimise removal of carcasses from scavengers. An area with a radius of 50 meters from each wind turbine was searched. Researchers were taking notes on the species of bats found in the field; position of carcasses (GPS coordinates, distance to the windturbine); state of carcasses; type of wounds; and evaluation of the date of death.

In accordance with the methodology, the shortest possible time interval between visits to windfarms was observed in about eight visits per month.

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In accordance with the methodology, the shortest possible time interval between visits to windfarms was observed in about eight visits per month.

RESULTS AND DISCUSSION

During a four-year period of this research, in the area of the windfarm “Možura”, a total of ten dead bats were found, namely:

- In 2019, one individual of the species: *Myotis myotis* (Borkhausen, 1779/*Myotis blythii* (Tomes, 1857);
- In 2021, three individuals of three species: *Pipistrellus pipistrellus* (Schreber, 1774) *Pipistrellus kuhlii* (Kuhl, 1817) and *Hypsugo savii* (Bonaparte, 1837);
- In 2022, six individuals of the species: *P. pipistrellus*, *P. kuhlii* and *Eptesicus serotinus* (Schreber, 1774).

Detailed findings are summarised below in Table 1.

Monitoring in 2019 was carried out from August, 22nd to October 30th, lasting 21 days. During that period, the wind power station was in trial mode, which means they were put into operation occasionally. In that period, no dead bats were found.

The second year field research was conducted from May 20th to October 21st 2020, lasting 40 fieldwork days. During this monitoring period, carcasses of bats were not found (Ivanović & Mulaomerović, 2020).

The third year of monitoring started on March 25th and ended on October 18th 2021, lasting 46 fieldwork days. In this period, three dead bats were found: *Pipistrellus pipistrellus*, *P. kuhlii* and *Hypsugo savii* (Ivanović, 2021; Ivanović & Mulaomerović, 2021).

The fourth year of field research, was conducted from April 15th to August 27th 2022. Before starting the research, we received a photo of a dead bat from the worker of the windfarm “Možura”, which was taken in July 2019. Based on it, it was concluded that it is most probably the species *Myotis myotis*/*M. blythii* (Figure 3) (Ivanović & Mulaomerović, 2019).

A bat carcass was found under WT 3 (41°59'12.53"N, 19°10'18.38"E, 406 m a.s.l.), according to the worker. Based on the photo, we concluded that the carcass is a few days old, partially eaten, and its left forearm was broken, which indicates a collision with wind turbine's rotor blades.

In the research period in 2019 (ultrasound detection with bat detector), the presence of *Myotis myotis* was not recorded in the windfarm, while the *Myotis blythii* was registered only a few times (Ivanović, 2019).

Table 1: Findings of dead bats on the windfarm “Možura”.

Species	Date	Location	Details
<i>Myotis myotis</i> / <i>Myotis blythii</i>	July 2019.	in the circle of the WT 3 41°59'12.53"N 19°10'18.38"E	An approximately 3-day-old carcass, partly mummified, open wounds were visible on the back side of the head and neck, partially eaten, the forearm was broken.
<i>Pipistrellus pipistrellus</i>	26.06.2021.	15 m west of WT 5 41°59'7.30"N 19°10'45.40"E	♂, ad, FA = 29,4mm, approximately 3 days old carcass, partly mummified.
<i>Pipistrellus kuhlii</i>	05.09.2021.	20 m northwest of WT 1 41°59'16.65"N 19°9'51.67"E	♂, ad, FA = 34,2 mm, approximately 3 days old carcass, partly mummified.
<i>Hypsugo savii</i>	05.09.2021.	25 m west of WT 1 41°59'16.67"N, 19°9'51.31"E	♀, ad, FA = 35,8 mm, fresh, bloody carcass, injury visible.
<i>Eptesicus serotinus</i>	05.06.2022.	35 m northwest of WT 2 41°59'15.30"N 19°10'2.82"E	♂, ad, FA = 48,3 mm, partly mummified, ruptured abdominal cavity (possible "barotrauma").
<i>Pipistrellus kuhlii</i>	05.06.2022.	Under WT 21 41°58'1.68"N 19°14'12.03"E	♂, ad, FA = 33,6 mm, approximately 2-day-old carcass, partly mummified.
<i>Eptesicus serotinus</i>	05.06.2022.	Under WT 21 41°58'1.94"N 19°14'11.55"E	♀, ad, FA = 48,7 mm, fresh carcass.
<i>Pipistrellus kuhlii</i>	05.06.2022.	Under WT 22 41°57'57.02"N 19°14'22.77"E	♂, ad, FA = 33,8 mm, fresh carcass.
<i>Pipistrellus pipistrellus</i>	06.06.2022.	Under WT 18 41°58'15.07"N 19°13'37.59"E	♀, ad, FA = 30,2 mm, fresh carcass.
<i>Eptesicus serotinus</i>	06.06.2022.	Under WT 18 41°58'14.73"N 19°13'37.50"E	♂, ad, FA = 49,2 mm, fresh carcass.

Abbreviations: WT- wind turbine, ♀ - female, ♂ - male, ad – adult, FA – forearm length

During the research in the years 2020, 2021 and 2022 (ultrasound detection with a bat detector), species from the genus *Myotis* had extremely low/negligible activity in the windfarm (Ivanović & Mulaomerović, 2020; 2021; 2022).

Species *Myotis myotis* and *Myotis blythii* were registered in a wider area of the windfarm, in the cave on Velika/Velja Gorana (41°59'33.77"N, 19°13'53.55"E), the Sumporna pećina Cave (41°55'11.76"N, 19°12'47.94"E), and the Jošova pećina Cave (41°55'7.02"N, 19°12'53.97"E) (Presetnik et al., 2014; 2017).

It can be assumed that the death of *Myotis myotis*/*Myotis blythii* in the windfarm has happened during an overflight the windfarm from the shelter/cave on Velja Gorana to the grassy areas on the southern side of the Možura hill and Ulcinj/Solana.

Mortality of these species in European windfarms is not significant due to their low flying, i.e. flight near and around vegetation (Dietz et al., 2009; Rodrigues et al., 2015).

Pipistrellus pipistrellus (Figure 4) is a very rare species in the area around Bar and Ulcinj (Presetnik et al., 2014; Théou & Đurović, 2015; Théou et al., 2020). During the four years of monitoring (ultrasound detection with a bat detector) on the windfarm "Možura", extremely low activity of this species was recorded (Ivanović, 2019; Ivanović & Mulaomerović, 2020; 2021; 2022).

Pipistrellus pipistrellus has the highest mortality rate from wind turbines (Rodrigues et al., 2015). Mortality of these species is very high where windfarms are located near forests, while in open areas, mortality is significantly lower (Niermann et al., 2009).

Pipistrellus kuhlii (Figure 5 and 7) is the most common species that has been recorded around Bar and Ulcinj (Presetnik et al. 2014, 2017; Théou & Đurović, 2015; Théou et al., 2020). Among all identified species (ultrasound detection) in the wind farm "Možura", *Pipistrellus kuhlii* had the highest activity (Ivanović, 2019; Ivanović & Mulaomerović, 2020; 2021; 2022).

Pipistrellus kuhlii has a high risk of collision with the wind turbines (Rodrigues et al., 2015). This species is also included in the high-risk category of mortality in windfarms (Rodrigues et al., 2015).

Hypsugo savii (Figure 6) is the third most numerous species (with the phonetic group *Pipistrellus kuhlii*/*nathusii* and *Tadarida teniotis*) that was recorded in the "Možura" windfarm during monitoring (Ivanović, 2019; Ivanović & Mulaomerović, 2020; 2021; 2022). This species also belongs to high-risk category of

mortality in windfarms (Rodrigues et al., 2015).

The activity of *Eptesicus serotinus* (Figure 7, in the middle) in the "Možura" windfarm, during four years of monitoring, was of low intensity. (Ivanović, 2019; Ivanović & Mulaomerović, 2020; 2021; 2022). Fatalities of this species from wind turbines have been recorded, but not in such significant numbers (Rodrigues et al., 2015).



Figure 3: Carcass of *Myotis myotis*/*M. blythii*.
Photo: Robin Lee



Figure 4: Carcass of *Pipistrellus pipistrellus*.
Photo: Vera Lasica



Figure 5: Carcass of *Pipistrellus kuhlii*.
Photo: Čeda Ivanović

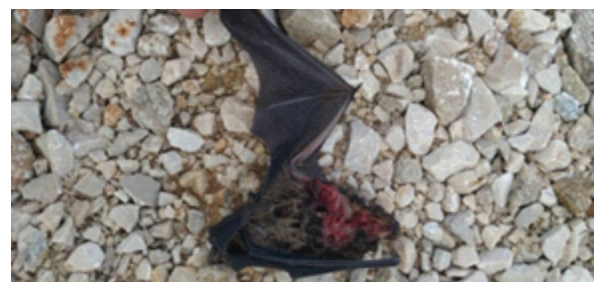


Figure 6: Carcass of *Hypsugo savii*.
Photo: Čeda Ivanović



Figure 7: Carcasses of *Pipistrellus kublii*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*.
Photo: Marko Lasica

CONCLUSION

During the monitoring period of four years (2019-2022), ten dead bats were found on the “Možura” windfarm.

All fatalities of species of bats are in the category of high risk of collision with wind turbines, except the species of the genus *Myotis*.

The number of days spent in the research field, the method of searching for carcasses, the number of searchers, etc., certainly has an effect on the final number of dead bats found. The number of days spent in the field, the carcass search methodology, the number of searchers and related factors undoubtedly influence the final number of recorded bat fatalities.

During surveys of bat mortality in this area, no searcher efficiency trials were conducted to assess carcass detection rates, nor were trials carried out to determine the proportion of placed carcasses removed by predators before searchers entered the field.

Considering a lack of data on the mortality of bats in windfarms from neighbouring countries (Bašić et al., 2017; Kapeš, 2018; Zgmajer et al., 2007; Jančar, 2006), we can conclude that these data represent a significant contribution to the knowledge in research about the ecology of bats in relation to wind power plants in Montenegro and thus in the entire European bat fauna.

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