BAT MONITORING AT THE LOCATION OF WINDFARM JELINAK DURING 2015.

- second monthly report (June, July, August, September, October 2015) -

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Zagreb, 10.11.2015.

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1. Introduction

According to the Cooperation agreement (Purchase Order Number: 310026655) the Bat monitoring at the Wind Farm Jelinak locality started on 11 June 2015 and lasted to the end of October 2015.

The monitoring was conducted on the complete field, at all twenty turbines. Visual search for dead bats on the site included visits every seven days during June, September and October and every day search during July and August. Bat activity was monitored on the site from June to October with batcorder system that automatically records bat calls. Additionally, activity was recorded along line transect (internal windfarm road in length of 8.5 km).

Mitigation measure was conducted at eight wind turbines from 1. July to the end of August from 9 pm to 3 am next day with cut in speed 5 m/s.

All monthly Reports and final Report will be written in Croatian and English language.

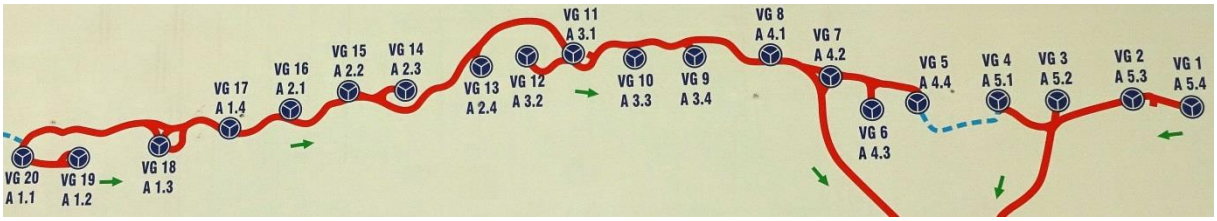


Figure 1. Layout view of wind turbines at the location of WF "Jelinak".

2. Methods

2.1. Methods for bat collision monitoring

Monitoring of bat collision at wind farm "Jelinak" during 2015 was carried out from June to the end of October. The search for dead bats included every seven days search during June, September and October, and daily search during July and August. Every time was searched the area around each of twenty wind turbines within a radius of no less than 70 meters. The search involved a minimum of two people. In order to increase the efficiency, we also used a dog trained in search of dead bats. The search generally started early in the morning in order to find bats in

the best possible condition, before being eaten by insects. Track was recorded during the entire duration of the search with mobile applications MotionX-GPS and OruxMaps, device Garmin GPSmap 60CSx and Garmin GPS watches Fenix 3, Forerunner 920XT and Forerunner 610. In the case of finding a dead bat, species, sex, age, in the case of female presence/absence of breasts what says if she had a young this season, condition of corpse and type of injury was recorded. GPS coordinates were taken for each found bat and each was photographed. Dead animals are stored in the Croatian Natural History Museum in Zagreb.

2.2. Methods for bat activity monitoring

Bat activity was monitored using device for automatic recording bat calls, Batcorder 3.0. On 27. June 2015. one device was placed close to the wind turbine O.U.01 (5.4) at six meters height and since than continuously recorded bat activity to the end of October or total duration of monitoring. The device was removed from location on 3. November 2015.

Second, an additional device was placed close to the wind turbine O.U.18 (1.3) at fifteen meters height and was recorded entire August (3. – 29.08.2015.).

Also, line transects were additionally recorded along the internal windfarm road in the length of 8.5 km. Transect were recorded on 11, 19, 26 and 27. June and in the period from 10. – 18. July 2015.

3. Results of field surveys

Field research included monitoring of bat collision and monitoring of bat activity at windfarm „Jelinak“. In this report are the results for June, July, August, September and October 2015.

3.1. Bat collision monitoring results

In 2015 during monitoring period at WF „Jelinak“ location 54 dead bats was recorded (Appendix 1). During field visits in July there were no dead bats, in July was

found 37 bats (69%), in August 11 bats (20%), in September 6 bats (11%), while in October there were none dead bats (Fig. 2, Table 1).

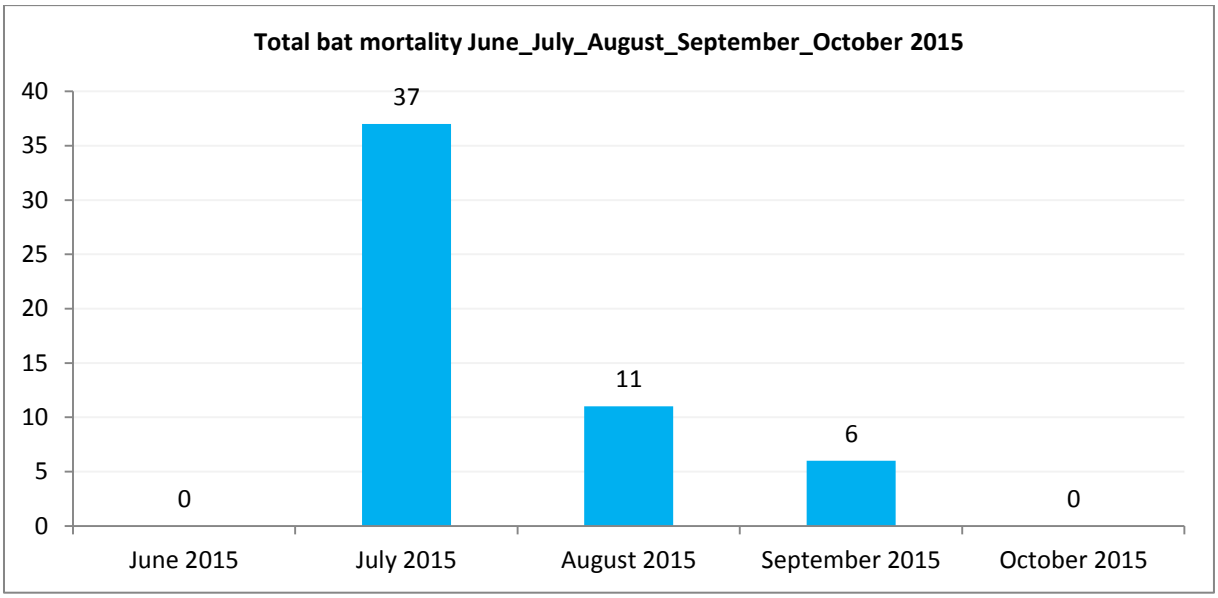


Figure 2. Total bat mortality during June, July, August, September and October 2015 at location of WF „Jelinak".

Figure 3 shows the total recorded bat mortality in July, August and September per wind turbines. Numbers in the orange boxes indicates the wind turbines with mitigation measure implemented in July and August. The mitigation measure has not been implemented in September.

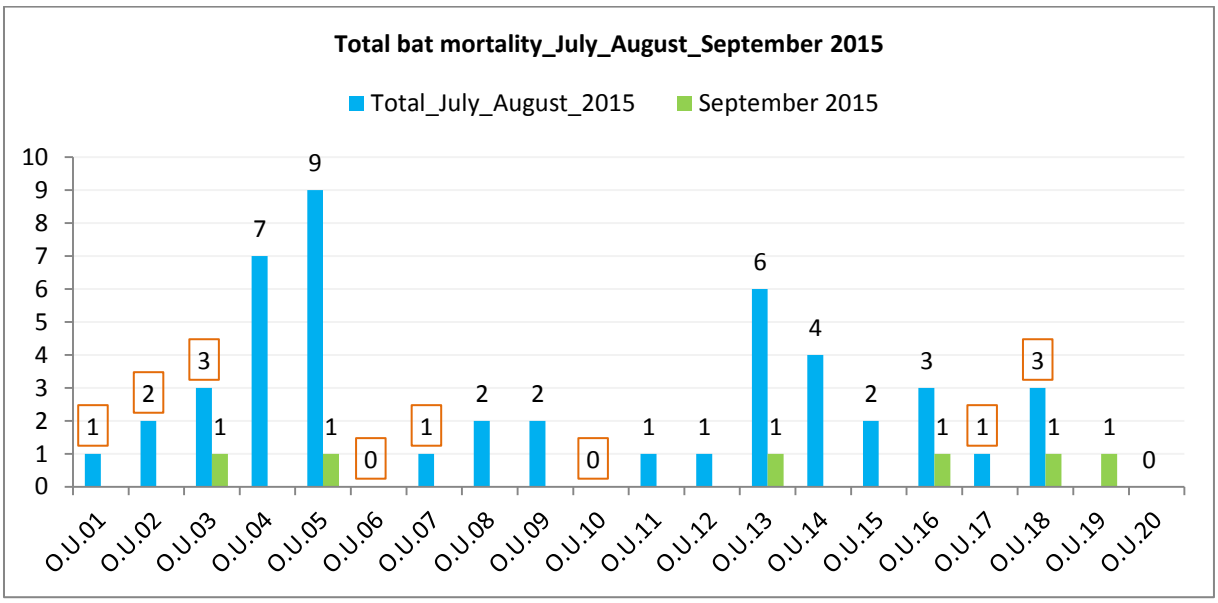


Figure 3. Total bat mortality during July, August and September 2015 per wind turbines at location of WF „Jelinak". (Orange boxes = wind turbines with mitigation measure in July and August).

As is shown in Figure 3 and Table 1, the most bats were killed at the wind turbine O.U.05 where were in total 10 dead bats (19%), at wind turbine O.U.04 with in total 7 dead bats (13%), and at wind turbine O.U.13 also with in total 7 dead bats (13%). At these three wind turbines were killed 24 bats which makes 45% of total mortality. Mitigation measure is not implemented at any of these three wind turbines.

Throughout the study period at three wind turbines there were not any dead bats. From these three wind turbines O.U.06 and O.U.10 have a mitigation measure, while wind turbine O.U.20 doesn't have a mitigation measure.

Mortality was recorded at six out of eight wind turbines with mitigation measure in July and August, in total 11 dead bats which is 23% of total mortality.

Figure 4 shows the total recorded bat mortality in July, August and September per months and per wind turbines. Numbers in the orange boxes indicates the wind turbines with mitigation measure implemented in July and August.

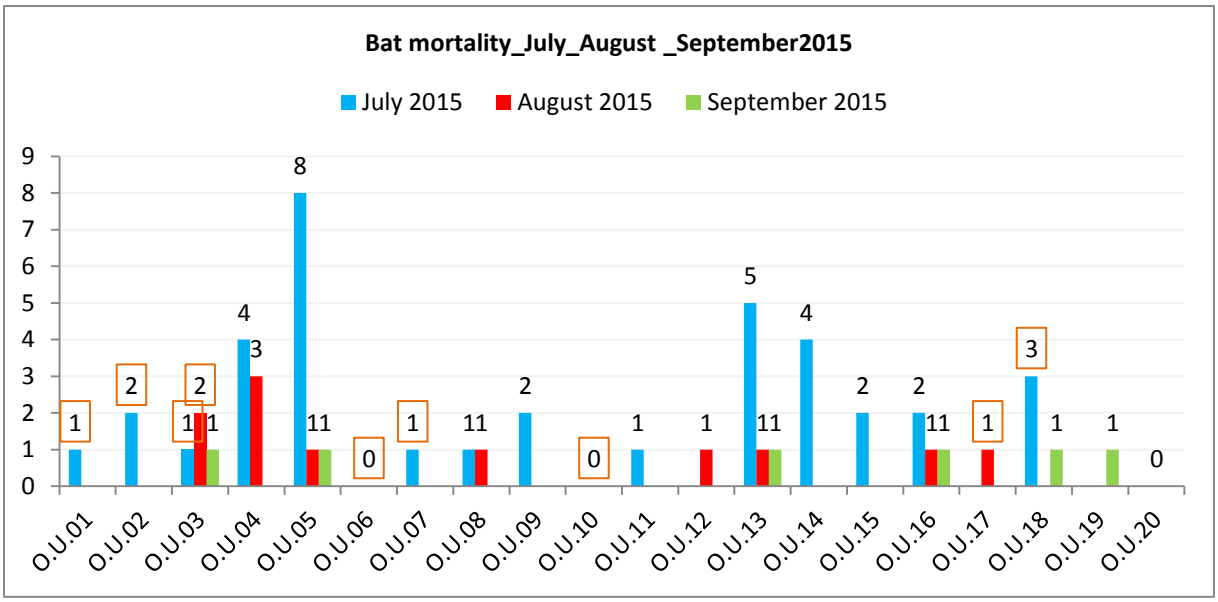


Figure 4. Bat mortality recorded during July, August and September 2015 per wind turbines and per months at location of WF „Jelinak". (Orange boxes = wind turbines with mitigation measure in July and August).

At wind turbines O.U.01, O.U.02, O.U.07, O.U.09, O.U.11, O.U.14 and O.U.15 mortality was recorded only during July while in August and September wasn't.

At wind turbines O.U.12 and O.U.17 mortality was recorded only in August while in July and September wasn't.

At wind turbine O.U.19 mortality was recorded only in September while in July and August wasn't.

Analyzing wind turbines with mortality recorded both in July and August, it is evident that at O.U.03 mortality was increased in August compared to July, while at other five wind turbines mortality was decreased or the same in August compared to July. These numbers correspond to a general mortality reduction in August compared to July.

In September there was a further mortality reduction.

Table 1. Number and percentage of dead bats per wind turbines in 2015 for July, August, September and in total for all three months at location of WF „Jelinak“. (Orange = wind turbines with mitigation measure in July and August).

WT	JULY 2015		AUGUST 2015		SEPTEMBER 2015		TOTAL	
	number of dead bats	%	number of dead bats	%	number of dead bats	%	number of dead bats	%
O.U.01	1	3%	0	0%		0%	1	2
O.U.02	2	5%	0	0%		0%	2	4
O.U.03	1	3%	2	18%	1	17%	4	7
O.U.04	4	11%	3	27%		0%	7	13
O.U.05	8	22%	1	9%	1	17%	10	19
O.U.06	0	0%	0	0%		0%	0	0
O.U.07	1	3%	0	0%		0%	1	2
O.U.08	1	3%	1	9%		0%	2	4
O.U.09	2	5%	0	0%		0%	2	4
O.U.10	0	0%	0	0%		0%	0	0
O.U.11	1	3%	0	0%		0%	1	2
O.U.12	0	0%	1	9%		0%	1	2
O.U.13	5	14%	1	9%	1	17%	7	13
O.U.14	4	11%	0	0%		0%	4	7
O.U.15	2	5%	0	0%		0%	2	4
O.U.16	2	5%	1	9%	1	17%	4	7
O.U.17	0	0%	1	9%		0%	1	2
O.U.18	3	8%	0	0%	1	17%	4	7
O.U.19	0	0%	0	0%	1	17%	1	2
O.U.20	0	0%	0	0%		0%	0	0
total	**37**	**69%**	**11**	**20%**	**6**	**11%**	**54**	

Figure 5 shows mortality recorded during July, August, September and total bat mortality during July, August and September per species.

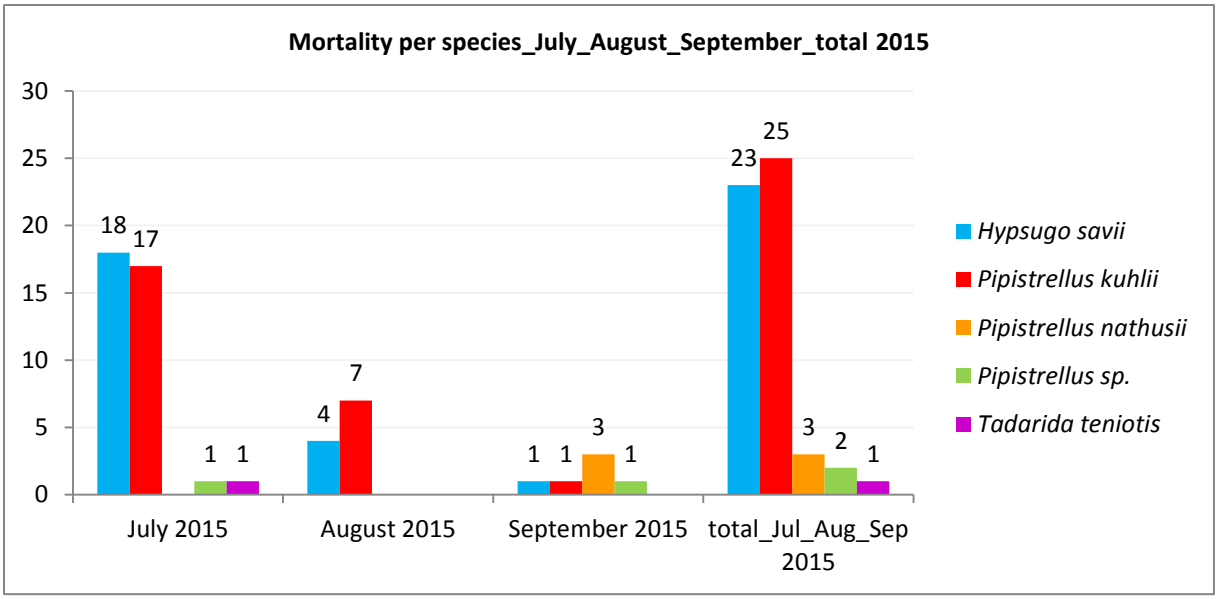


Figure 5. Bat mortality during July, August and September 2015 and total mortality for all three months 2015 per species at location of WF „Jelinak".

In total 46% of dead bats during July, August and September 2015 belongs to species *P. kuhlii* (25 bats), and 43% of dead bats belongs to species *H. savii* (23 bats) (Figure 5).

The most recorded dead bats in July belongs to species *H. savii* (48%, 18 bats), followed by species *P. kuhlii* (46%, 17 bats). In July another found dead bat belongs to species *T. teniotis* (3%, 1 bat), and for one bat was impossible to determine species because of the state of the body, so it was determine to gender, *Pipistrellus sp.* (3%, 1 bat) (Figure 5).

All dead bats in August belongs to two species, *P. kuhlii* (64%, 7 bats) and *H. savii* (36%, 4 bats) (Figure 5).

The most recorded dead bats in September belongs to species *P. nathusii* (50%, 3 bats) that for the first time appears in September, the remaining 50% is divided to three bats, one of species *P. kuhlii*, *H. savii* and to bat for which was impossible to determine species because of the state of the body, so it was determine to gender, *Pipistrellus sp.* (Figure 5).

Figure 6a shows the mortality recorded during each day of July and August, and Figure 6b shows the mortality recorded during two-day searches every seven days in September.

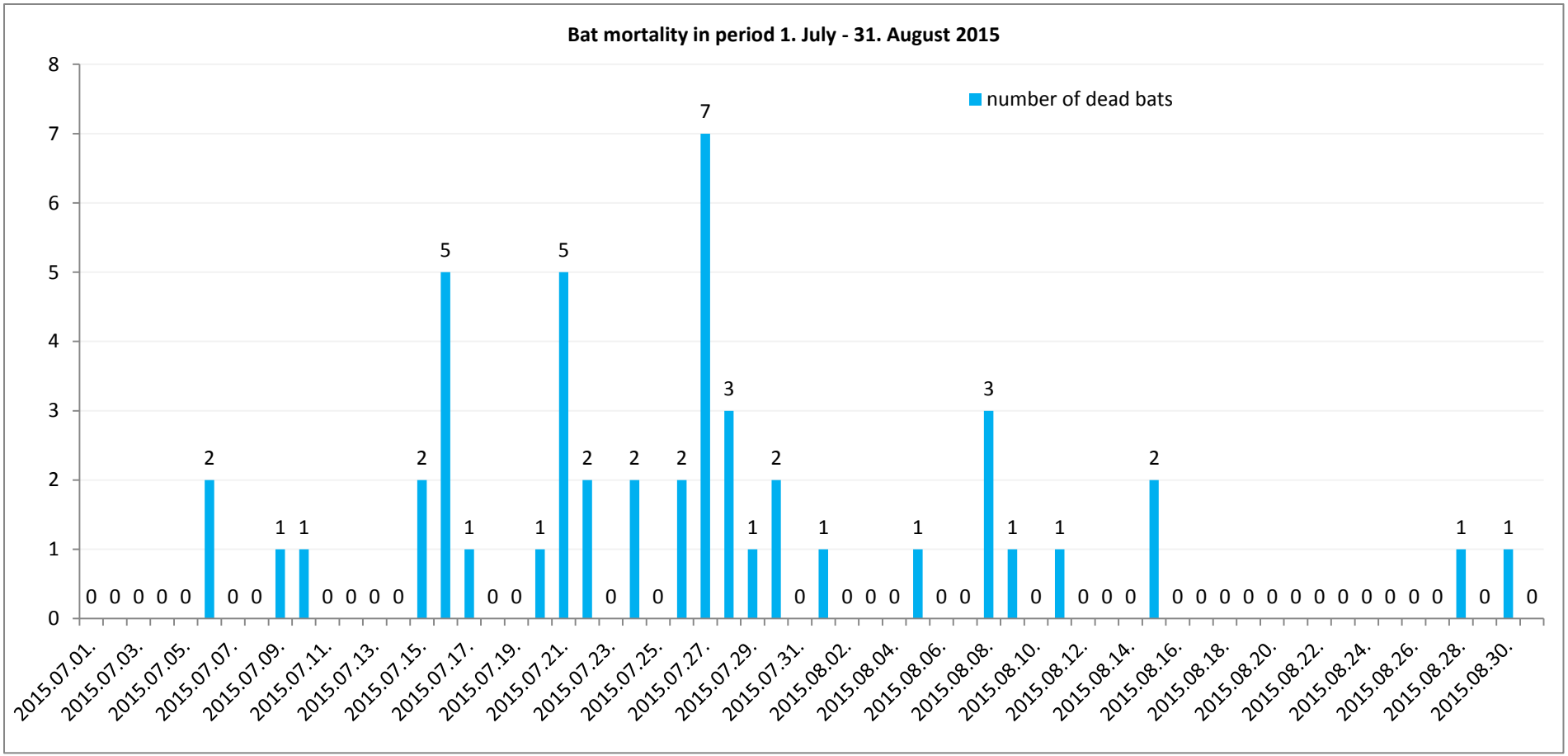


Figure 6a. Number of dead bats during each day of July and August 2015 at location of WF „Jelinak“.

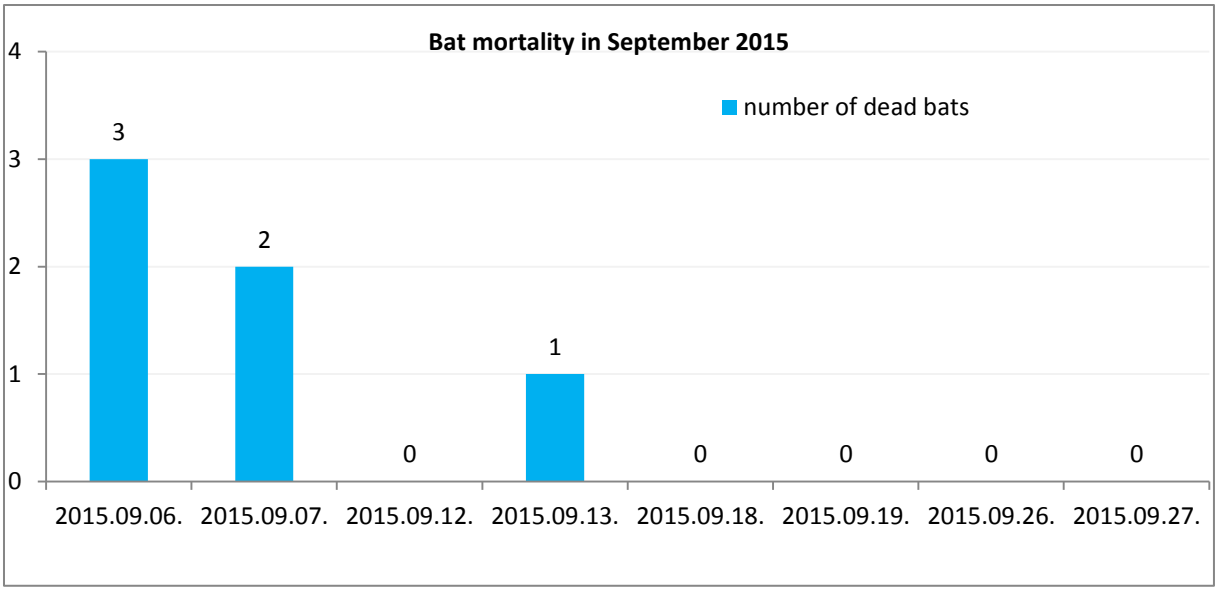


Figure 6b. Number of dead bats during every seven days of September 2015 at location of WF „Jelinak".

In the period from 1. to 14. July four dead bats were recorded. The most of dead bats, thirty three bats, were recorded in the period from 15. to 31. July. From 1. to 14. August seven dead bats were recorded, and in the period from 15. to 31. August four bats (Figure 6a). During two-days searches every seven days in September six dead bats were recorded. In the beginning of September (6-7.09.2015) five dead bats were recorded. During second field survey in September (12-13.09.2015) one dead bat was recorded which is the last recorded mortality to the end of monitoring in 2015 (Figure 6b).

Figure 7 shows total recorded bat mortality during July and August at eight wind turbines with mitigation measure implemented in that period.

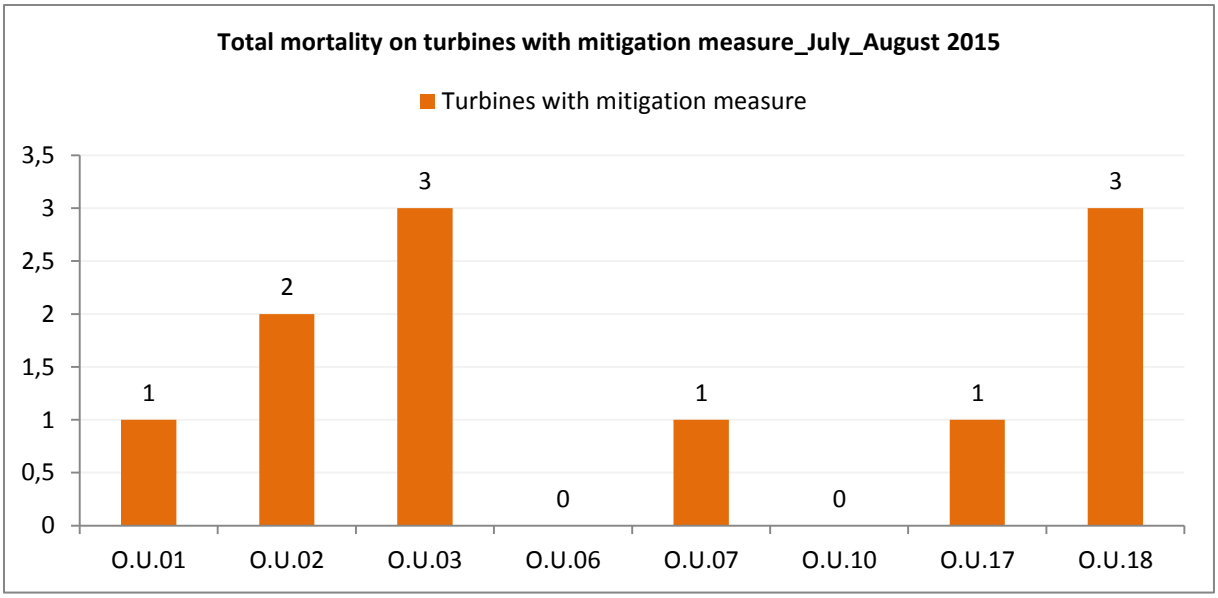


Figure 7. Total recorded bat mortality during July and August 2015 at wind turbines with mitigation measure at location of WF „Jelinak".

Mortality was recorded at six out of eight wind turbines with implemented mitigation measure. Mortality wasn't recorded at wind turbines O.U.06 and O.U.10. Total of 11 dead bats were recorded, a maximum of three bats per wind turbine (Figure 7).

Figure 8 shows bat mortality recorded during July, August and in total for July and August at wind turbines with mitigation measure compared to wind turbines without mitigation measure.

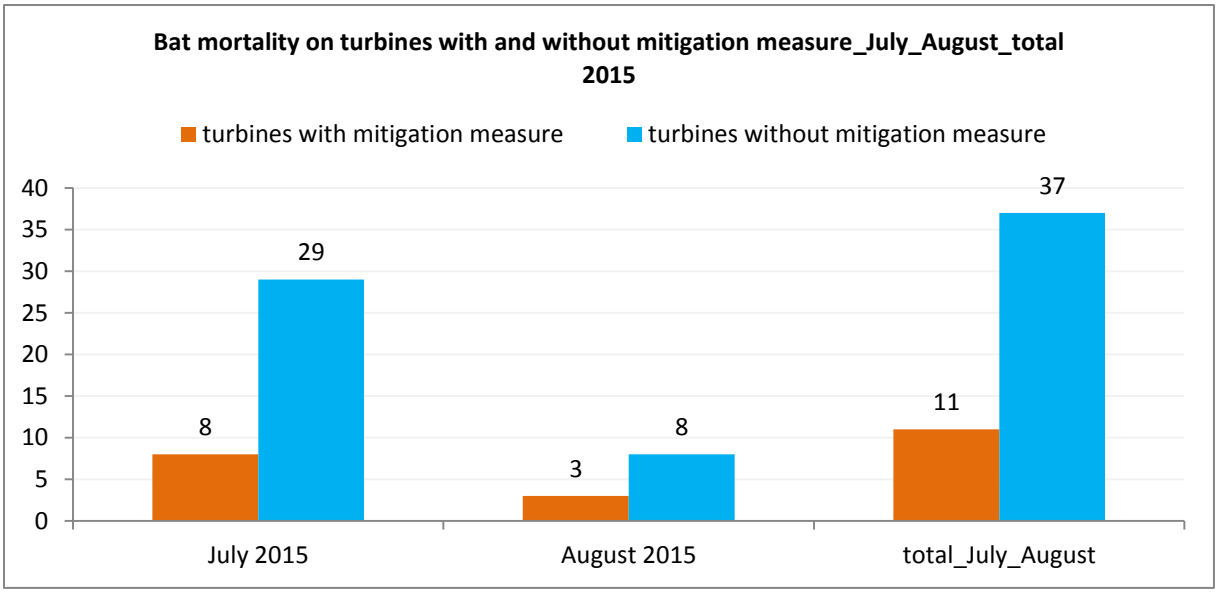


Figure 8. Bat mortality recorded in 2015. during July, August and total for both months at wind turbines with mitigation measure and wind turbines without measure at location of WF „Jelinak".

Comparing wind turbines with implemented mitigation measure with wind turbines without measure (Figure 8) it is evident that at wind turbines with measure total of 11 dead bats (23%) was recorded and at wind turbines without measure 37 dead bats (77%). During July at wind turbines with measure 8 dead bats (22%) was recorded and at wind turbines without measure 29 dead bats (78%). During August at wind turbines with measure 3 dead bats (27%) was recorded and at wind turbines without measure 8 dead bats (73%).

Figure 9 shows total recorded bat mortality per species in July and August at wind turbines with mitigation measure at that period compared to wind turbines without measure. Considering the species composition there is no difference in the number of dead bats at wind turbines with mitigation measure compared to wind turbines without measure.

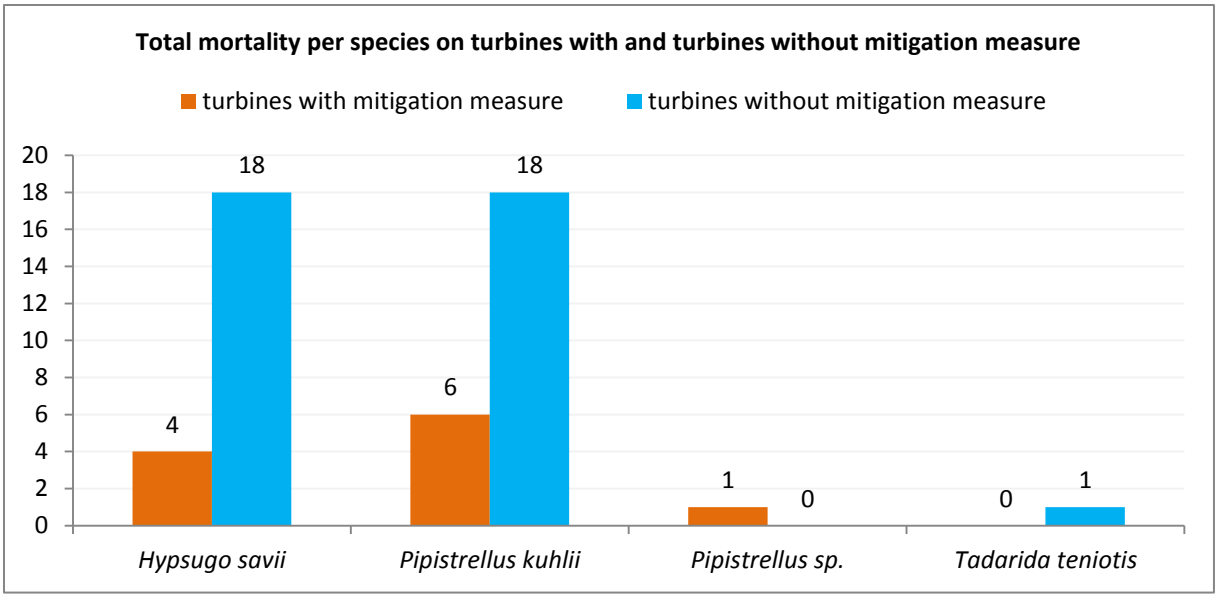


Figure 9. Total bat mortality recorded during July and August 2015 per species at wind turbines with mitigation measure and wind turbines without measure at location of WF „Jelinak“.

3.2. Bat activity monitoring results

Batcorder windturbine O.U.01 (5.4)
June 2015

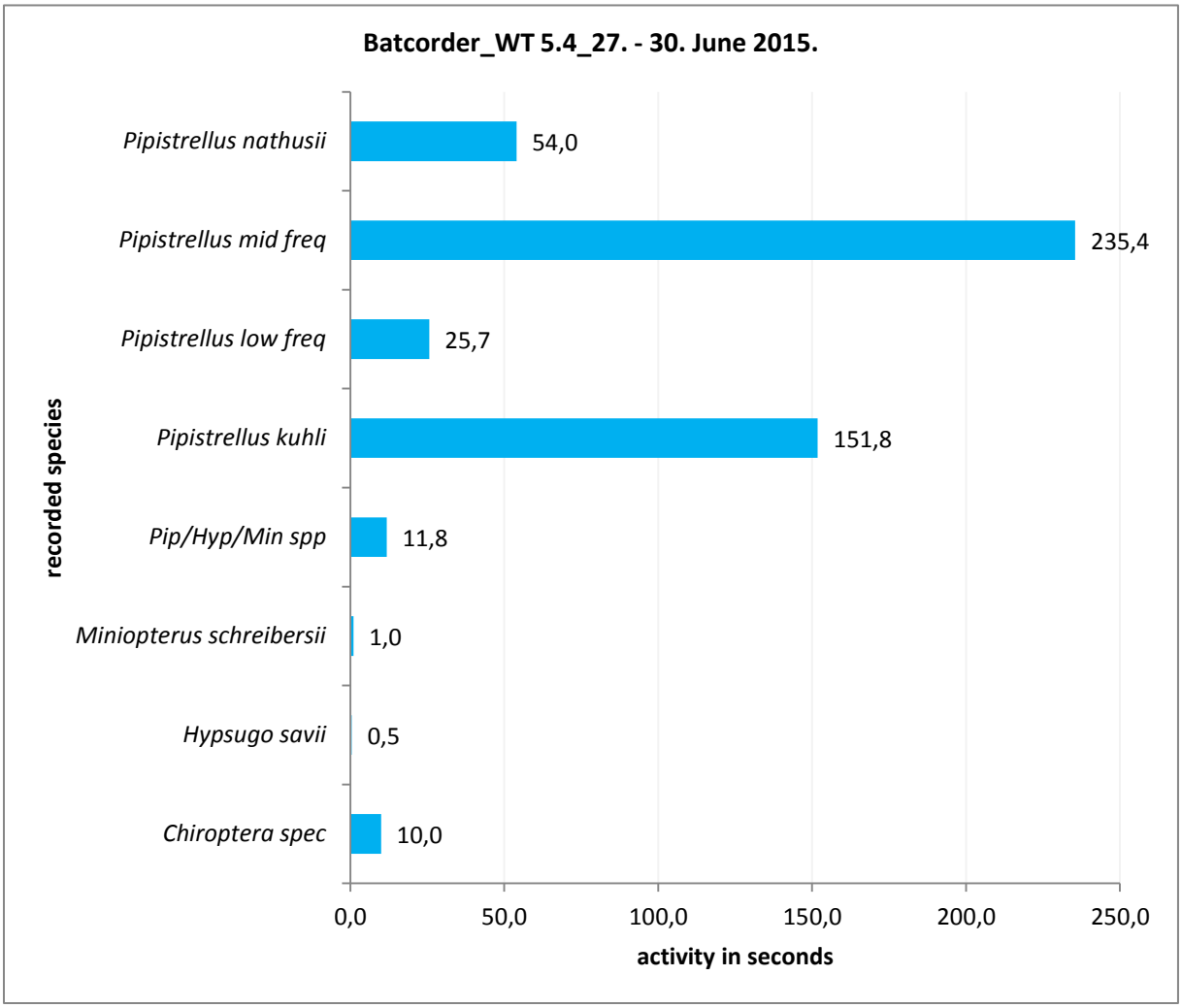


Figure 10. Total activity of all recorded bat species at wind turbine O.U.01 in the period 27 - 30. June 2015. at location of WF „Jelinak“.

Figure 10 shows all recorded bat species in the period 27 - 30. June 2015. at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share are bat group *Pipistrellus* middle frequency (48%), followed by species *P. kuhlii* (31%) and species *P. nathusii* (11%).

Activity of all recorded bats in June (Figure 11) was the highest in the period from 22 to 24 hours.

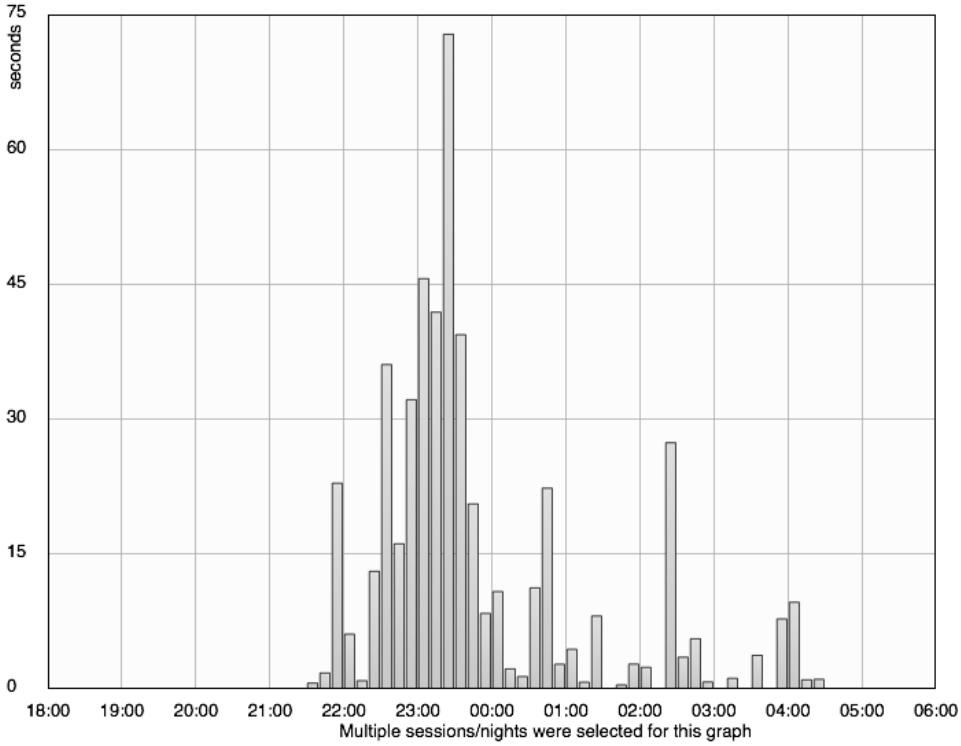


Figure 11. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in the period 27 - 30. June 2015. at location of WF „Jelinak“.

The group *Pipistrellus* middle frequency (Figure 12) in June was the most active in the period from 22 to 24 hours while activity was decreased the rest of the night.

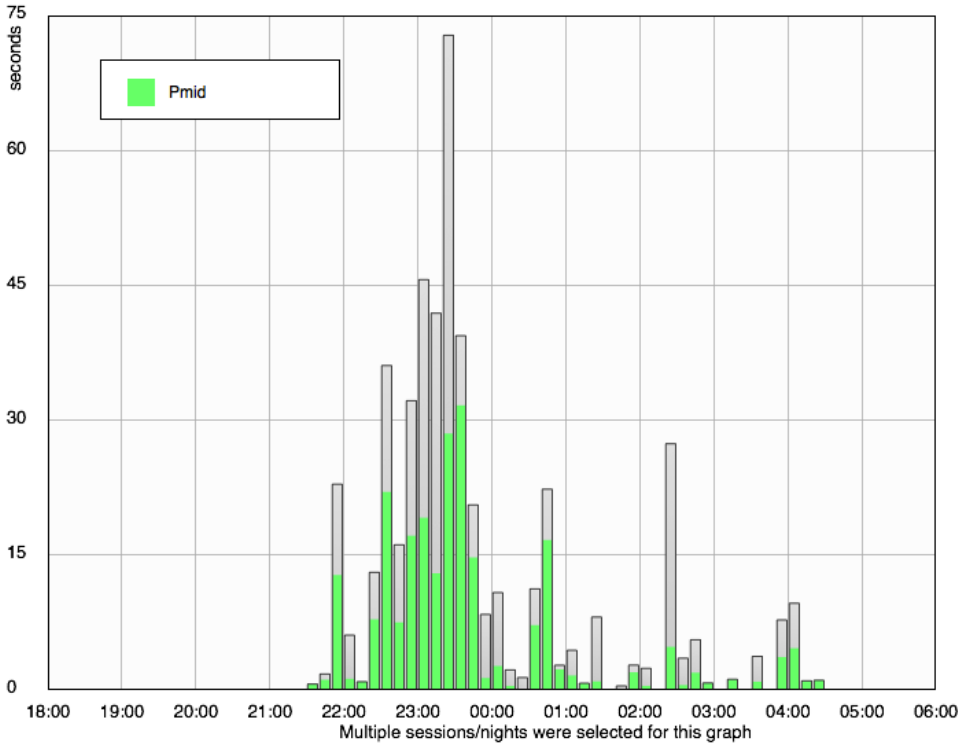


Figure 12. Activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in the period 27 - 30. June 2015. at location of WF „Jelinak“.

Species *P. kuhlii* (Figure 13) in June was the most active around 23 hours, while activity was decreased the rest of the night.

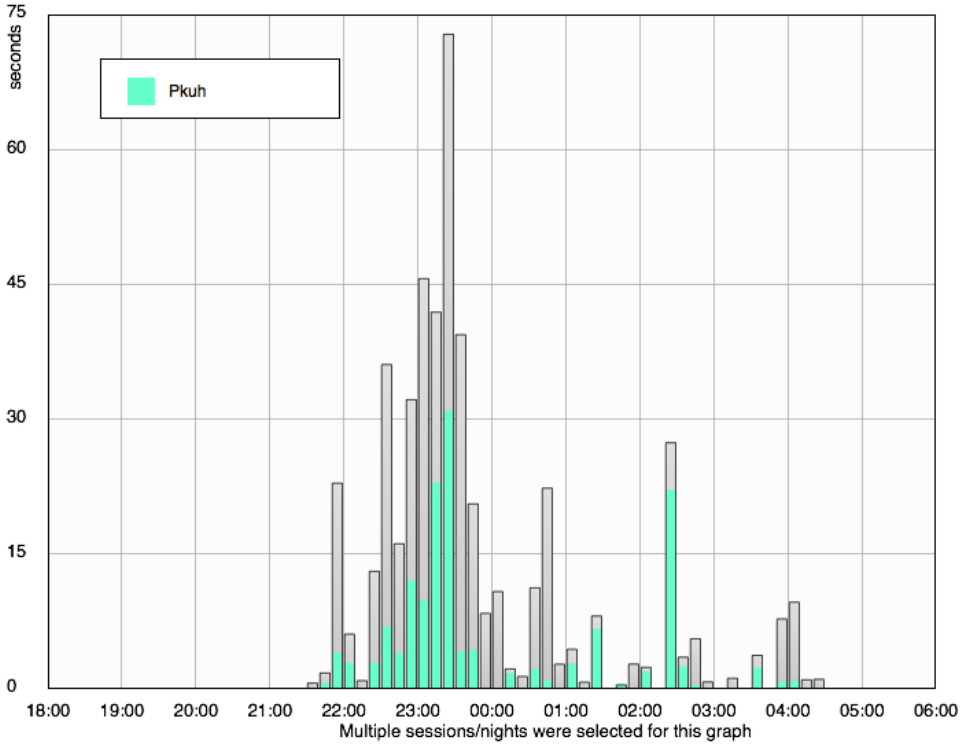


Figure 13. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in the period 27 - 30. June 2015. at location of WF „Jelinak“.

Species *P. nathusii* (Figure 14) in June was present in period from 22 to 24 hours, while the rest of the night was present only sporadically.

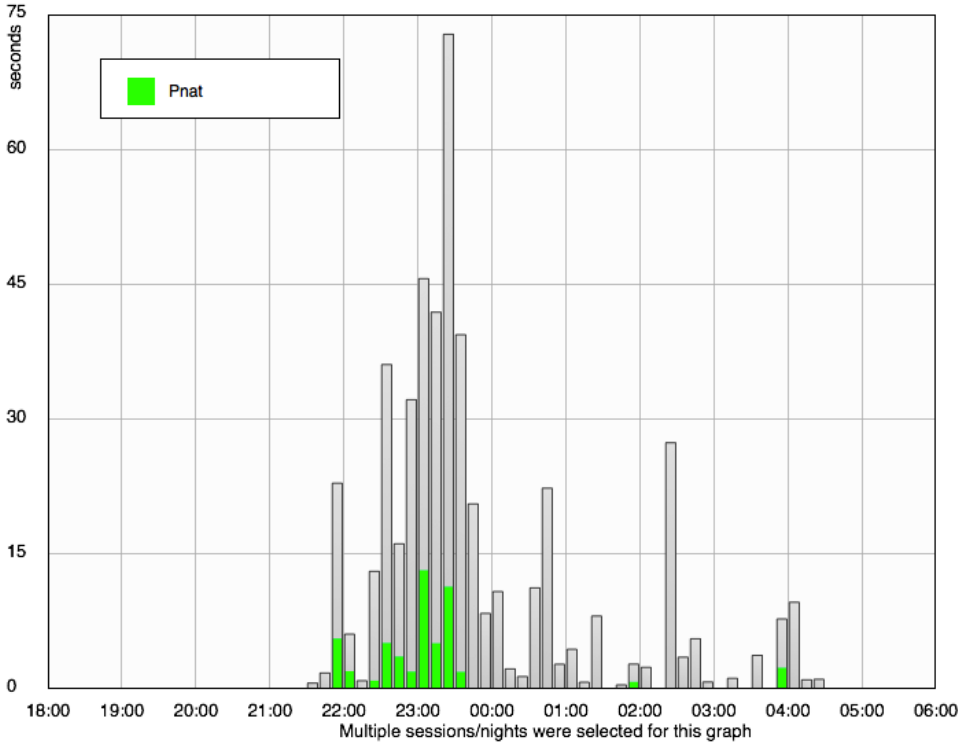


Figure 14. Activity of species *Pipistrellus nathusii* during entire nights at wind turbine O.U.01 in the period 27 - 30. June 2015. at location of WF „Jelinak“.

July 2015

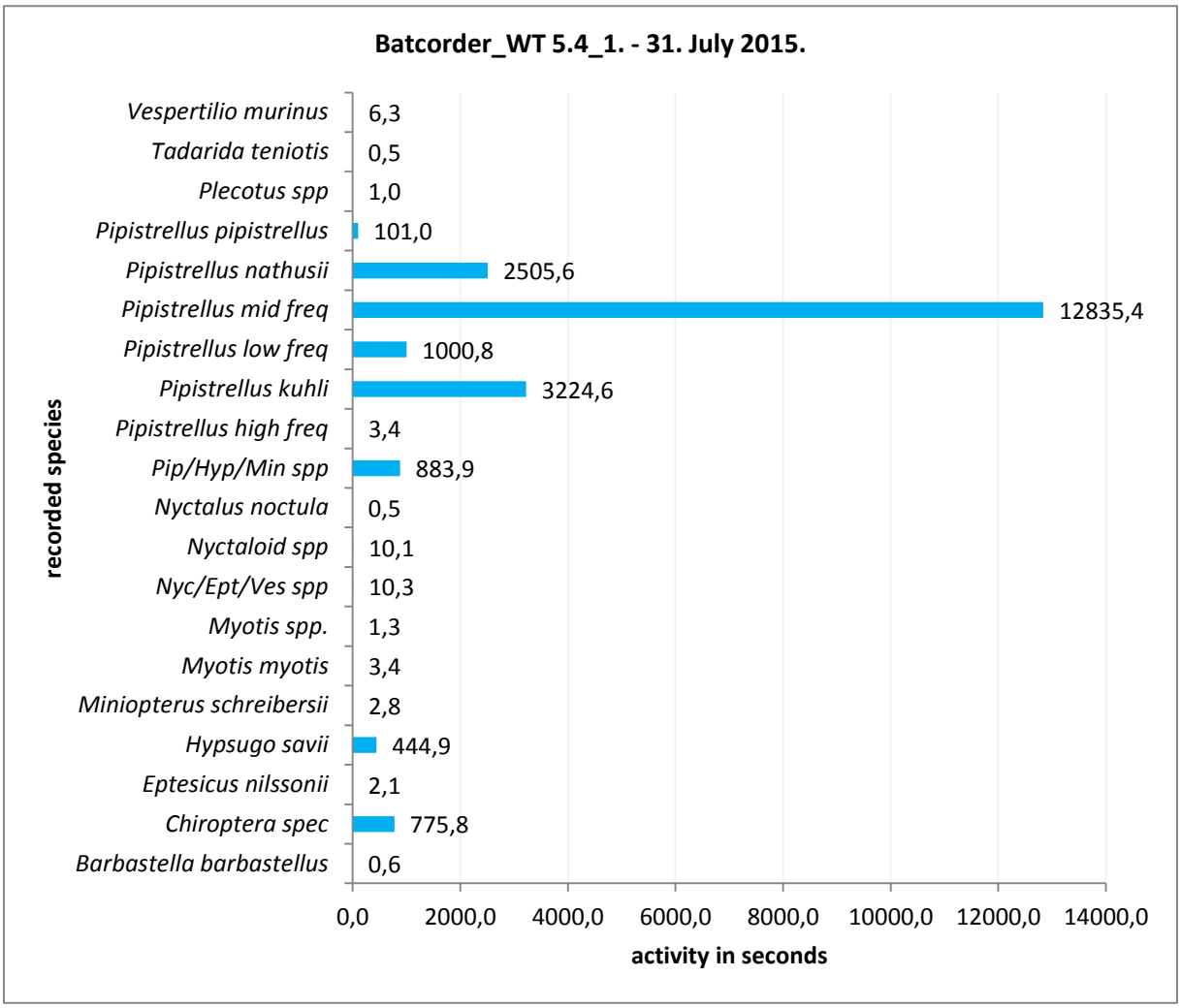


Figure 15. Total activity of all recorded bat species at wind turbine O.U.01 in July 2015. at location of WF „Jelinak“.

Figure 15 shows all recorded bat species in the period 1. - 31. July 2015. at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share are bat group *Pipistrellus* middle frequency (59%), followed by species *P. kuhlii* (15%) and species *P. nathusii* (11%).

Activity of all recorded bats in July (Figure 16) was evenly distributed throughout the night.

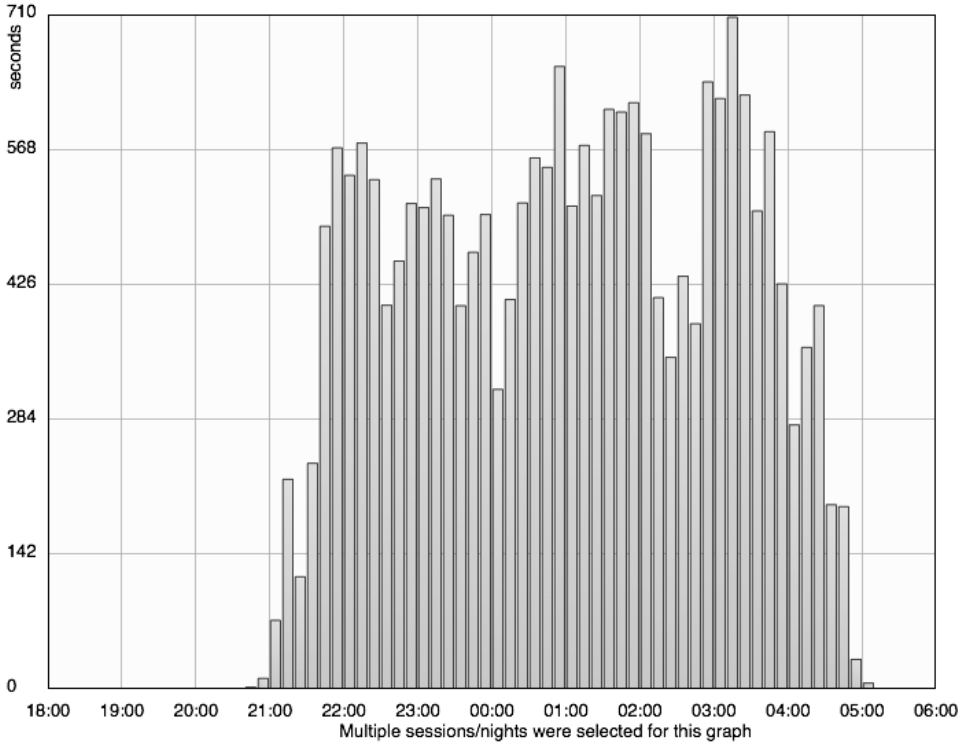


Figure 16. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in July 2015. at location of WF „Jelinak“.

Activity of group *Pipistrellus* middle frequency in July (Figure 17) was evenly distributed throughout the night.

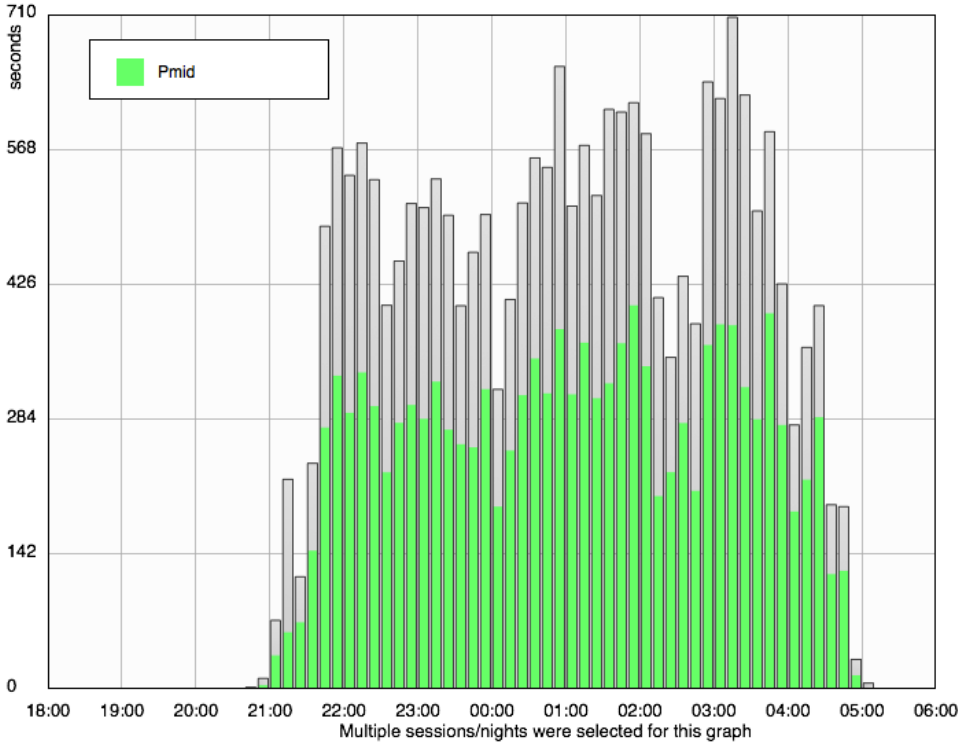


Figure 17. Activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in July 2015. at location of WF „Jelinak“.

Activity of species *P. kuhlii* in July (Figure 18) was evenly distributed throughout the night.

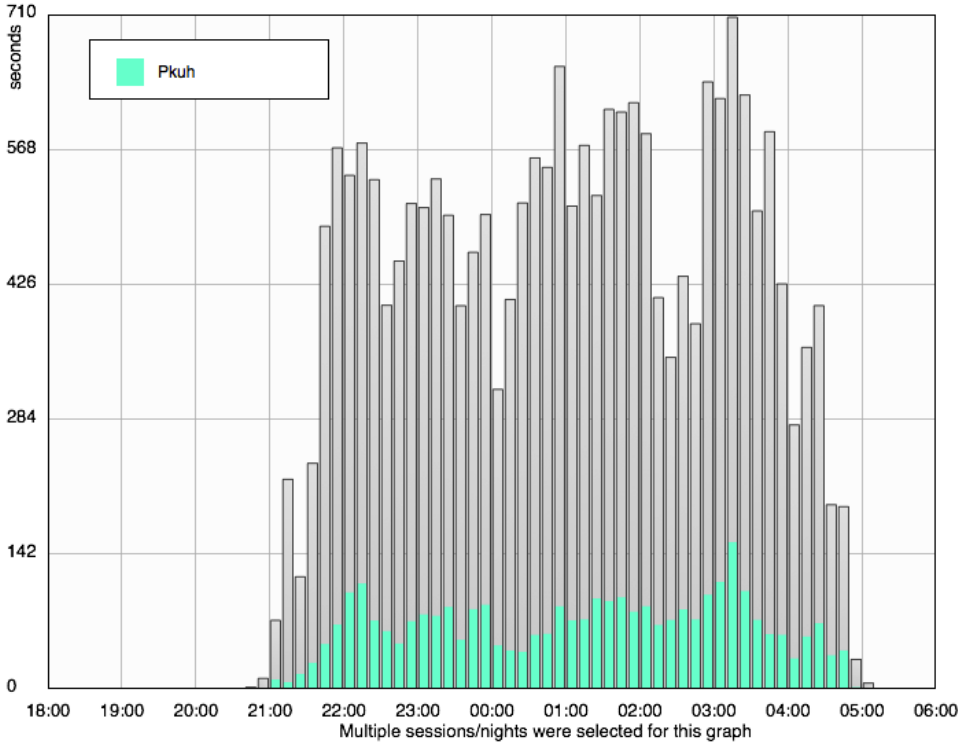


Figure 18. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in July 2015. at location of WF „Jelinak“.

Activity of species *P. nathusii* in July (Figure 19) was evenly distributed throughout the night.

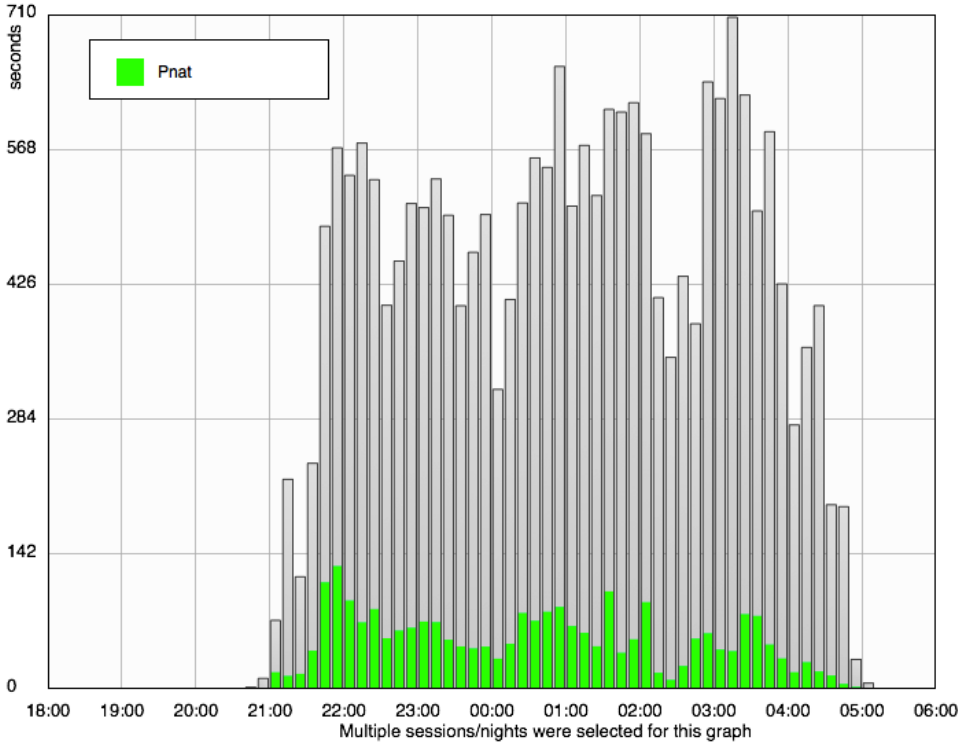


Figure 19. Activity of species *Pipistrellus nathusii* during entire nights at wind turbine O.U.01 in July 2015. at location of WF „Jelinak“.

August 2015

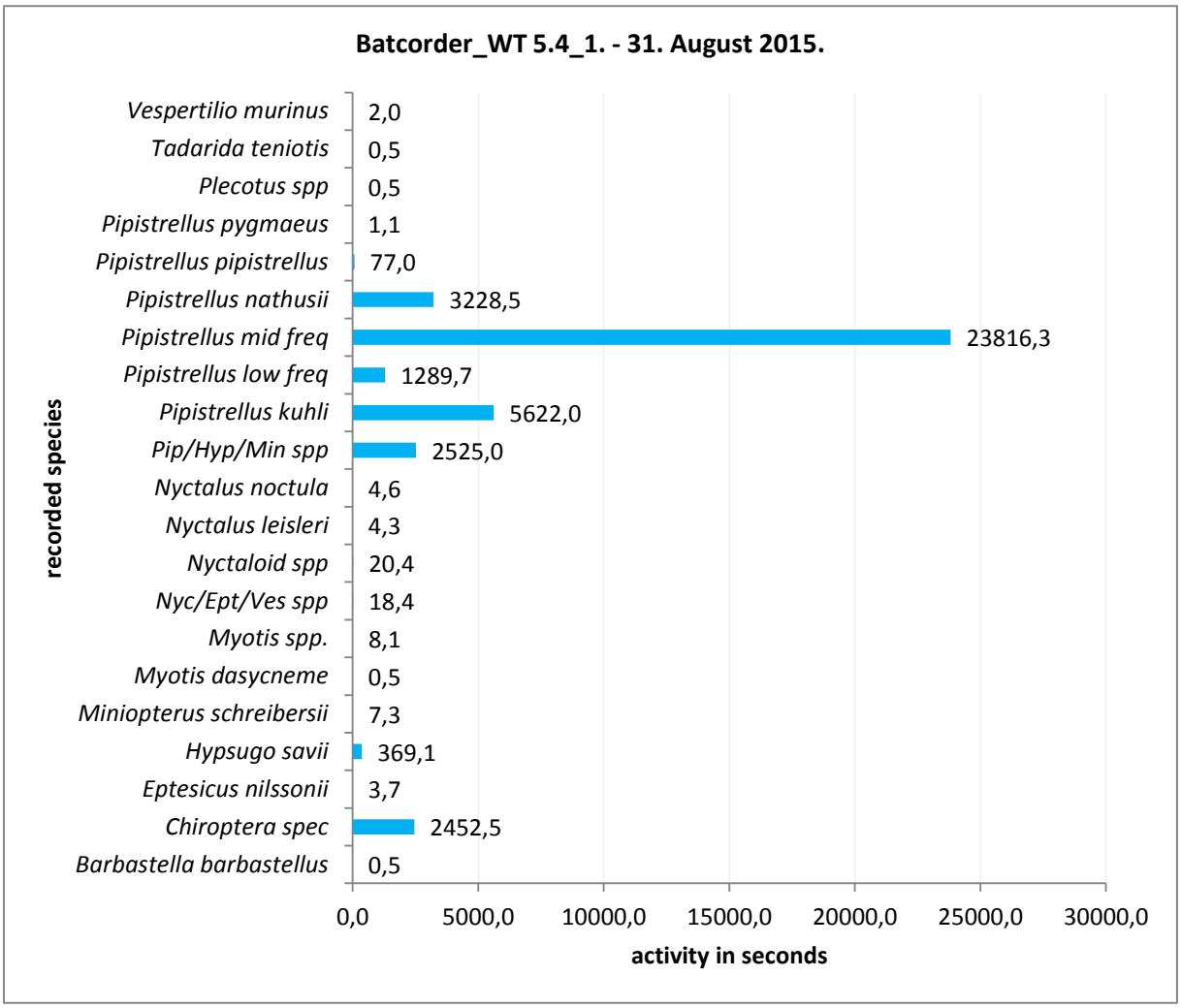


Figure 20. Total activity of all recorded bat species at wind turbine O.U.01 in July 2015. at location of WF „Jelinak“.

Figure 20 shows all recorded bat species in the period 1. - 31. August 2015. at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share are bat group *Pipistrellus* middle frequency (60%), followed by species *P. kuhlii* (14%) and species *P. nathusii* (8%).

Activity of all recorded bats in August (Figure 21) was distributed throughout the night with activity peaks between 22 and 23 hours, around 2 am and between 4 and 5 am.

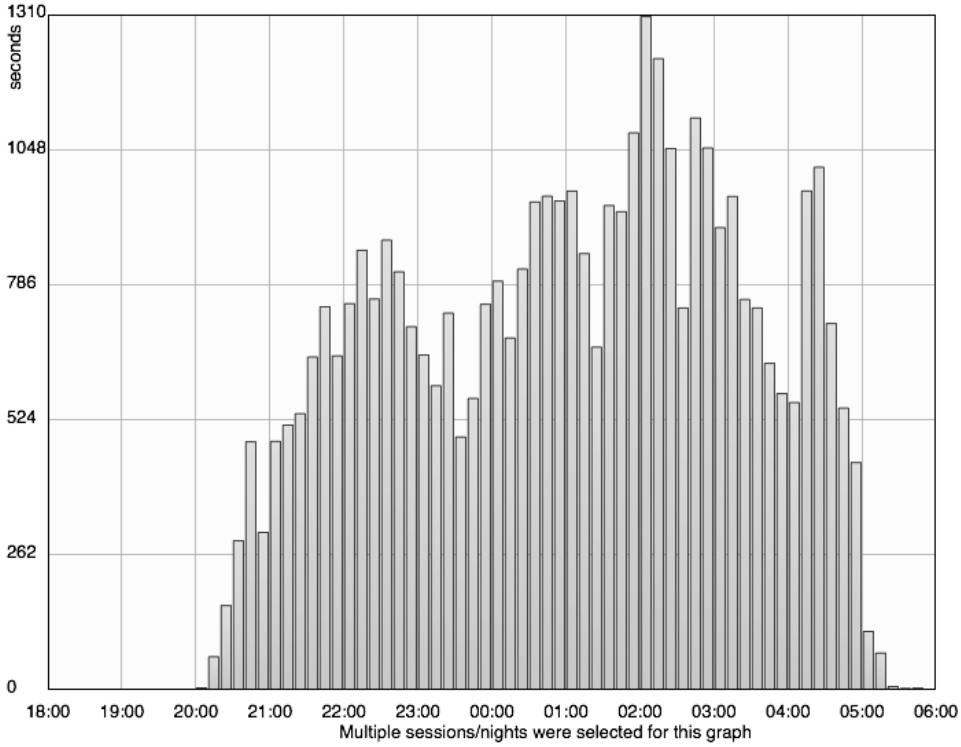


Figure 21. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in August 2015. at location of WF „Jelinak“.

Activity of group *Pipistrellus* middle frequency in August (Figure 22) was distributed throughout the night with activity peaks between 22 and 23 hours and around 2 am.

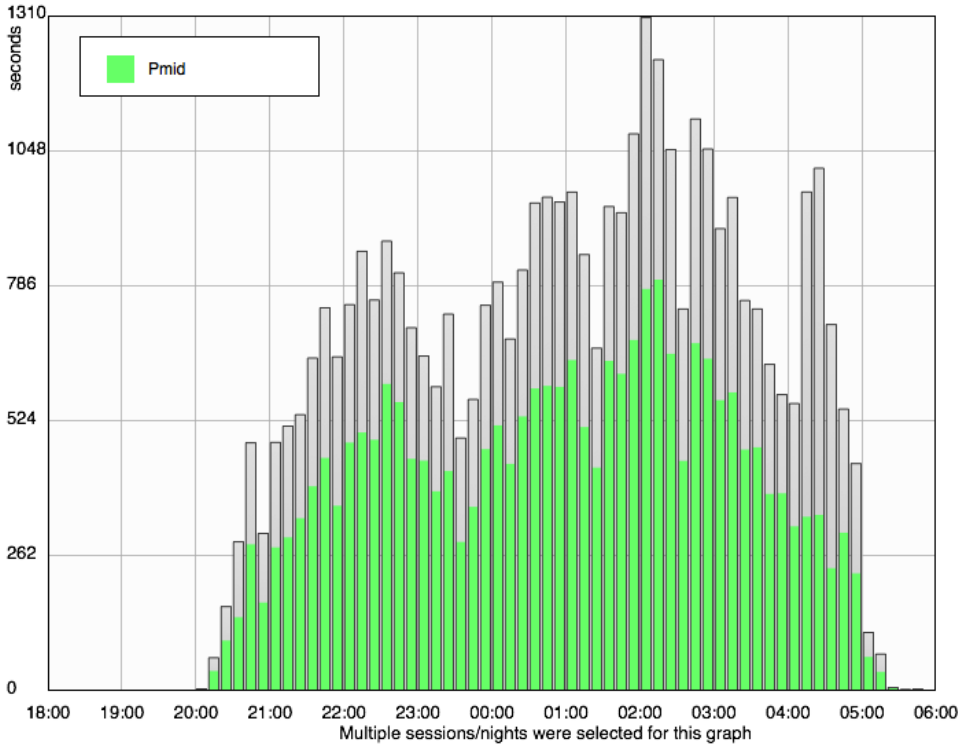


Figure 22. Activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in August 2015. at location of WF „Jelinak“.

Activity of species *P. kuhlii* in August (Figure 23) was distributed throughout the night with activity peaks between 24 and 1 hour and between 2 and 3 am.

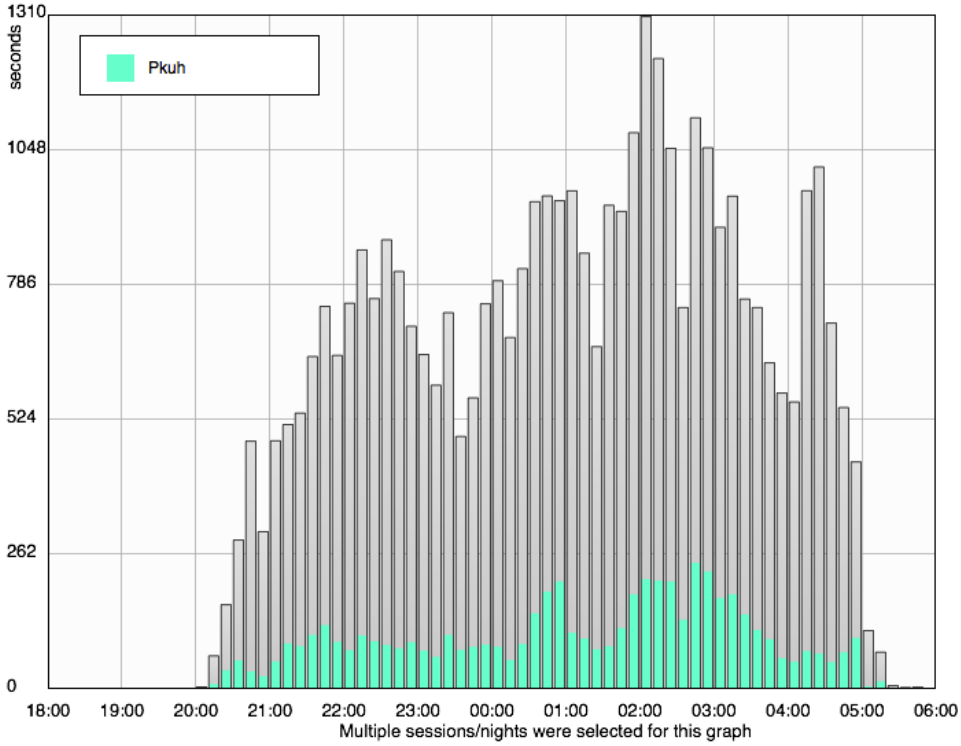


Figure 23. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in August 2015. at location of WF „Jelinak“.

Activity of species *P. nathusii* in August (Figure 24) was low but evenly distributed throughout the night.

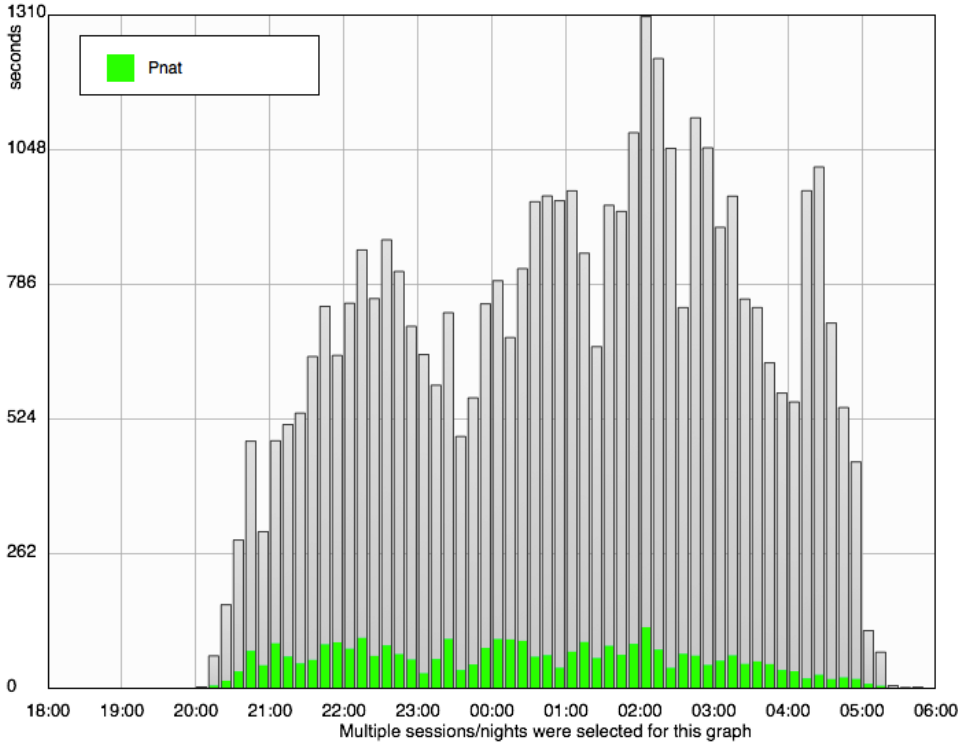


Figure 24. Activity of species *Pipistrellus nathusii* during entire nights at wind turbine O.U.01 in August 2015. at location of WF „Jelinak“.

September 2015

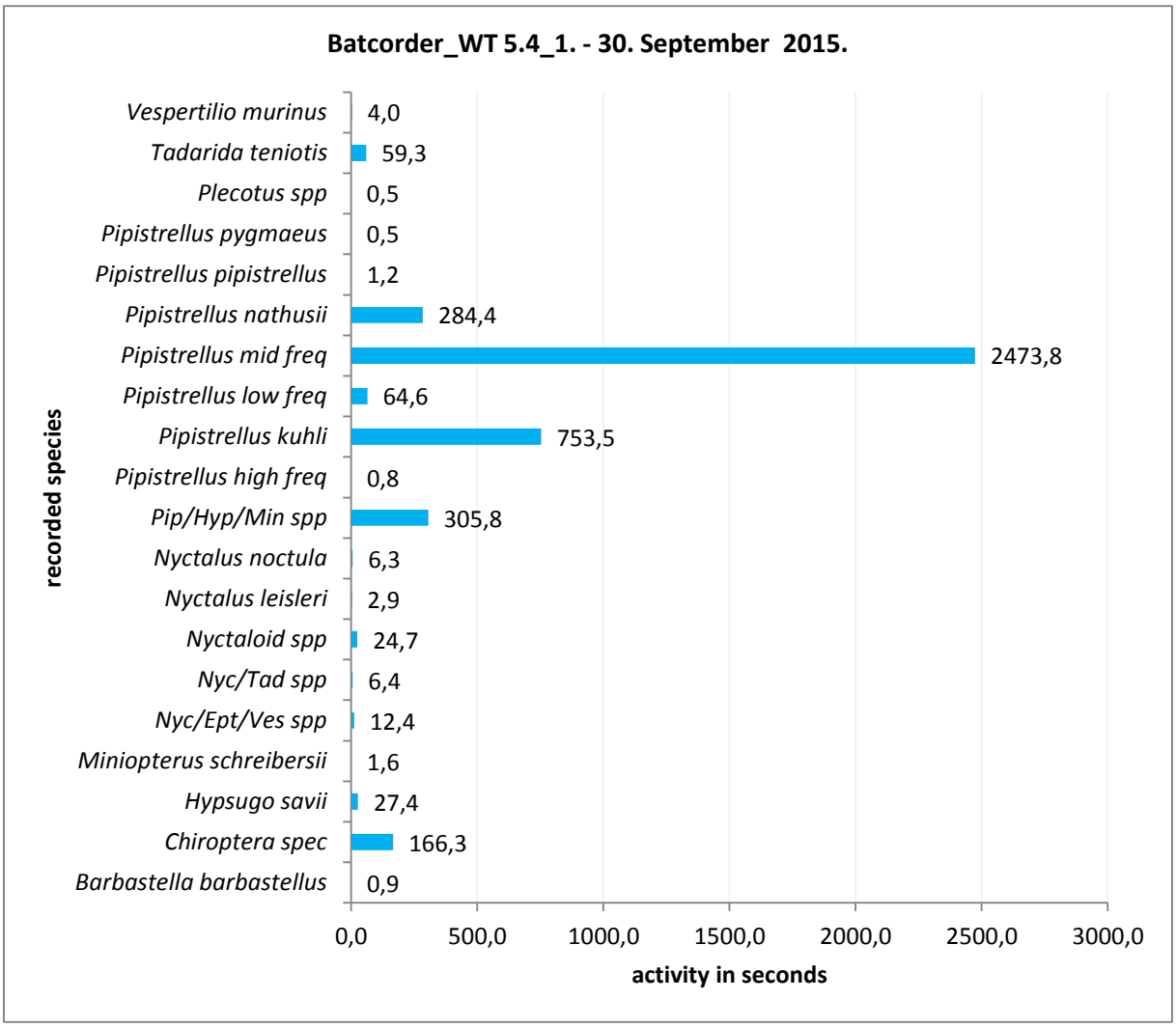


Figure 25. Total activity of all recorded bat species at wind turbine O.U.01 inSeptember 2015. at location of WF „Jelinak“.

Figure 25 shows all recorded bat species in the period 1. - 30. September 2015. at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share are bat group *Pipistrellus* middle frequency (59%), followed by species *P. kuhlii* (18%) and species *P. nathusii* (7%).

Activity of all recorded bats in September (Figure 26) was the highest up to 2 am.

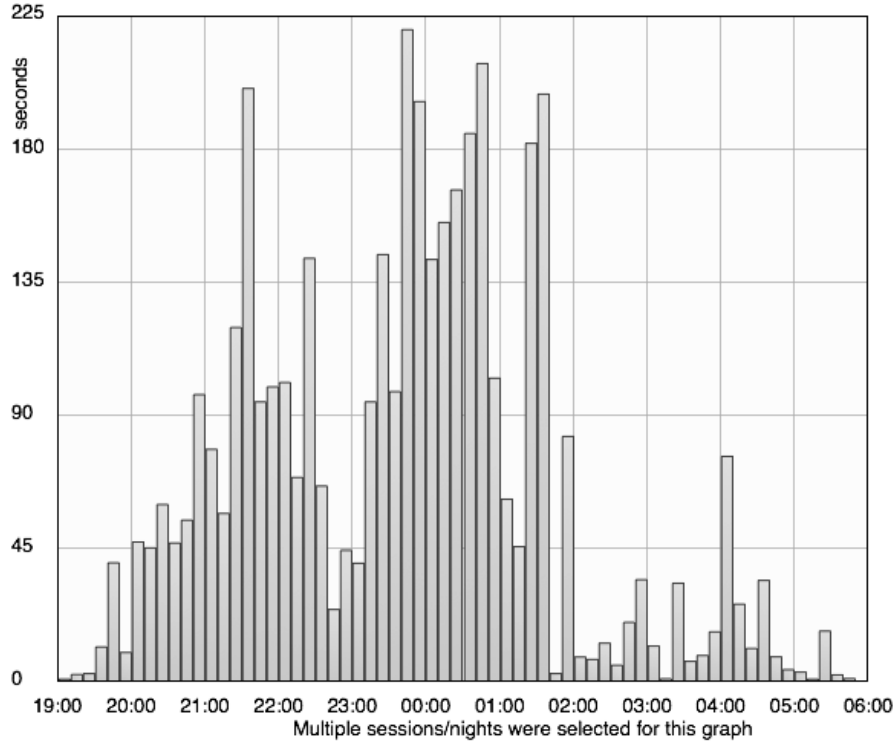


Figure 26. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in September 2015. at location of WF „Jelinak“.

The highest activity of group *Pipistrellus* middle frequency (Figure 27) in September was up to 2 am.

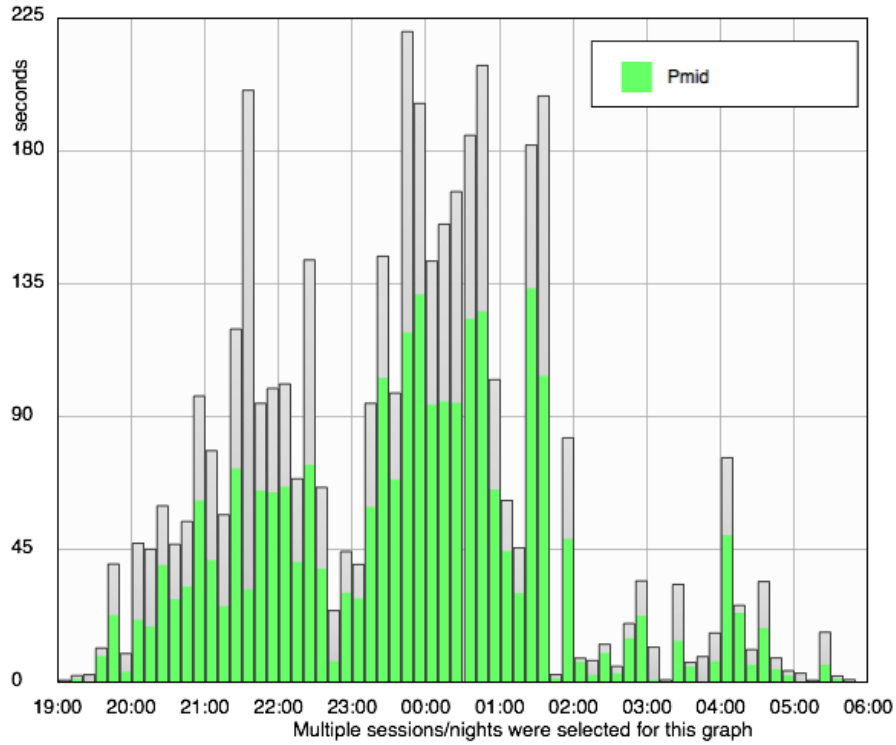


Figure 27. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in September 2015. at location of WF „Jelinak“.

The most of activity of species *P. kuhlii* (Figure 28) in September was up to 2 am while after 2 am the species was present only sporadically.

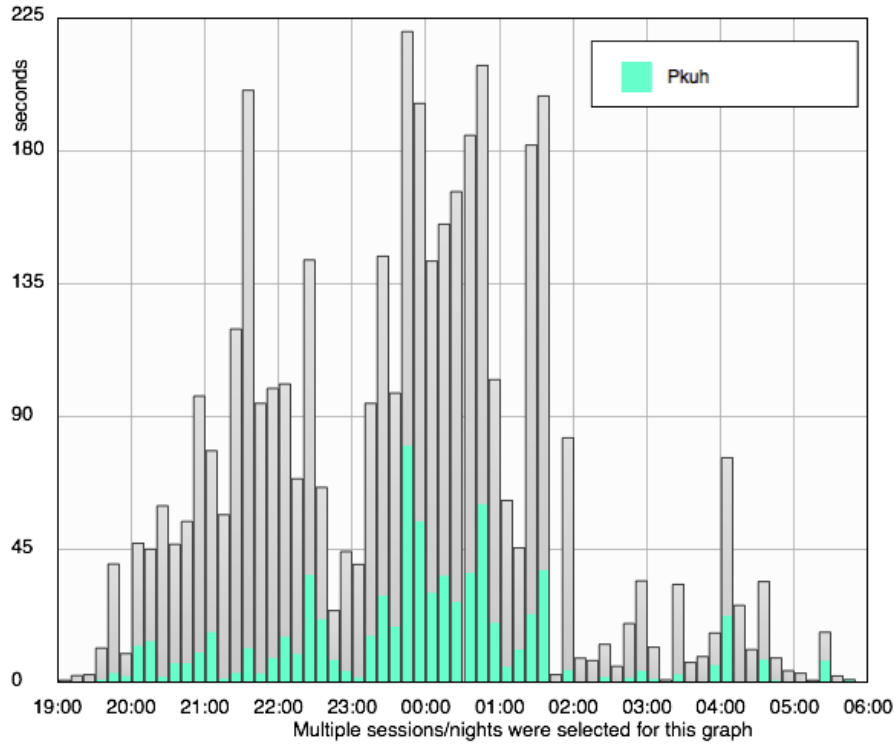


Figure 28. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in September 2015. at location of WF „Jelinak“.

The most of activity of species *P. nathusii* (Figure 29) in September was up to 2 am while after 2 am the species was present only sporadically.

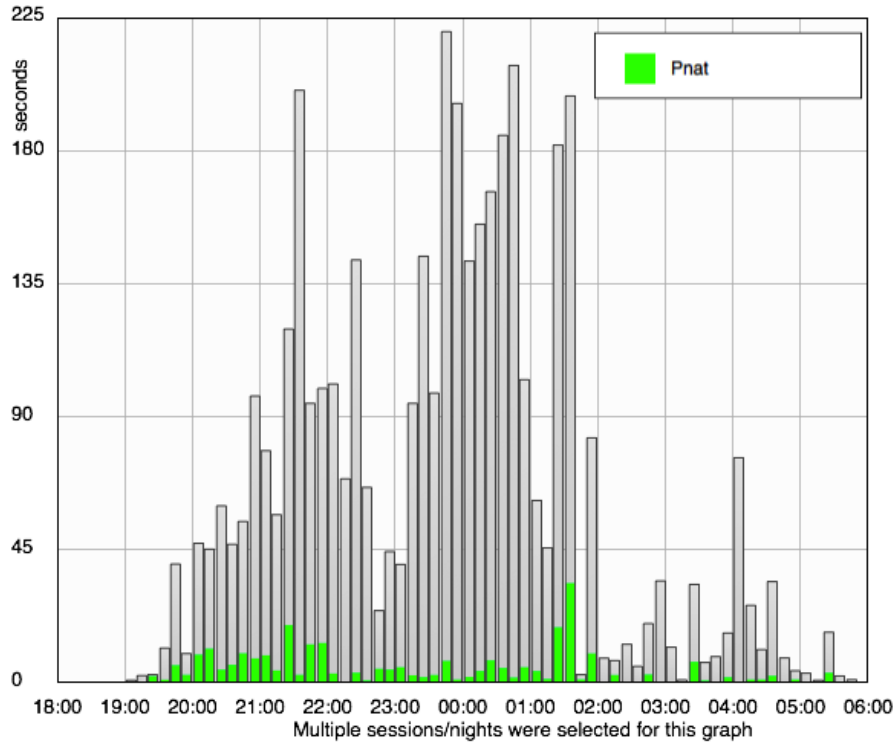


Figure 29. Total activity of species *Pipistrellus nathusii* during entire nights at wind turbine O.U.01 in September 2015. at location of WF „Jelinak“.

October 2015

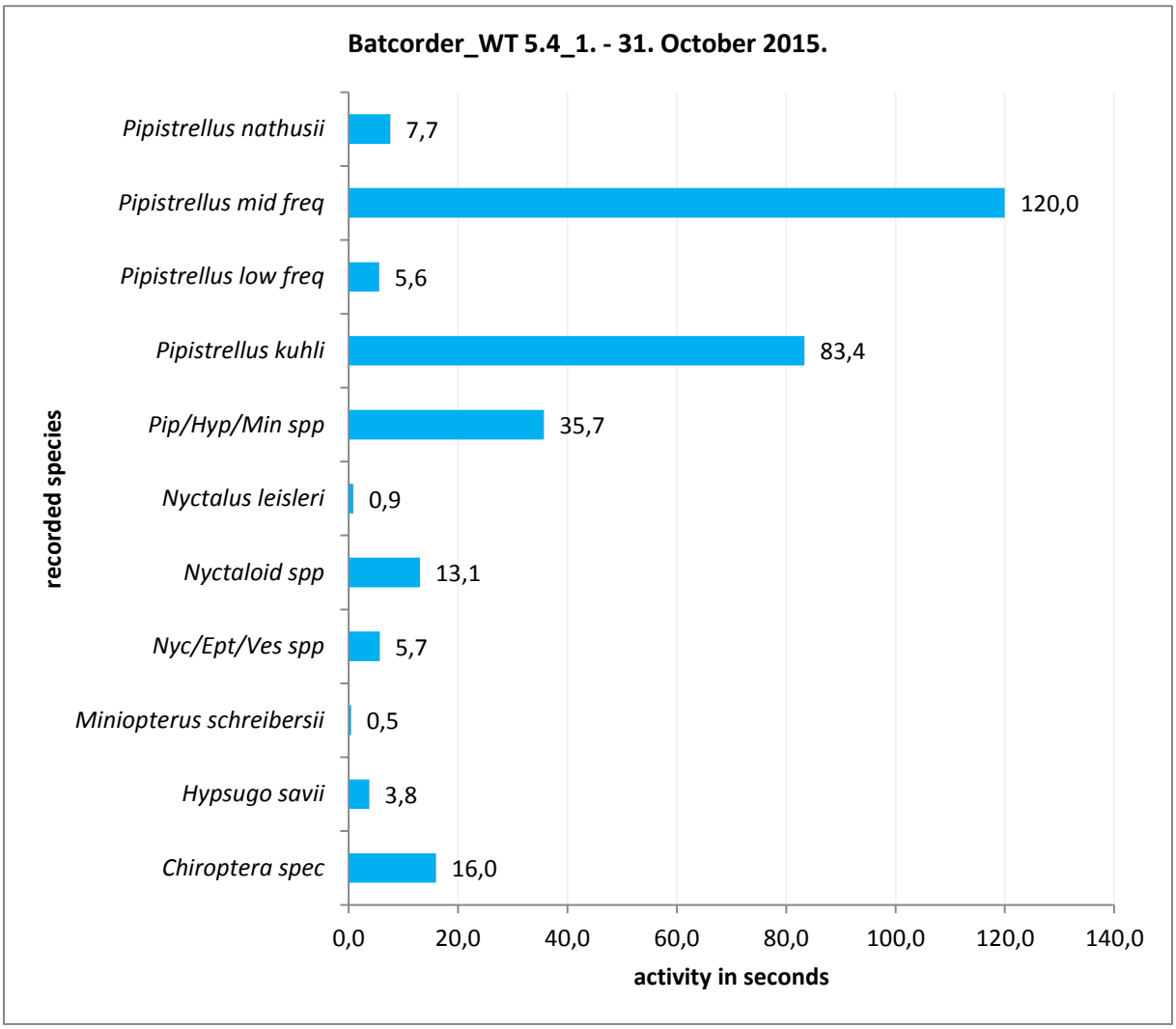


Figure 30. Total activity of all recorded bat species at wind turbine O.U.01 in October 2015. at location of WF „Jelinak“.

Figure 30 shows all recorded bat species in the period 1. - 31. October 2015. at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share are bat group *Pipistrellus* middle frequency (41%), followed by species *P. kuhlii* (29%).

Activity of all recorded bats in October (Figure 31) was sporadically with interruptions and shows four activity peaks, in period between 19 and 20 hours, then around midnight, before 2 am and between 3 and 4 am.

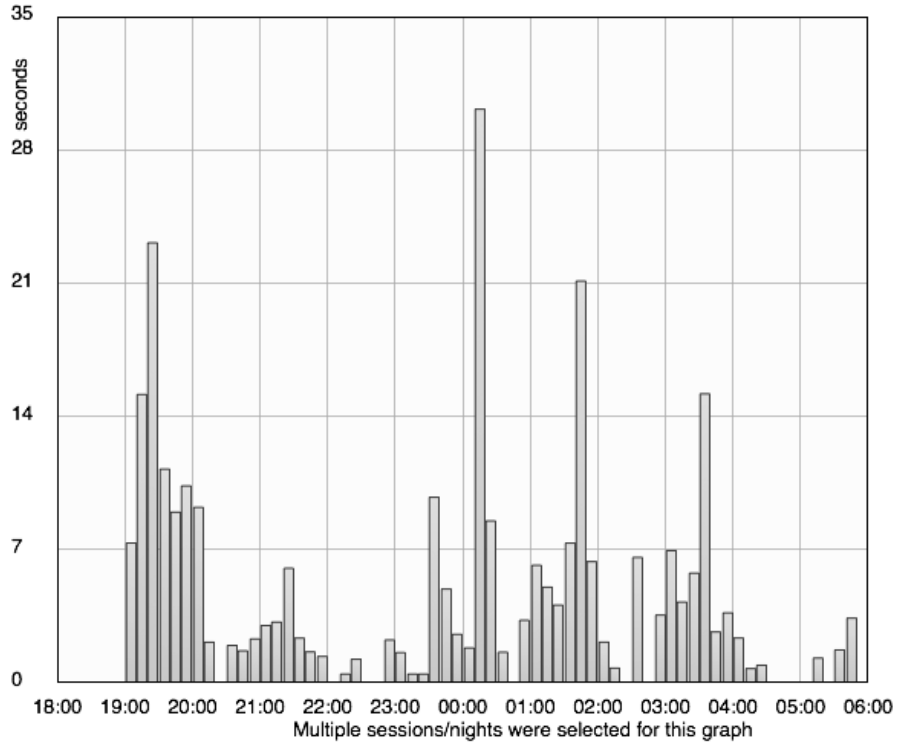


Figure 31. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in October 2015. at location of WF „Jelinak“.

Activity of group *Pipistrellus* middle frequency in October (Figure 32) was sporadically with interruptions and shows four activity peaks, in period between 19 and 20 hours, then around midnight, before 2 am and between 3 and 4 am.

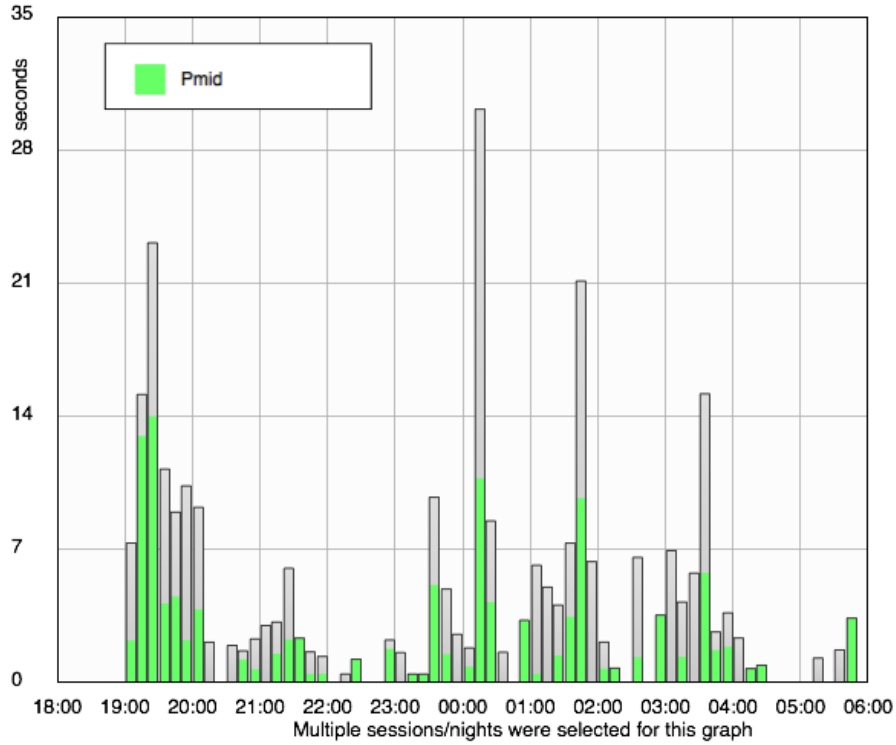


Figure 32. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in October 2015. at location of WF „Jelinak“.

Activity of species *P. kuhlii* in October (Figure 33) was sporadically with interruptions and shows two activity peaks, in period between 19 and 20 hours, and around midnight.

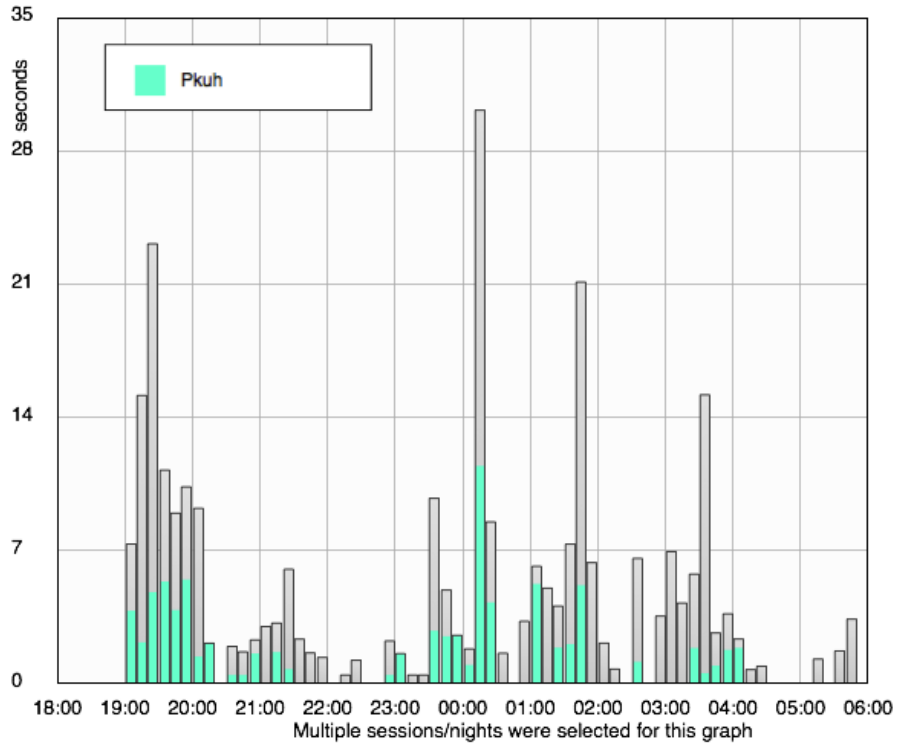


Figure 33. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in October 2015. at location of WF „Jelinak“.

Batcorder windturbine O.U.18 (1.3)

August 2015

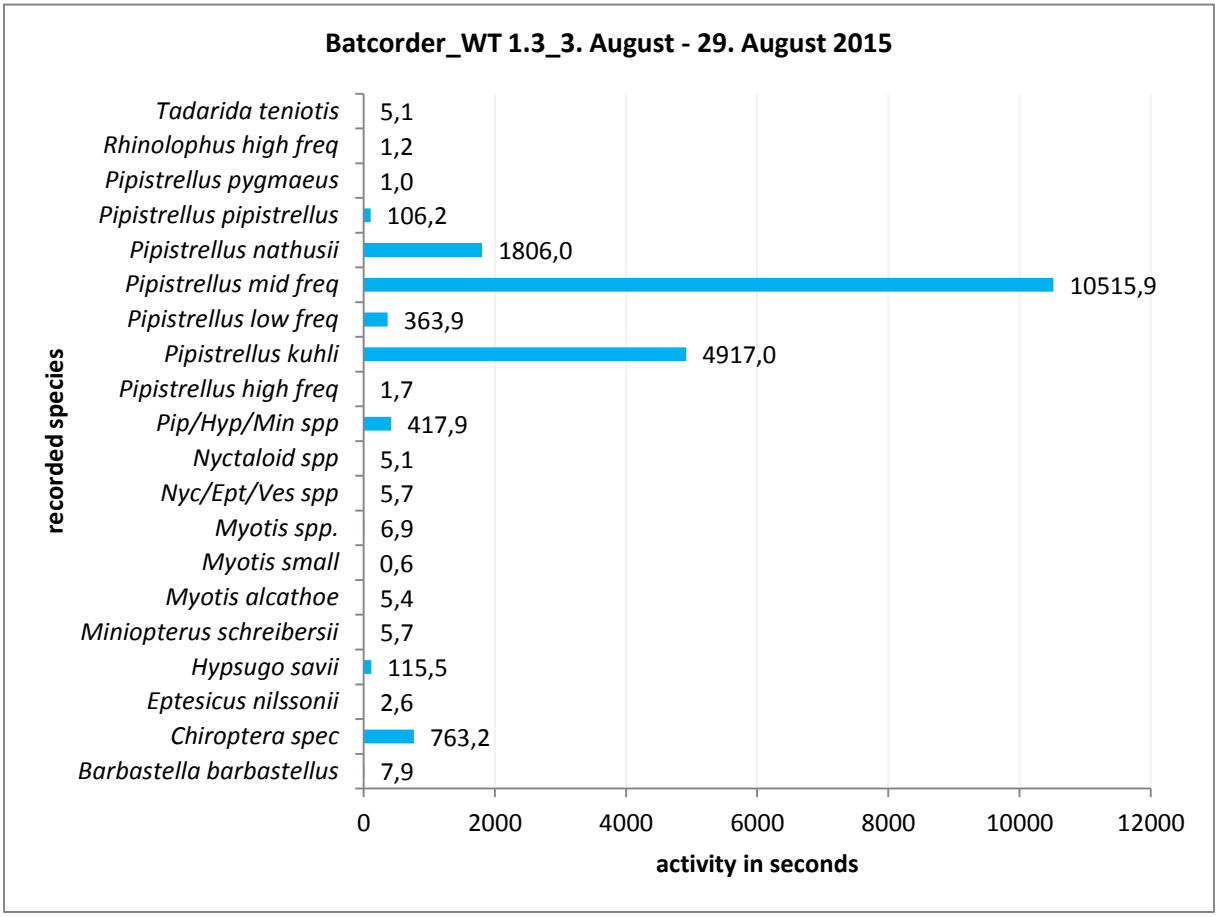


Figure 34. Total activity of all recorded bat species at wind turbine O.U.18 in August 2015. at location of WF „Jelinak“.

Figure 34 shows all recorded bat species in August 2015 at wind turbine O.U.18 and their total recorded activity in seconds. According to the species/groups share, the largest share are bat group *Pipistrellus* middle frequency (55%), followed by species *P. kuhlii* (26%) and species *P. nathusii* (9%). Total recorded activity in August was twice less at wind turbine O.U.18 compared to O.U.01 in the same period. The largest difference was in the activity of group *Pipistrellus* middle frequency and species *P. nathusii*, while for species *P. kuhlii* difference in activity was insignificant.

Activity of all recorded bats (Figure 35) shows two activity peaks, first in period between 21 and 23 hours and second between 2 and 3 am. Total recorded bat activity in August at wind turbine O.U.18 compared to the same period at O.U.01 doesn't have the third activity peak in period from 4 to 5 am.

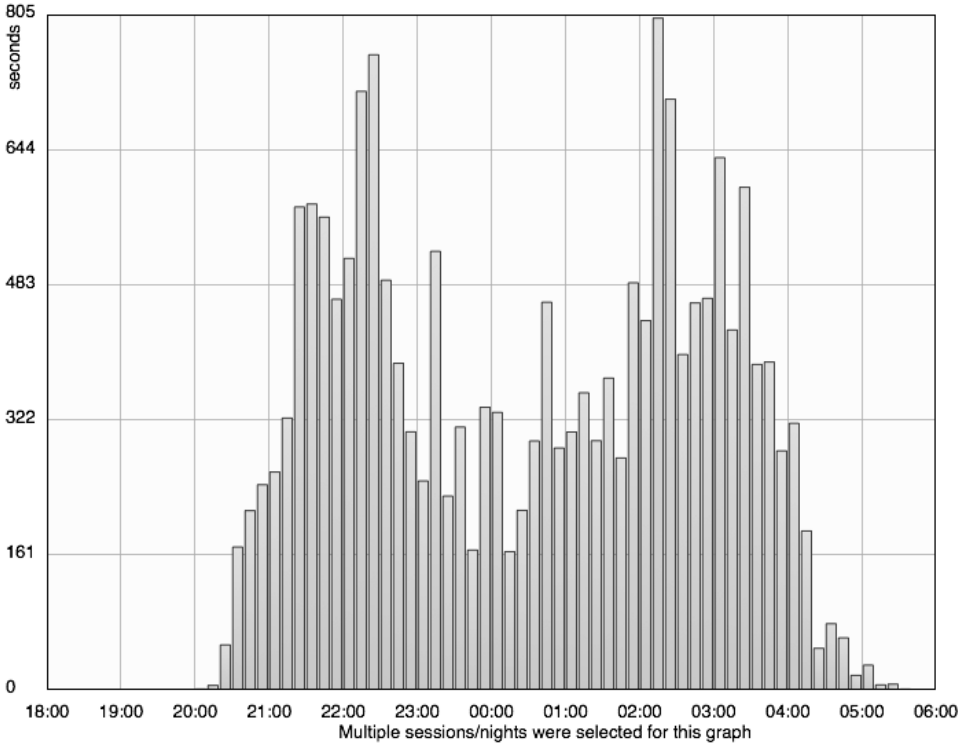


Figure 35. Total activity of all recorded bat species during entire nights at wind turbine O.U.18 in August 2015. at location of WF „Jelinak“.

The group *Pipistrellus* middle frequency in August (Figure 36) was active throughout the entire night with activity peaks around 22 hours and between 2 and 4 am. This group recorded activity in August at wind turbine O.U.18 compared to the same period at O.U.01 has longer second activity peak.

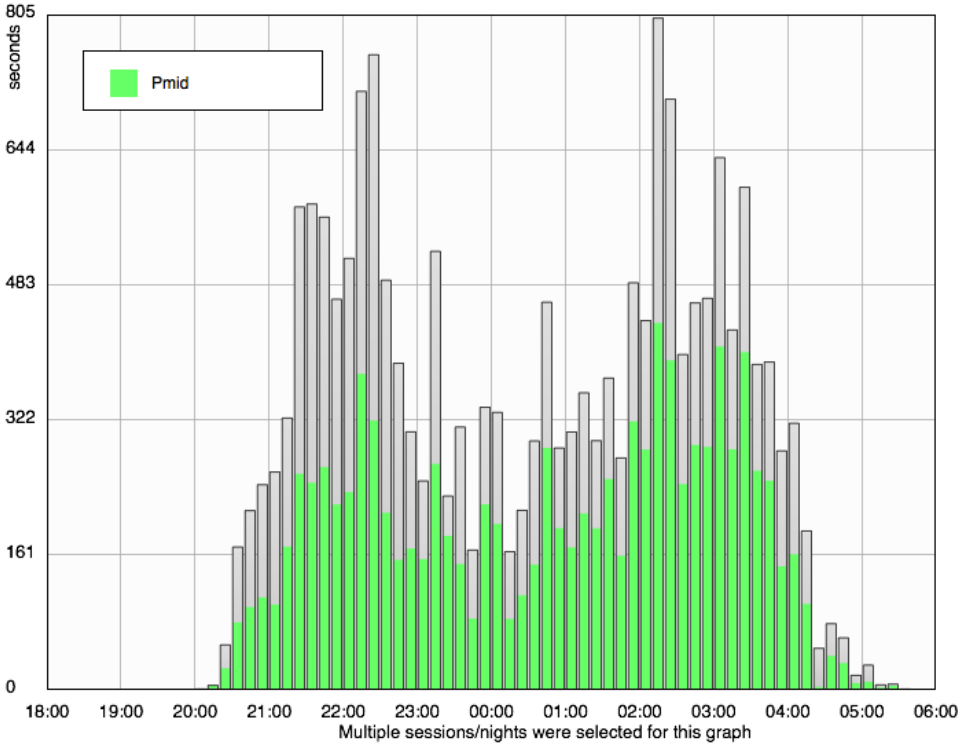


Figure 36. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.18 in August 2015. at location of WF „Jelinak“.

Species *P. kuhlii* in August (Figure 37) was active throughout the night with two activity peaks, around 22 hours and around 2 am. This species recorded activity in August at wind turbine O.U.18 compared to the same period at O.U.01 has both activity peaks shorter.

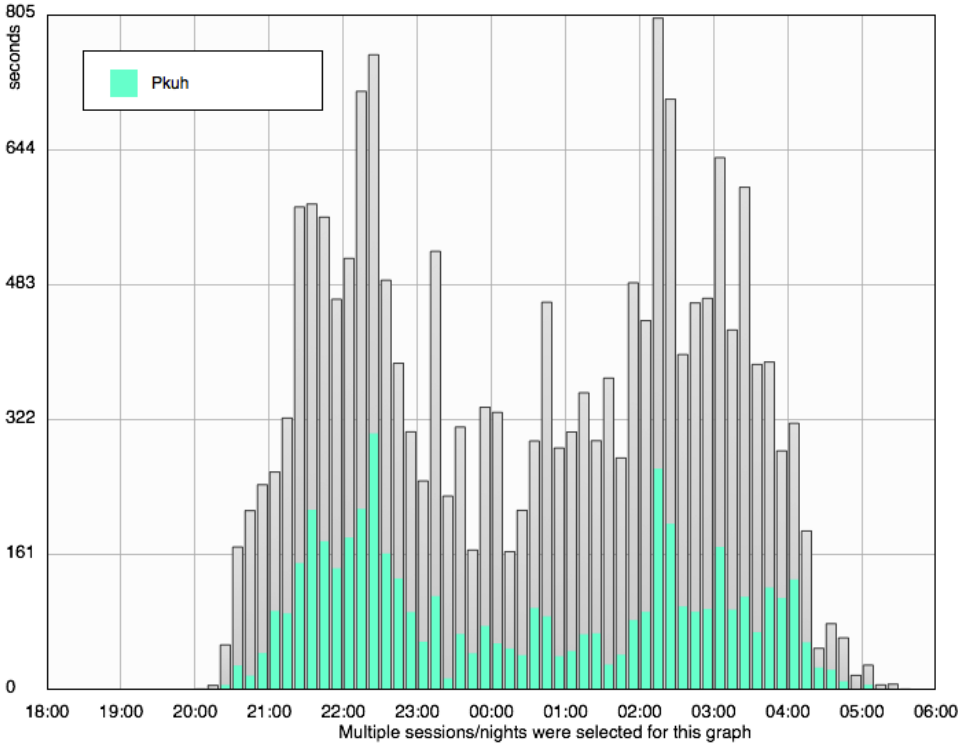


Figure 37. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.18 in August 2015. at location of WF „Jelinak“.

Activity of species *P. nathusii* (Figure 38) was low but distributed throughout the night. There was no difference in this species recorded activity in August at wind turbine O.U.18 compared to the same period at O.U.01.

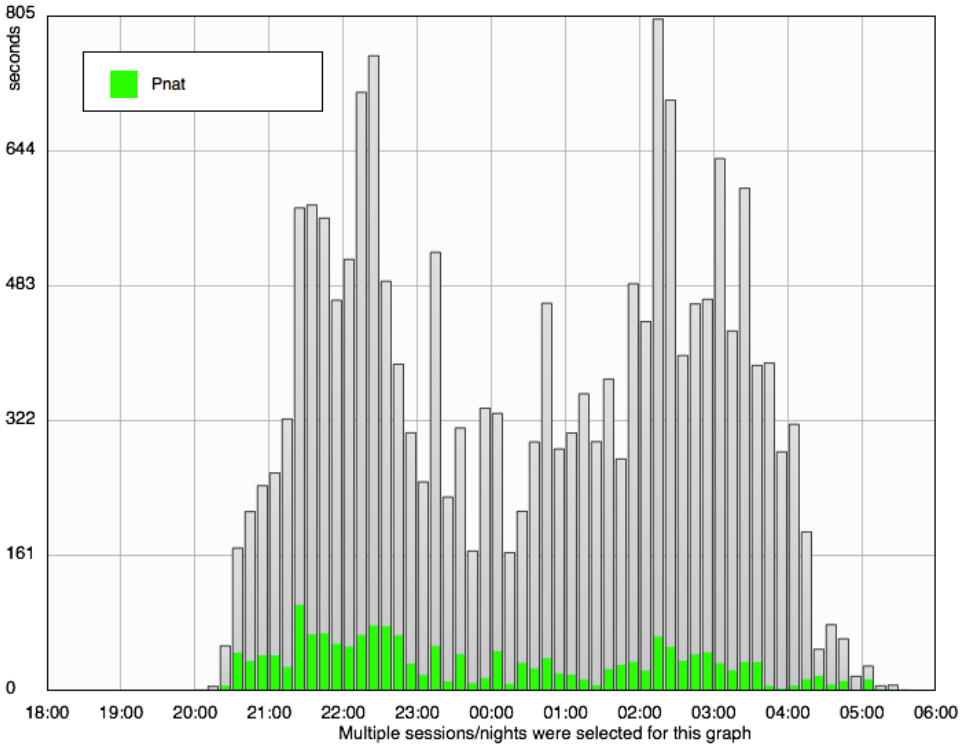


Figure 38. Total activity of species *Pipistrellus nathusii* during entire nights at wind turbine O.U.18 in August 2015. at location of WF „Jelinak“.

Transects

Transects were recorded in June and July. In June they were recorded during 4 nights (11., 19., 26. and 27. June), and in July during 9 nights (10. – 18. July).

Figure 39 shows that during transects recorded on 19. and 26. June there were no bats flights recorded. Species *P. kuhlii* and group *Pipistrellus* middle frequency were recorded on 11. June, and on 27. June only group *Pipistrellus* middle frequency was recorded. The recorded activity was very low, there were individual flights.

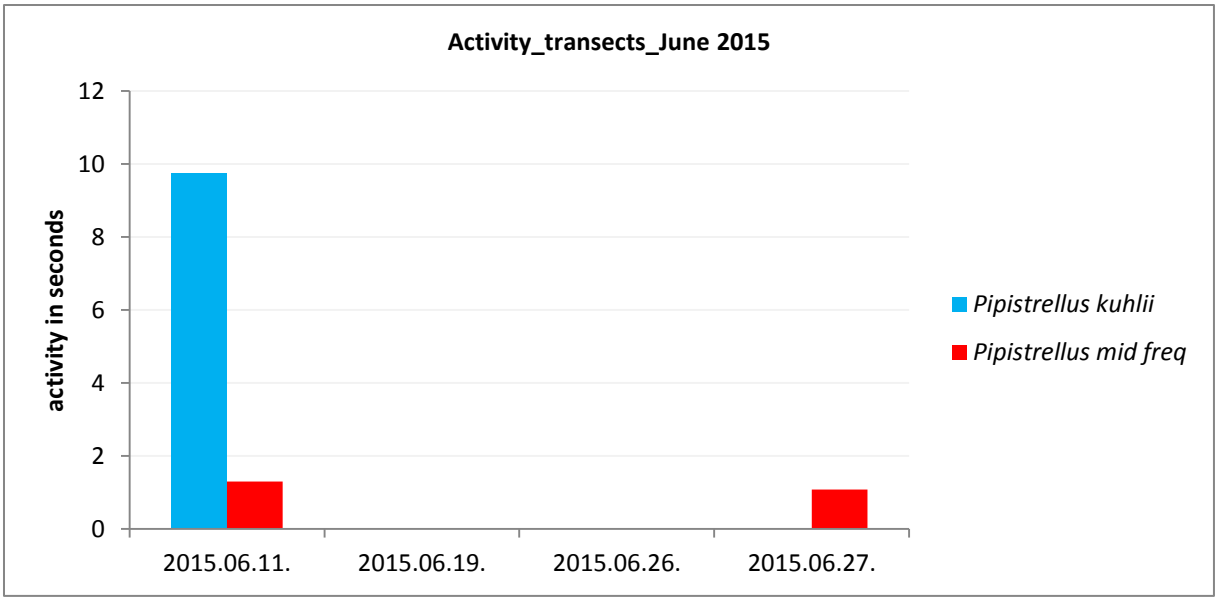


Figure 39. Activity of bats recorded on transects during four nights in June 2015. at location of WF „Jelinak“.

Figure 40 shows a comparison of the total recorded activity on transect with regard to total activity recorded with batcorder at wind turbine O.U.01 (5.4) in period from 10. to 18. July. It shows that activity recorded on transect is significantly lower compared to activity recorded with batcorder. In particular nights activity recorded on transect was 23 times lower than those recorded with batcorder. Also, by recording transect we get insight only in activity in a certain part of the night. For this reason, recording transects wasn't continued.

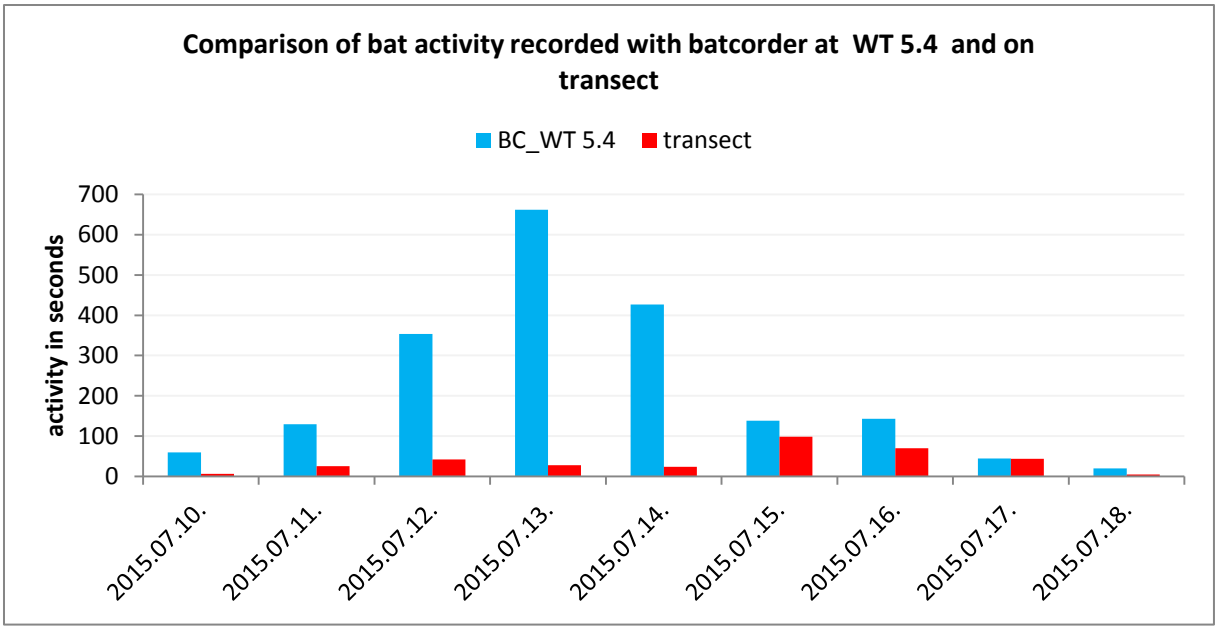


Figure 40. Comparison of the total bat activity recorded with batcorder at wind turbine O.U.01 (5.4) and on transect from 10. to 18. July 2015 at location of WF „Jelinak“.

Figure 41 shows a comparison of activity and species recorded on transects with activity and species recorded with batcorder at wind turbine O.U.01 in period from 10. to 18. July. The graph shows that in the period of 9 consecutive night transect method partially recorded present bat species but recorded activity was significantly lower than the activity recorded with batcorder.

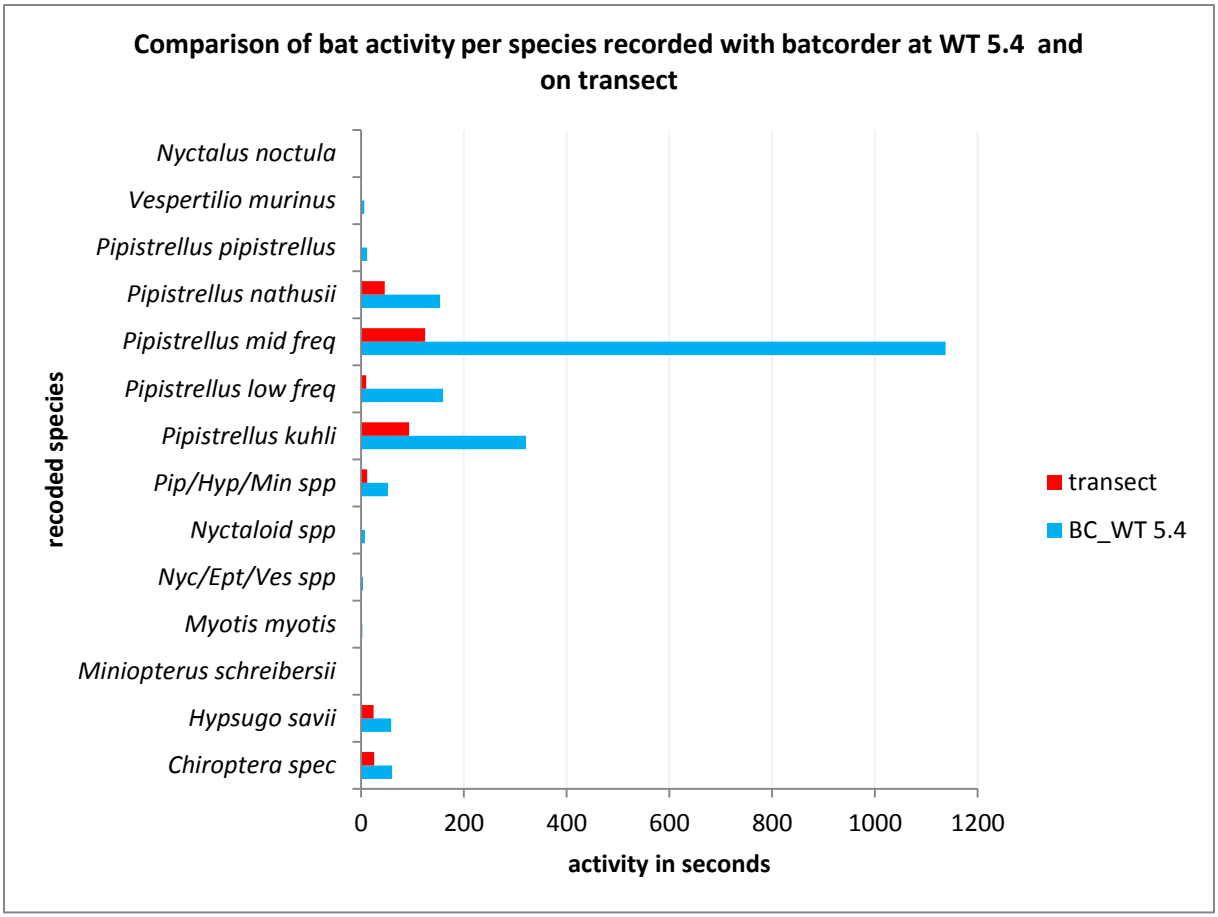


Figure 41. Comparison of the activity per species recorded with batcorder at wind turbine O.U.01 (5.4) and on transect from 10. to 18. July 2015 at location of WF „Jelinak“.

4. The proposal of mitigation measures, ways of their implementation and monitoring of their effectiveness

Proposal for further mitigation measures in order to decrease negative impact on bats at wind farm “Jelinak” will be given in Final report for monitoring program in 2015.

5. Appendix

Appendix 1. Table of total recorded mortality during monitoring in June, July, August, September and October 2015. (Sex: M=male, H=female, I=indefinite.)

Mortality_monitoring_WF_Jelinak_June_July_August_September_October_2015.					
No.	**Date**	**Species**	**Sex**	**Turbine**	**note**
1	2015.07.06.	*Pipistrellus kuhlii*	H	O.U.08	female with breasts
2	2015.07.06.	*Pipistrellus kuhlii*	M	O.U.04	
3	2015.07.09.	*Pipistrellus sp.*	H	O.U.18	
4	2015.07.10.	*Hypsugo savii*	H	O.U.13	
5	2015.07.15.	*Hypsugo savii*	H	O.U.05	female with breasts
6	2015.07.15.	*Pipistrellus kuhlii*	H	O.U.04	female with breasts
7	2015.07.16.	*Hypsugo savii*	H	O.U.05	female with breasts
8	2015.07.16.	*Hypsugo savii*	I	O.U.05	
9	2015.07.16.	*Hypsugo savii*	H	O.U.09	female with breasts
10	2015.07.16.	*Hypsugo savii*	H	O.U.09	female with breasts
11	2015.07.16.	*Hypsugo savii*	H	O.U.14	female with breasts
12	2015.07.17.	*Pipistrellus kuhlii*	H	O.U.05	female with breasts
13	2015.07.20.	*Pipistrellus kuhlii*	H	O.U.05	female with breasts
14	2015.07.21.	*Pipistrellus kuhlii*	M	O.U.03	
15	2015.07.21.	*Hypsugo savii*	I	O.U.07	
16	2015.07.21.	*Pipistrellus kuhlii*	H	O.U.18	
17	2015.07.21.	*Pipistrellus kuhlii*	H	O.U.05	female with breasts
18	2015.07.21.	*Pipistrellus kuhlii*	H	O.U.05	female with breasts
19	2015.07.22.	*Tadarida teniotis*	H	O.U.15	
20	2015.07.22.	*Hypsugo savii*	I	O.U.02	
21	2015.07.24.	*Hypsugo savii*	M	O.U.13	
22	2015.07.24.	*Pipistrellus kuhlii*	I	O.U.01	
23	2015.07.26.	*Pipistrellus kuhlii*	H	O.U.04	female with breasts
24	2015.07.26.	*Pipistrellus kuhlii*	H	O.U.14	female with breasts
25	2015.07.27.	*Hypsugo savii*	M	O.U.13	
26	2015.07.27.	*Hypsugo savii*	H	O.U.13	
27	2015.07.27.	*Pipistrellus kuhlii*	M	O.U.11	

28	2015.07.27.	*Hypsugo savii*	M	O.U.16	
29	2015.07.27.	*Hypsugo savii*	H	O.U.14	
30	2015.07.27.	*Pipistrellus kuhlii*	M	O.U.14	
31	2015.07.27.	*Hypsugo savii*	H	O.U.15	female with breasts
32	2015.07.28.	*Pipistrellus kuhlii*	H	O.U.13	female with breasts
33	2015.07.28.	*Hypsugo savii*	H	O.U.05	
34	2015.07.28.	*Pipistrellus kuhlii*	H	O.U.18	female with breasts
35	2015.07.29.	*Hypsugo savii*	M	O.U.02	
36	2015.07.30.	*Hypsugo savii*	H	O.U.04	
37	2015.07.30.	*Pipistrellus kuhlii*	M	O.U.16	
38	2015.08.01.	*Pipistrellus kuhlii*	H	O.U.04	
39	2015.08.05.	*Pipistrellus kuhlii*	M	O.U.04	
40	2015.08.08.	*Pipistrellus kuhlii*	I	O.U.03	
41	2015.08.08.	*Hypsugo savii*	H	O.U.08	
42	2015.08.08.	*Pipistrellus kuhlii*	H	O.U.16	female with breasts
43	2015.08.09.	*Hypsugo savii*	H	O.U.04	
44	2015.08.11.	*Hypsugo savii*	H	O.U.05	
45	2015.08.15.	*Pipistrellus kuhlii*	M	O.U.12	
46	2015.08.15.	*Pipistrellus kuhlii*	M	O.U.13	
47	2015.08.28.	*Hypsugo savii*	M	O.U.17	
48	2015.08.30.	*Pipistrellus kuhlii*	M	O.U.03	
49	2015.09.06.	*Pipistrellus kuhlii*	H	O.U.03	
50	2015.09.06.	*Hypsugo savii*	H	O.U.13	
51	2015.09.06.	*Pipistrellus nathusii*	I	O.U.16	
52	2015.09.07.	*Pipistrellus nathusii*	H	O.U.18	
53	2015.09.07.	*Pipistrellus nathusii*	M	O.U.19	
54	2015.09.13.	*Pipistrellus sp.*	M	O.U.05	

BAT MONITORING AT THE LOCATION OF WINDFARM „JELINAK" DURING 2016.

- Final report (period June - October 2016) -

FOKUS ECOLOGY d.o.o.
Zagreb

dr. sc. Igor Pavlinić

Maja Đaković, M.Ed.(Biol).

Zagreb, 29.12.2016.

CONTENTS

1. Introduction

According to the Purchase Order (Purchase Order Number: 3100381229) the bat monitoring at the Wind Farm „Jelinak“ locality started from beginning of June 2016 and lasted till 5th October 2016.

The monitoring was conducted on complete field, at all twenty turbines. Visual search for dead bats on the site included visits every seven days during June and September, every day search during July and August, and last search from 1st to 5th October. Bat activity was monitored on the site from June to October with two batcorder systems that automatically records bat calls.

During June mitigation measure wasn't implemented. During periods with mitigation measure it was conducted at fourteen wind turbines (O.U.01, O.U.02, O.U.03, O.U.04, O.U.05, O.U.06, O.U.07, O.U.10, O.U.13, O.U.14, O.U.16¸ O.U.17, O.U.18, and O.U.20). Six wind turbines were without mitigation measure (O.U.08, O.U.09, O.U.11, O.U.12, O.U.15, and O.U.19). There were two different protocols of mitigation measure in July and August which differed in whether measure was implemented in part of the night (from 9 pm till 3 am) or it was implemented during complete night. First protocol was conducted in two parts. From 1st July 2016 till 15th July 2016 mitigation measure was conducted at fourteen wind turbines from 9 pm to 3 am next day with cut in speed 5.0 m/s and with feathering below that wind speed. Same mitigation protocol was conducted from 16th August 2016 till 31st August 2016 (mitigation measure was conducted at fourteen wind turbines from 9 pm to 3 am next day with cut in speed 5.0 m/s and with feathering below that wind speed). Second protocol was conducted from 16th July 2016 till 15th August 2016 in a way that mitigation measure was conducted at fourteen wind turbines during complete night (from half an hour before sunset till half an hour after sunrise) with cut in speed 5.0 m/s and with feathering below that wind speed.

During the monitoring in 2016, there has been vandalism at the used equipment for monitoring of bat activity (batcorders) placed at the site of WF „Jelinak“. In August device near wind turbine O.U.18 (1.3) someone touched but without permanent damage. The same device was stolen at the end of the monitoring, at the end of September. At the end of October, workers at WF „Jelinak“ found that stolen device near one of the wind turbines.

All monthly Reports and Final Report are written in Croatian and English language.

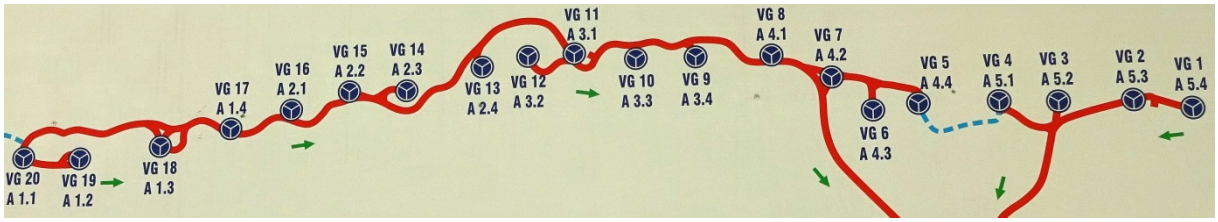


Figure 1. Layout view of wind turbines at the location of WF „Jelinak“.

2. Methods

2.1. Methods for bat collision monitoring

Monitoring of bat collision at wind farm „Jelinak“ during 2016 started in beginning of June and was carried out to the 2nd October. The search for dead bats included every seven days search during June and September, daily search during July and August and search from 1st to 2nd October. At every visit we searched the area around each of the twenty wind turbines within a radius of no less than 70 meters. The search involved a minimum of two people. We also used a dog trained in search for dead bats but only as a backup and all calculations are related to the human team. The search generally started early in the morning in order to find bats in the best possible condition, before being eaten by insects. Track was recorded during the entire duration of the search with mobile applications MotionX-GPS and OruxMaps, Garmin GPS watches Fenix 3, Forerunner 920XT and Forerunner 610. In the case of finding a dead bat, species, sex, age, in the case of female presence/absence of breasts (indication if she had a young this season), condition of corpse and type of injury was recorded. GPS coordinates were taken for each found bat and each was photographed.

2.2. Methods for bat activity monitoring

Bat activity was monitored using devices for automatic recording of bat calls, Batcorder 3.0 at same locations as during monitoring in 2015. One device was placed close to the wind turbine O.U.01 (5.4) at six meters high. Second device was placed close to the wind turbine O.U.18 (1.3) at fifteen meters high.

3. Results of field surveys

Field research included monitoring of bat collision and monitoring of bat activity at wind farm „Jelinak“. This Final report contains results for June, July, August, September and October 2016.

Bat mortality data for 2016 are presented according to periods of implementation of different protocols of mitigation measure.

3.1. Bat collision monitoring results

During monitoring in 2016 at WF „Jelinak“ location 30 dead bats were recorded (Appendix 1). During field visits in June two dead bats were found (7%) (Figure 2, Table 1). From 1st July till 15th July 2016 two dead bats were found (7%), one on turbine with implemented mitigation measure and one on turbine without measure (Figure 2, Table 1). From 16th July till 15th August 2016 twenty dead bats were found (67%), three on turbines with implemented mitigation measure and seventeen on turbines without measure (Figure 2, Table 1). From 16th August till 31st August 2016 four dead bats were found (13%), two on turbines with implemented mitigation measure and two on turbines without measure (Figure 2, Table 1). During field visits in September two dead bats were found (7%), while during visits in October no dead bats were found (Figure 2, Table 1).

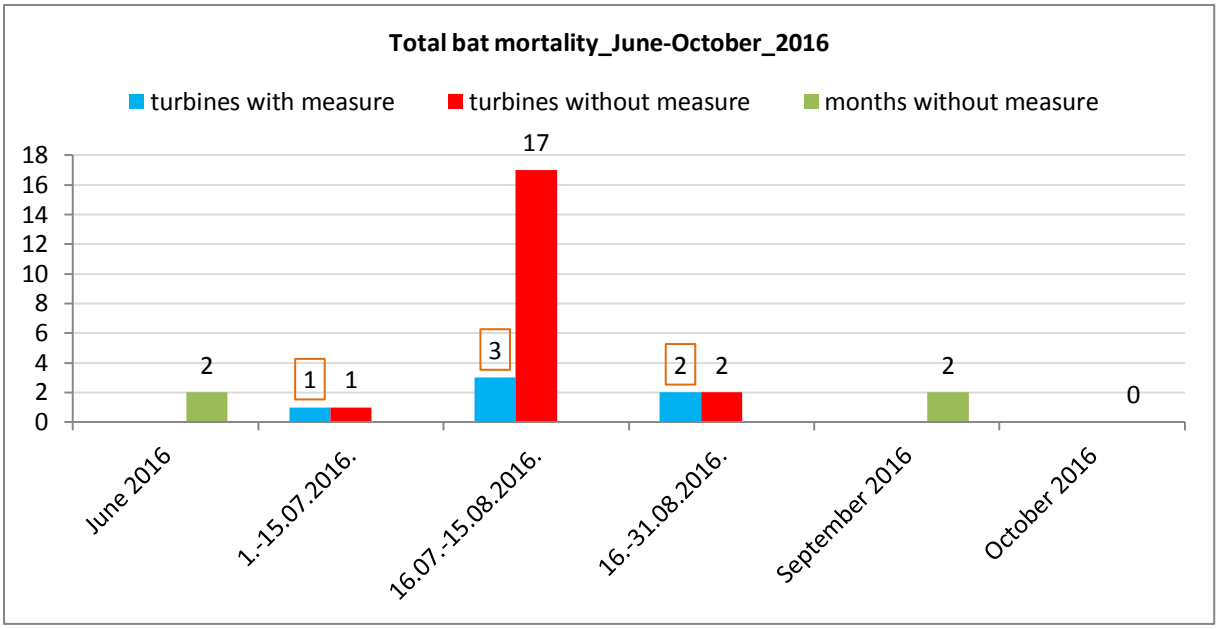


Figure 2. Total bat mortality during June, July, August, September and October 2016 at location of WF „Jelinak“. (Orange boxes = turbines with implemented mitigation measure).

Figure 3 shows the total recorded bat mortality during 2016 per periods of different mitigation measure protocols and per wind turbine. Numbers in the orange boxes indicate the wind turbines with mitigation measure implemented in certain periods. Mortality peak was recorded in period from 16th July till 15th August 2016.

The most bats were killed at the wind turbines O.U.08, O.U.09 and O.U.12, each with 5 dead bats. At these three wind turbines 15 bats were killed which makes 50% of total mortality. When we add the results from two additional turbines, O.U.11 and O.U.15, each with three dead bats, then the total number of dead bats at these five wind turbines (O.U.08, O.U.09, O.U.12, O.U.11, O.U.15) is 21, which makes 70% of total mortality. None of these five wind turbines had implemented mitigation measure.

During entire investigated period at eight wind turbines there weren't any dead bats. From these eight wind turbines, wind turbines O.U.01, O.U.04, O.U.05, O.U.06, O.U.07, O.U.13 and O.U.14 had a mitigation measure, while wind turbine O.U.19 did not have a mitigation measure.

From fourteen wind turbines with implemented mitigation measure, in period with measure (July - August) mortality was recorded at five wind turbines (O.U.02, O.U.10, O.U.17, O.U.18 and O.U.20), two dead bats at O.U.02 and one on other, in total 6 dead bats which makes 20% of total mortality.

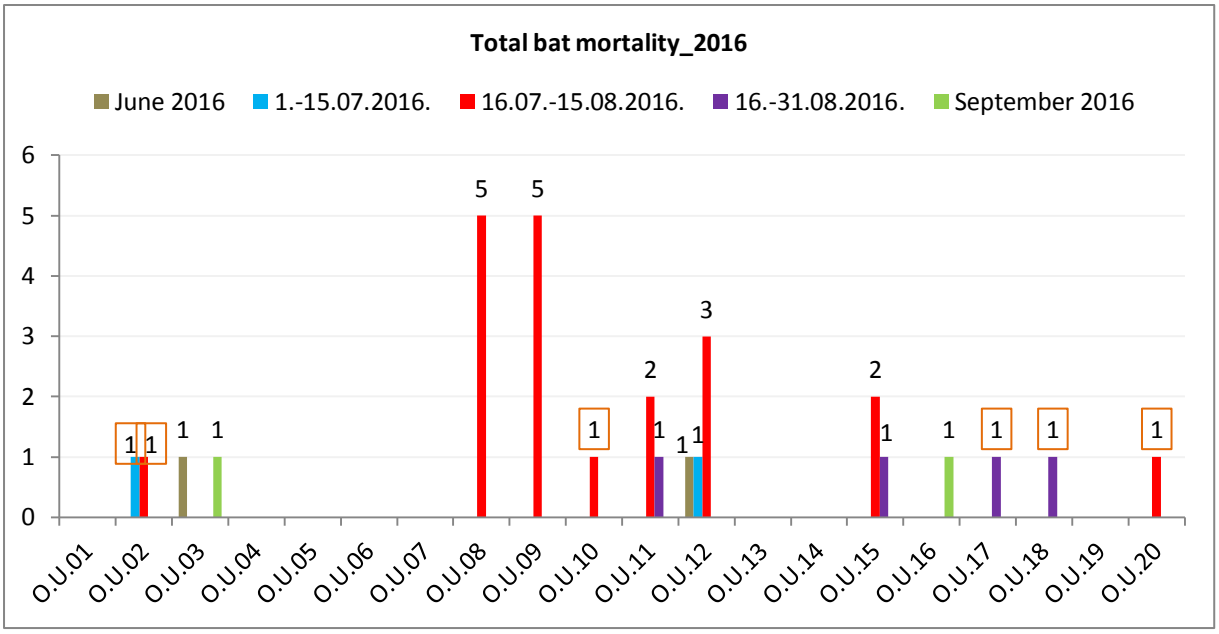


Figure 3. Bat mortality recorded during 2016 per wind turbines and per periods of different mitigation measure protocols at location of WF „Jelinak“. (Orange boxes = wind turbines with mitigation measure in certain periods).

In June when mitigation measure wasn't implemented individual mortality was recorded at only two wind turbines O.U.03 and O.U.12. In September when mitigation measure wasn't implemented individual mortality was recorded at only two wind turbines O.U.03 and O.U.16. In total in periods when mitigation measure wasn't implemented 4 dead bats were found which makes 13% of total mortality in 2016.

Table 1. Number and percentage of dead bats per wind turbine in 2016 for June, July-August, September and total at location of WF „Jelinak“. (Orange = wind turbines with mitigation measure.)

VA	JUNE 2016		JULY-AUGUST 2016		SEPTEMBER 2016		TOTAL	
	number of dead bats	%	number of dead bats	%	number of dead bats	%	number of dead bats	%
O.U.01	0	0%	0	0%	0	0%	0	0%
O.U.02	0	0%	2	8%	0	0%	2	7%
O.U.03	1	50%	0	0%	1	50%	2	7%
O.U.04	0	0%	0	0%	0	0%	0	0%
O.U.05	0	0%	0	0%	0	0%	0	0%
O.U.06	0	0%	0	0%	0	0%	0	0%
O.U.07	0	0%	0	0%	0	0%	0	0%
O.U.08	0	0%	5	19%	0	0%	5	17%
O.U.09	0	0%	5	19%	0	0%	5	17%
O.U.10	0	0%	1	4%	0	0%	1	3%
O.U.11	0	0%	3	12%	0	0%	3	10%
O.U.12	1	50%	4	15%	0	0%	5	17%
O.U.13	0	0%	0	0%	0	0%	0	0%
O.U.14	0	0%	0	0%	0	0%	0	0%
O.U.15	0	0%	3	12%	0	0%	3	10%
O.U.16	0	0%	0	0%	1	50%	1	3%
O.U.17	0	0%	1	4%	0	0%	1	3%
O.U.18	0	0%	1	4%	0	0%	1	3%
O.U.19	0	0%	0	0%	0	0%	0	0%
O.U.20	0	0%	1	4%	0	0%	1	3%
total	**2**	**7%**	**26**	**87%**	**2**	**7%**	**30**	

Figure 4 shows mortality recorded during monitoring in 2016 shown per periods of different protocols of mitigation measure and total bat mortality per species.

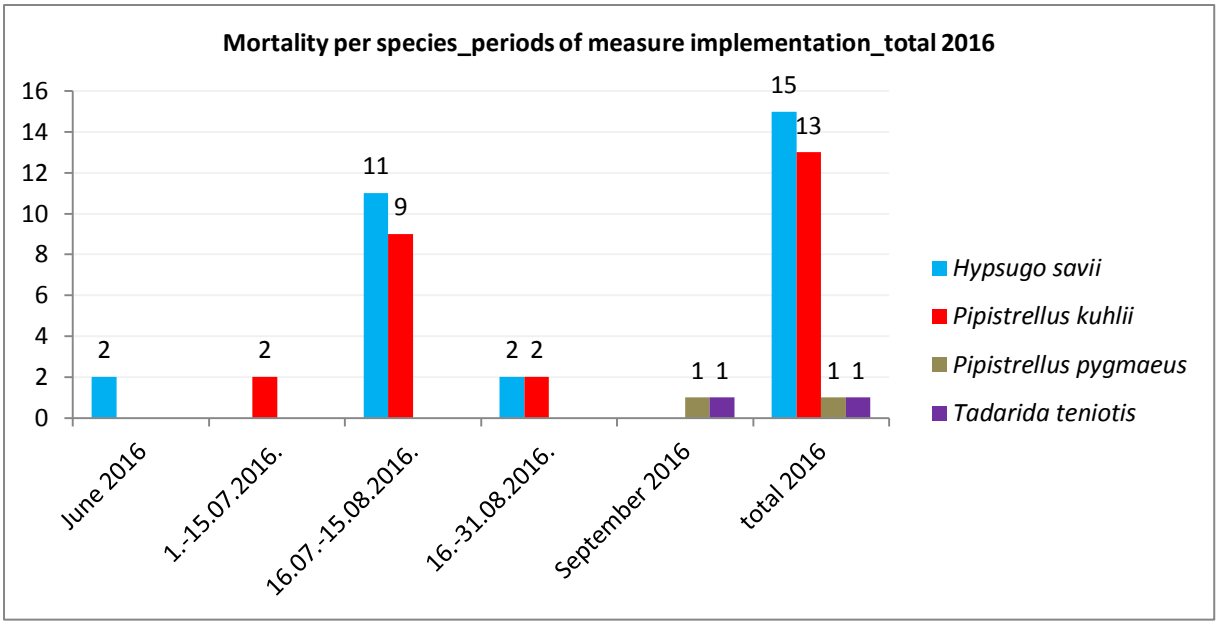


Figure 4. Bat mortality per periods of mitigation measure protocols in 2016 per species at location of WF „Jelinak“.

In total 50% of dead bats during 2016 belongs to species *H. savii* (15 bats), and 43% of dead bats belongs to species *P. kuhlii* (13 bats). The rest of 7% are individual dead bats of species *P. pygmaeus* and *T. teniotis* (Figure 4).

Both dead bats in June belong to species *H. savii*. During the first mitigation period two dead bats of *P. kuhlii* species were found, while during second mitigation measure period from total of 20 dead bats found 11 (55%) were *H. savii* and 9 (45%) *P. kuhlii*. During third mitigation period 4 dead bats were found, 2 were *P. kuhlii* (50%) and 2 *H. savii* (50%). In September one dead *T. teniotis* and one dead *P. pygmaeus* were found.

From 30 found dead bats, 14 were females, 7 males and 9 bats with indefinite sex (because of the state of corpse). From 14 females, 6 had young this season (females with breasts).

Figure 5 shows the mortality recorded during each day of July and August 2016.

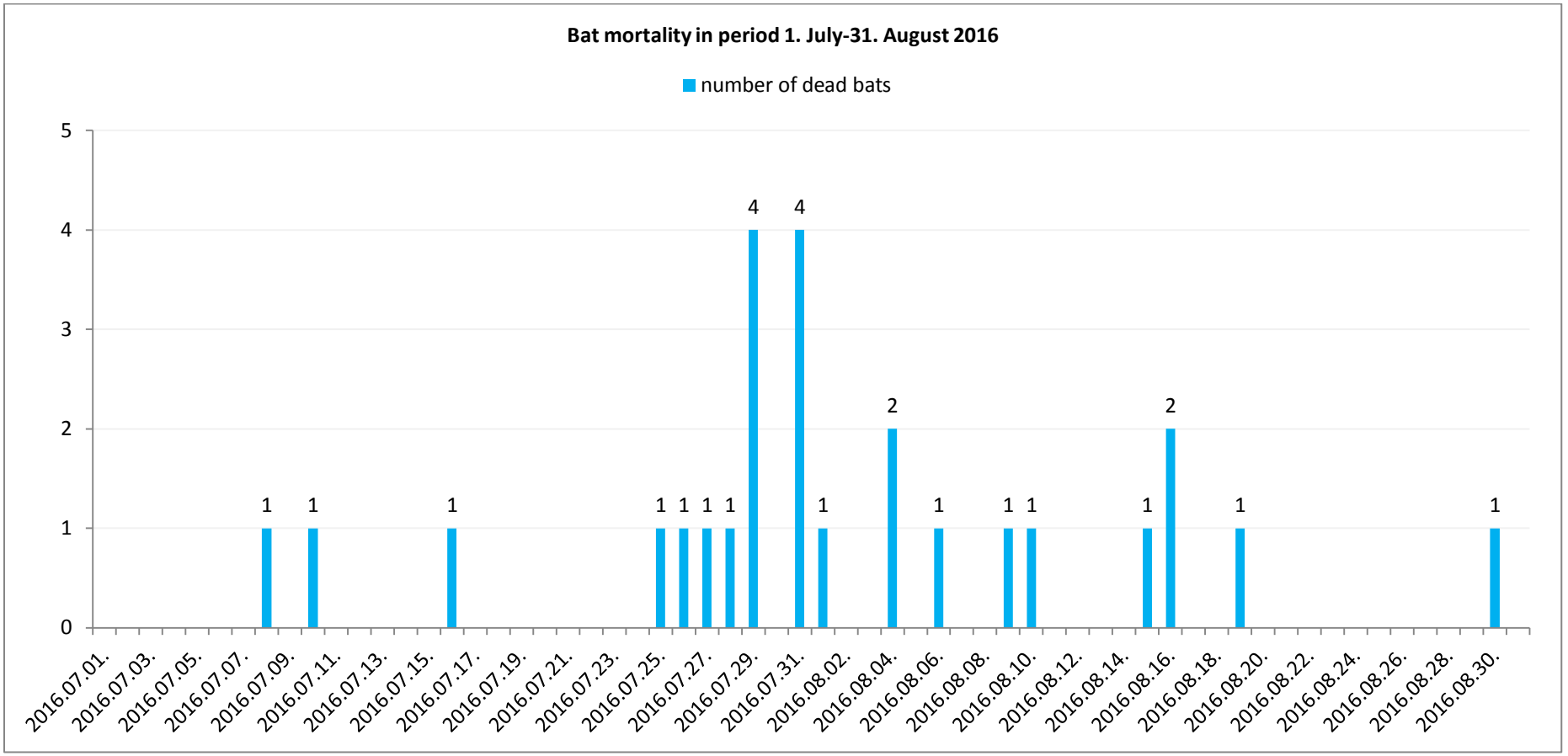


Figure 5. Number of dead bats during each day of July and August 2016 at location of WF „Jelinak“.

Searches for dead bats in June were carried out every 7 days and individual dead bats were found at two occasions. In period from 1st to 15th July two dead bats were recorded. In period from 16th July to 15th August twenty dead bats were recorded. In period from 16th August to 31st August four dead bats were found. During September two dead bats were found on the same visit. Comparing every day search data during July and August 2016 with the same period and visits protocol in 2015, the same bat mortality peak period at WF "Jelinak" was confirmed.

Figure 6 shows bat mortality recorded in period with implemented mitigation measure i.e. in July and August, divided per periods of mitigation measure protocols at wind turbines with mitigation measure in relation to wind turbines without measure.

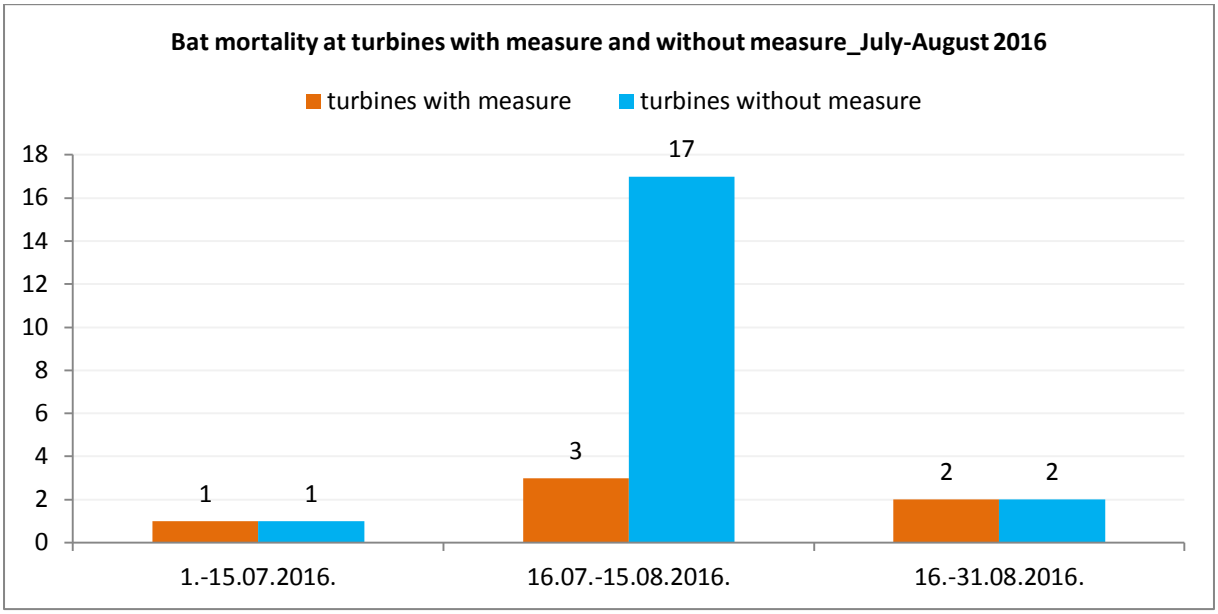


Figure 6. Bat mortality recorded in 2016 during July and August per different periods of mitigation measure protocols at wind turbines with mitigation measure and wind turbines without measure at location of WF „Jelinak".

Comparing wind turbines with mitigation measure and wind turbines without measure (Figure 6) during July and August, shows that 6 dead bats (23%) were recorded at wind turbines with measure and 20 dead bats (77%) at wind turbines without measure.

3.1.1. Mortality estimators (Shoenfeld and Huso)

For estimating the mortality occurring at the wind farm „Jelinak“ we used two statistical estimators, Schoenfeld and Huso. In order to use such statistical calculations, we tested and established a value for searcher efficiency (percent of bat carcasses found versus not found). Result was 80% searcher efficiency, so we took for mortality estimator's calculation range from 72% – 88% (or 10% below and 10% above obtained value). Also, for each month we tested and established a value for carcass removal/persistence due to scavengers. Average removal time in June was 9 days, in July and August 4 days and in September 6 days.

Both mortality estimators share the same input parameters but use different formula. Used parameters are *t* – average removal time (in days), *p* – searchers efficiency value (values from 0 to 1, result of multiplication of more factors) and *I* – average interval between searches (in days). Considering different time span between searches for dead bats (during June searches every 7 days, *I*=6; during July and August every day searches, *I*=1, during September searches every 7 days, *I*=6), mortality estimators calculations were made separately for June and September and together for July and August (Table 2).

Table 2. Mortality estimators, Shoenfeld and Huso, for months with recorded mortality (June; July and August; September) 2016 at location of WF „Jelinak“.

Mortality estimators	June		July - August		September	
	min	max	min	max	min	max
Shoenfeld						
mortality per turbine	0.15	0.16	1.51	1.60	0.17	0.20
total	2.92	3.26	30.27	31.91	3.44	3.94
Huso						
mortality per turbine	0.16	0.19	1.67	2.04	0.18	0.22
total	3.11	3.81	33.39	40.81	3.60	4.39

During June at all twenty turbines we have found total of 2 dead bats or 0.1 bats per turbine. Shoenfeld estimator for this period estimated mortality ranging from 0.15 to 0.16 bats per turbine. For total number of bats at all 20 turbines estimated range is from 2.92 to 3.26 dead bats. Another used estimator, Huso, estimated the number of dead bats per turbine from 0.16 to 0.19 with total of dead bats from 3.11 to 3.81. Taking into account that searches in June were done every 7 days, it is

expected that mortality estimations are higher than the number of really recorded dead bats but we can say that in this period field effort and search efficiency are sufficient. In June the numbers of found dead bats as well as the estimated number of dead bats are very small.

During July – August period at all twenty turbines we have found total of 26 dead bats or 0.3 bats per turbine. Estimation of Shoenfeld estimator for this period is slightly higher than recorded mortality and ranges from 1.51 to 1.60 bats per turbine. For total number of bats at all 20 turbines estimated range is from 30.27 to 31.91 dead bats. Another used estimator, Huso, estimated the number of dead bats per turbine from 1.67 to 2.04 with total of dead bats from 33.39 to 40.81. Expectedly both estimators estimated higher mortality than really recorded, but we consider that with every day searches of all 20 turbines in July – August period real number of dead bats was obtained.

During September at all twenty turbines we have found total of 2 dead bats or 0.1 bats per turbine. Shoenfeld estimator for this period estimated mortality ranging from 0.17 to 0.20 per turbine. For total number of bats at all 20 turbines estimated range is from 3.44 to 3.94 dead bats. Another used estimator, Huso, estimated the number of dead bats per turbine from 0.18 to 0.22 with total of dead bats from 3.60 to 4.39. Taking into account that searches in September were done every 7 days, it is expected that mortality estimations are higher than the number of really recorded dead bats but we can say that in this period field effort and search efficiency are sufficient. In September the numbers of found dead bats as well as the estimated number of dead bats are small.

3.2. Bat activity monitoring results

Batcorder windturbine O.U.01 (5.4)

June 2016

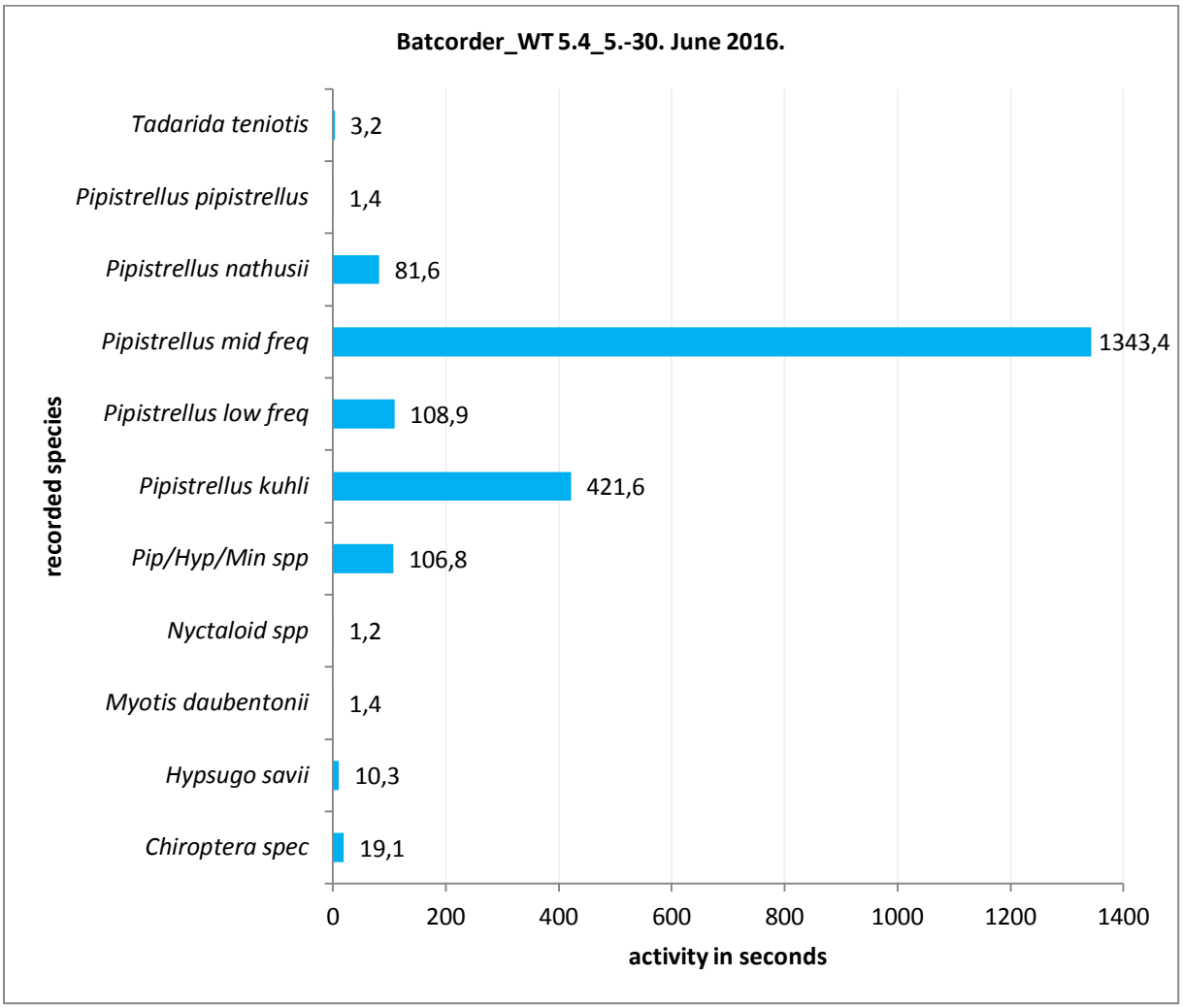


Figure 7. Total activity of all recorded bat species at wind turbine O.U.01 in the period 5th – 30th June 2016 at location of WF „Jelinak".

Figure 7 shows all recorded bat species in the period 5th – 30th June 2016 at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/group share, the largest share belongs to bat group *Pipistrellus* middle frequency (64%), followed by species *P. kuhlii* (20%). Analysis was also done for species *H. savii* (<1%) because of its share in recorded mortality.

Activity of all recorded bats in June (Appendix 2; 1) was distributed from 9 pm to 4.30 am with activity peak from 9.30 pm to 11 pm. Activity of group *Pipistrellus* middle frequency in June (Appendix 2; 2) was distributed from after 9 pm to 4.30 am

with activity peak from 9.30 pm to 11 pm. Species *P. kuhlii* in June (Appendix 2; 3) was active from after 9 pm to 4.30 am with activity peak from 9.30 pm to 11 pm, after what activity significantly decreased, around 1.30 am activity stopped, while at few occasions between 1 am and 2 am and also 3 am and 4 am activity increased. Activity of species *H. savii* in June (Appendix 2; 4) was low and sporadically, besides main recorded activity from 10.30 pm to 11 pm, species occur individually only on few occasions.

July 2016

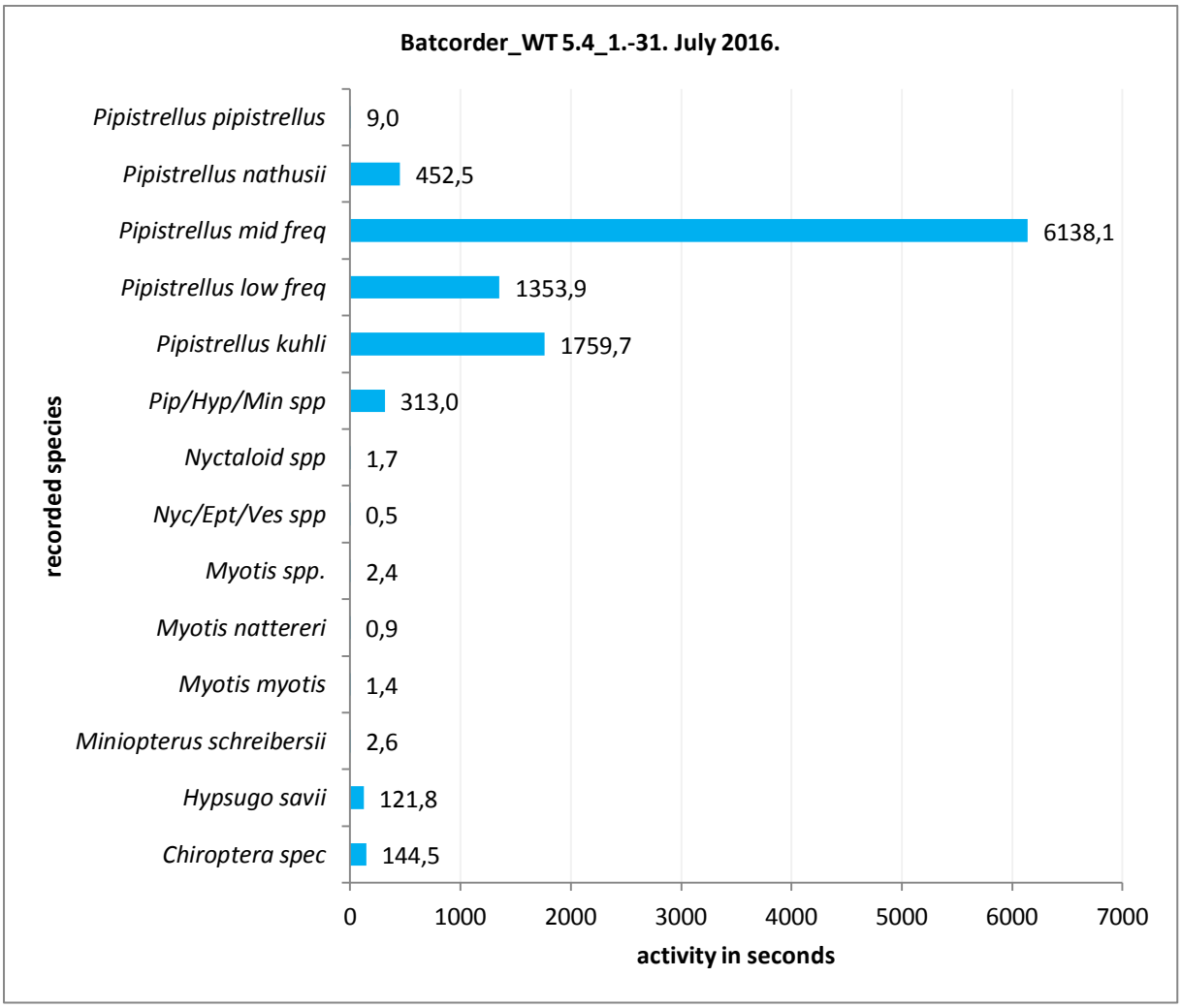


Figure 8. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 31st July 2016 at location of WF „Jelinak".

Figure 8 shows all recorded bat species in the period 1st – 31st July 2016 at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share belongs to bat group *Pipistrellus* middle

frequency (60%), followed by species *P. kuhlii* (17%). Analysis was also done for species *H. savii* (1%) because of its share in recorded mortality.

Activity of all recorded bats in July (Appendix 2; 5) was distributed from before 9 pm to after 5 am, while activity decreased from 3 am and activity peak was recorded around 10.30 pm. Activity of group *Pipistrellus* middle frequency in July (Appendix 2; 6) was distributed from before 9 pm to after 5 am, activity decreased from 3 am, and activity peaks are from 10 pm to 11 pm, shortly before midnight and around 2 am. Species *P. kuhlii* in July (Appendix 2; 7) was active from before 9 pm to after 5 am, activity decreased from 3 am and till then there were several noticeable activity peaks and drops. Activity of species *H. savii* in July (Appendix 2; 8) was low and during night there were occasional activity stops.

August 2016

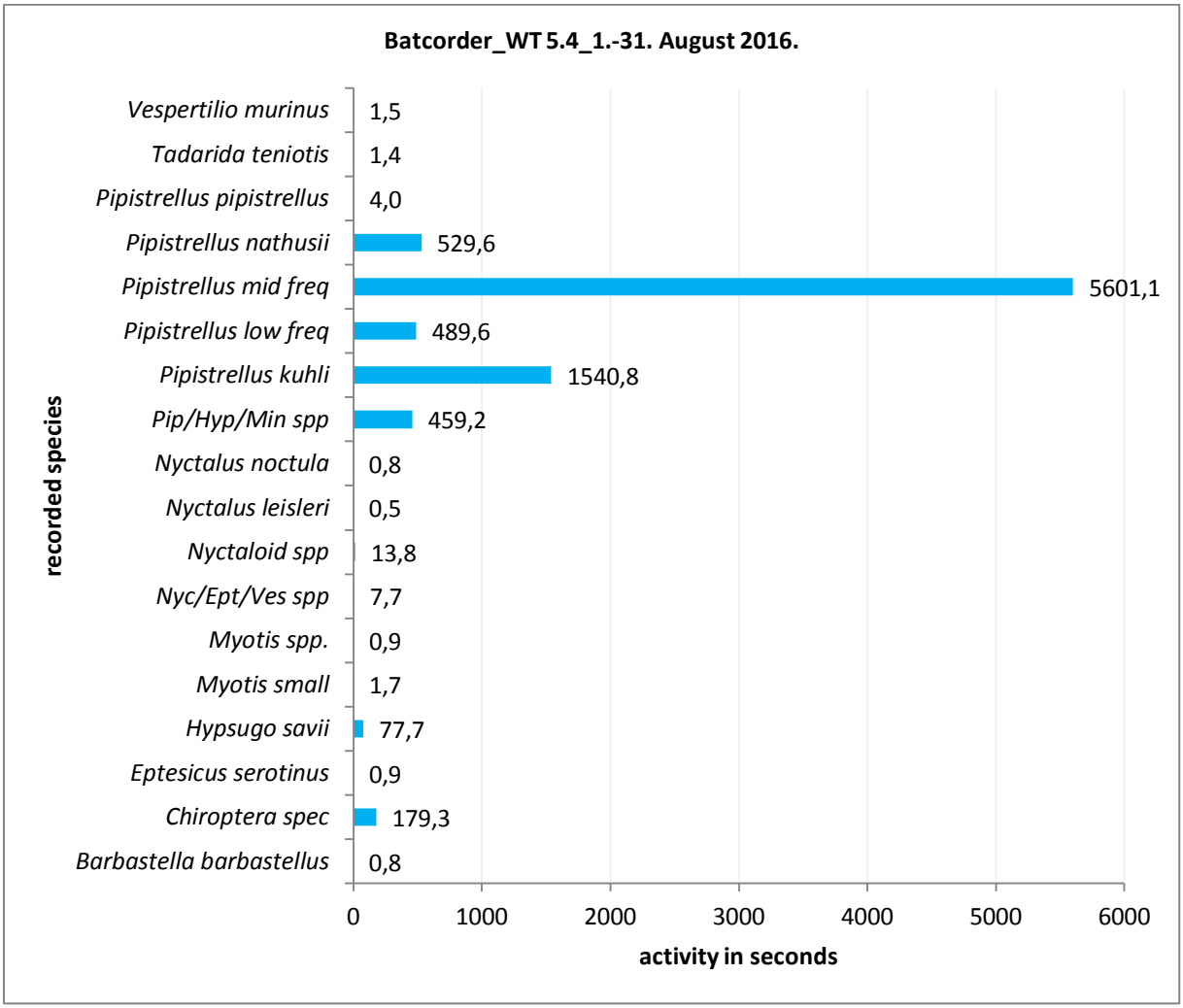


Figure 9. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 31st August 2016 at location of WF „Jelinak“.

Figure 9 shows all recorded bat species in the period 1st – 31st August 2016 at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/group share, the largest share belongs to bat group *Pipistrellus* middle frequency (63%), followed by species *P. kuhlii* (17%). Analysis was also done for species *H. savii* (1%) because of its share in recorded mortality.

Activity of all recorded bats in August (Appendix 2; 9) was distributed from 8 pm to 5.40 am, highest activity was recorded in the second part of the night (after midnight) with activity peaks around 12.30 pm and between 1.30 am and 2.30 am. Activity of group *Pipistrellus* middle frequency in August (Appendix 2; 10) was distributed from after 8 pm to 5.40 am, highest activity was recorded in the second part of the night (after midnight) with activity peaks around 12.30 pm and between 1.30 am and 2.30 am. Species *P. kuhlii* in August (Appendix 2; 11) was active from 8.30 pm to 5.30 am. During the night there were several activity peaks and drops. Activity peaks were around 9.30 pm, around 12.30 pm and shortly after 1.30 am. Activity of species *H. savii* in August (Appendix 2; 12) was low and during the night there were several periodically activity stops.

September 2016

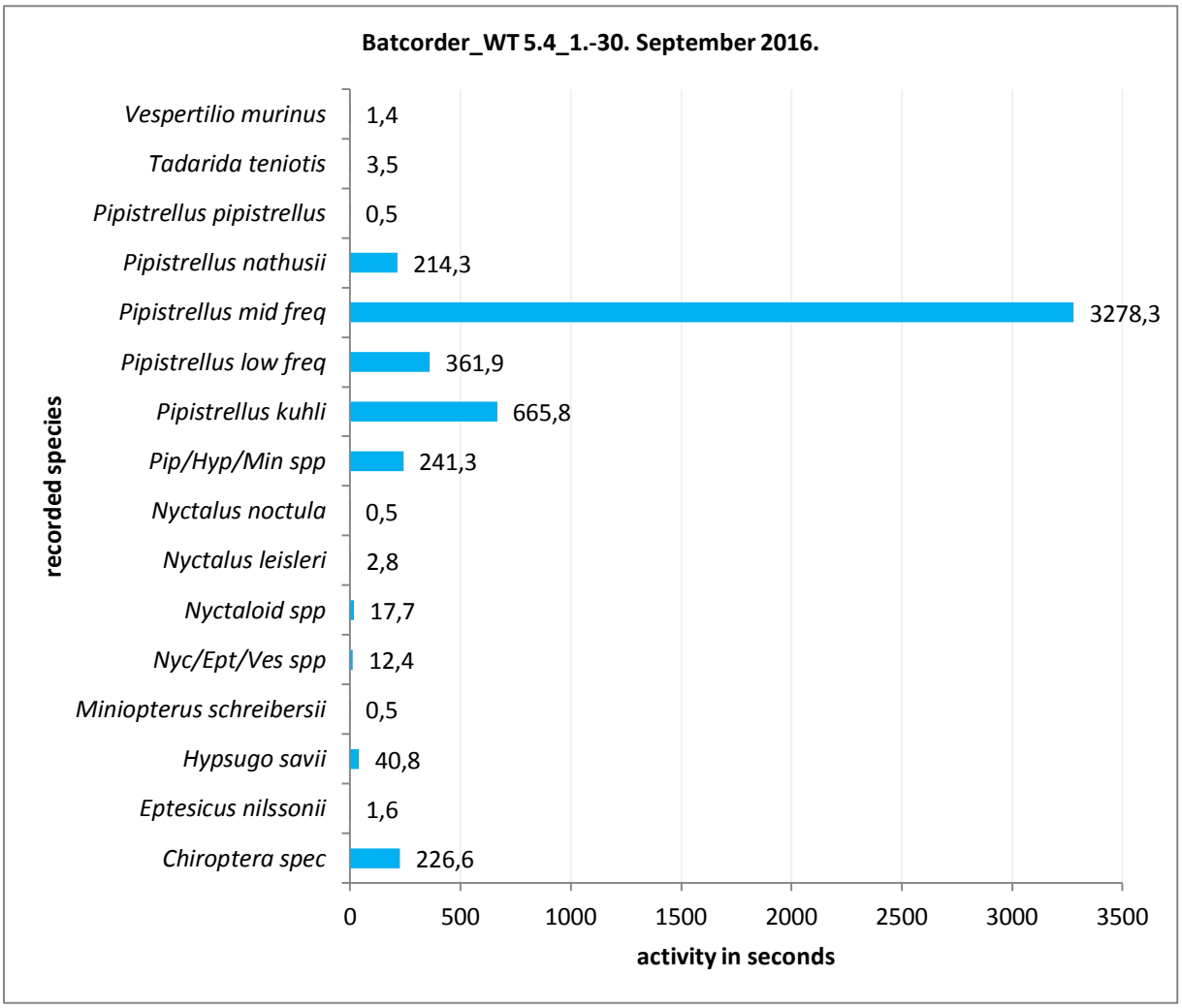


Figure 10. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 30th September 2016 at location of WF „Jelinak".

Figure 10 shows all recorded bat species in the period 1st – 30th September 2016 at wind turbine O.U.01 and their total recorded activity in seconds. According to species/groups share, the largest share belongs to group *Pipistrellus* middle frequency (65%), followed by species *P. kuhlii* (13%). Analysis was also done for species *H. savii* (1%) because of its share in recorded mortality.

In September individual death of species *P. pygmaeus* and *T. teniotis* was recorded. During complete monitoring period (June-October) at wind turbine O.U.01, species *T. teniotis* was recorded only sporadically at only few occasions as individual flights, while for species *P. pygmaeus* none flight for which would be able to undoubtedly determine as this species was recorded.

Activity of all recorded bats in September (Appendix 2; 13) was distributed from 7 pm to 6 am, during nights there were several activity increases and decreases, and after 3.30 am activity was significantly decreased. Activity of group *Pipistrellus* middle frequency in September (Appendix 2; 14) was distributed from 7 pm to 6 am, during nights there were several activity increases and decreases, and after 3.30 am activity was significantly decreased. The most prominent activity peaks were after 10 pm, around 11.30 pm and around midnight. Species *P. kuhlii* in September (Appendix 2; 15) was active from 7 pm to 5.30 am, during nights there were several activity increases and decreases, and after 1.30 am activity was significantly decreased. Activity from 7.30 pm to 9 pm is clearly separate from activity after 10 pm. Activity of species *H. savii* in September (Appendix 2; 16) was low and sporadic.

October 2016

In the period 1st – 3rd October 2016 at wind turbine O.U.01 only individual flights of species *Nyctalus leisleri* and *P. kuhlii* were recorded, in total 16 seconds activity during both nights, with main activity from 7 pm to 10 pm.

Batcorder windturbine O.U.18 (1.3)
July 2016

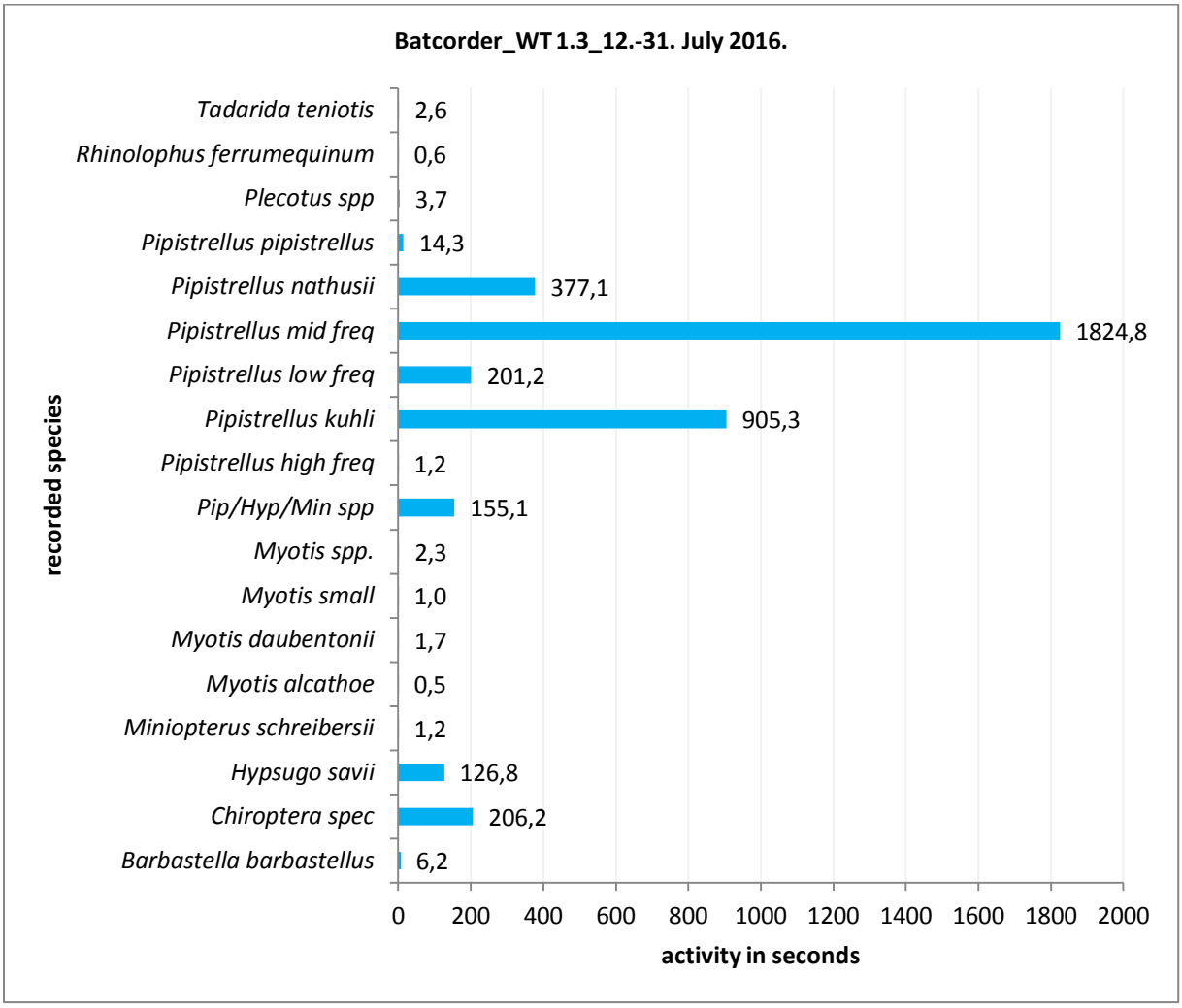


Figure 11. Total activity of all recorded bat species at wind turbine O.U.18 in the period 12th – 31st July 2016 at location of WF „Jelinak".

Figure 11 shows all recorded bat species in the period from 12th – 31st July 2016 at wind turbine O.U.18 and their total recorded activity in seconds. According to the species/group share, the largest share belongs to group *Pipistrellus* middle frequency (48%), followed by species *P. kuhlii* (24%). Analysis was also done for species *H. savii* (3%) because of its share in recorded mortality.

Activity of all recorded bats in July (Appendix 3; 1) was distributed from 7 pm to after 5 am. Activity peak was from 9.30 pm to 10.40 pm, after what activity generally decreased, and around 1 am significant activity drop occurred. Activity of group *Pipistrellus* middle frequency in July (Appendix 3; 2) was distributed from before 9 pm to 5 am. Period from 9 pm to 12.40 pm with activity peak from 9.30 pm

to 10 pm is clearly separated from period after 12.40 pm when activity significantly dropped. Species *P. kuhlii* in July (Appendix 3; 3) was active from before 9 pm to 5 am. Period from after 9 pm to 12.50 pm with activity peak around 9.50 pm is clearly separated from period after 12.50 pm when activity significantly dropped with several activity stops. Activity of species *H. savii* in July (Appendix 3; 4) was low and during night there were occasional activity stops, activity peak was around 9 pm.

August 2016

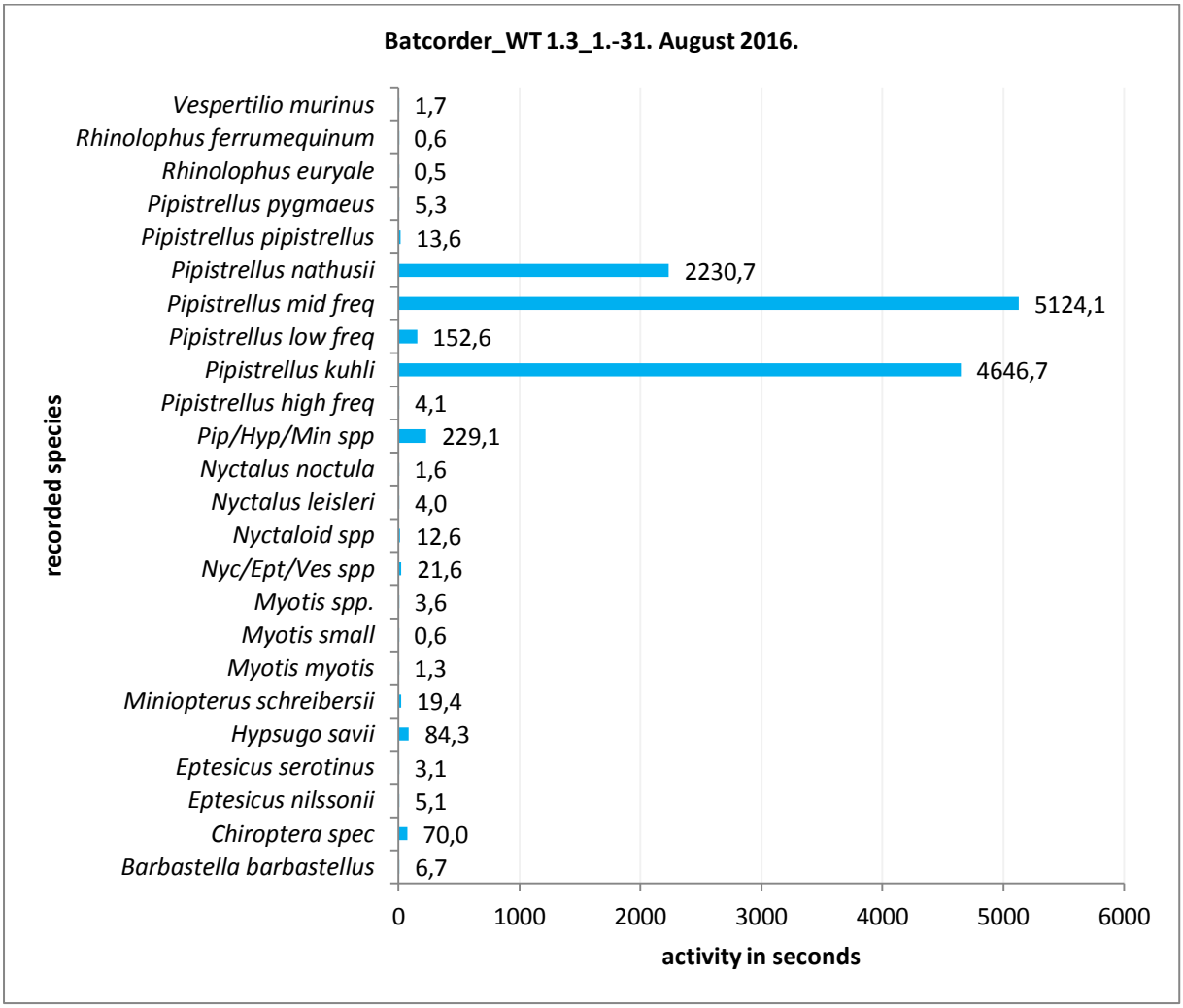


Figure 12. Total activity of all recorded bat species at wind turbine O.U.18 in the period 1st – 31st August 2016 at location of WF „Jelinak".

Figure 12 shows all recorded bat species in the period from 1st – 31st August 2016 at wind turbine O.U.18 and their total recorded activity in seconds. According to species/groups share, the largest share belongs to group *Pipistrellus* middle

frequency (41%), followed by *P. kuhlii* (37%). Analysis was also done for species *H. savii* (1%) because of its share in recorded mortality.

Activity of all recorded bats in August (Appendix 3; 5) was distributed from 7.30 pm to shortly before 6 am. Activity peak was from 9.30 pm to 11 pm, then till 3 am alternate activity drops and increases, from 3 am to 5 am decreased activity level maintained and then new activity increases occur shortly before 5 am to 5.40 am. Activity of group *Pipistrellus* middle frequency in August (Appendix 3; 6) was distributed from after 8 pm to shortly before 6 am. During nights alternate activity drops and increases. Activity peak was from 10.30 pm to around 11 pm. Higher activity drop was recorded from 3 am to before 5 am when comes to short activity increasing. Species *P. kuhlii* in August (Appendix 3; 7) was active from 8.30 pm to 5.40 am. During nights alternate activity drops and increases. Activity peak was from 10.40 pm to 11 pm. Higher activity drop was recorded after 4 am, and from 4.40 am to 5.40 am activity again increases. Activity of species *H. savii* in August (Appendix 3; 8) was low and species wasn't present all night. It was constantly present from 8.30 pm to around 11 pm and again before morning, shortly before 5 am to 5.40 am, and outside this period species occurs sporadically.

September 2016

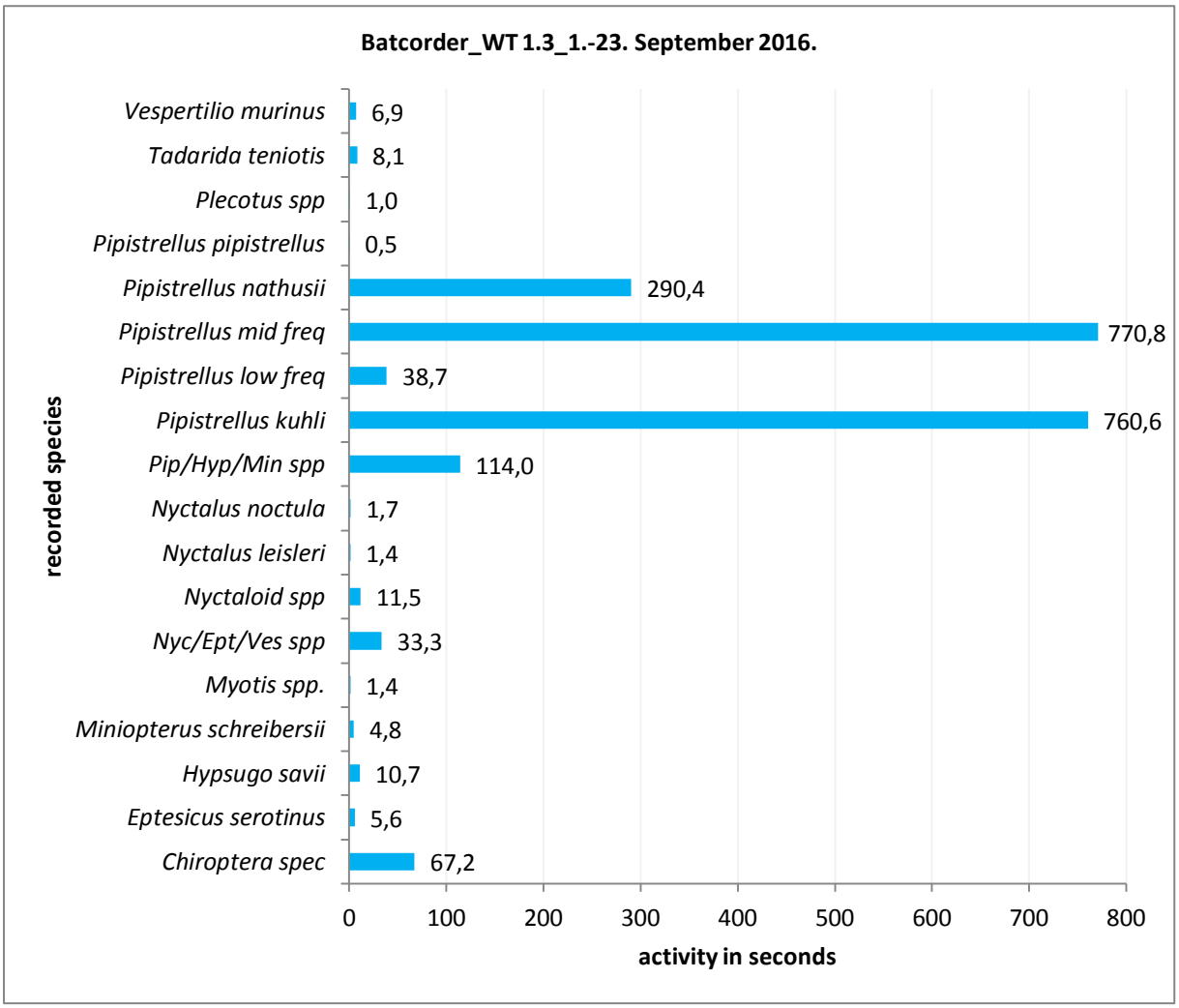


Figure 13. Total activity of all recorded bat species at wind turbine O.U.18 in the period 1st - 23rd September 2016 at location of WF „Jelinak".

Figure 13 shows all recorded bat species in the period 1st – 23rd September 2016 at wind turbine O.U.18 and their total activity in seconds. According to the species/group share, the largest share belongs to group *Pipistrellus* middle frequency (36%), followed by species *P. kuhlii* (36%). Analysis was also done for species *H. savii* (1%) because of its share in recorded mortality.

In September when individual death of species *P. pygmaeus* and *T. teniotis* was recorded and also during complete monitoring period at wind turbine O.U.18, species *T. teniotis* was recorded only sporadically at only few occasions as individual flights, while for species *P. pygmaeus* none flight for which would be undoubtedly able to determine as this species was recorded.

Activity of all recorded bats in September (Appendix 3; 9) was distributed from 7.30 pm to 6 am. It is clearly separated higher activity period from 7.40 pm to 8.50 pm that includes activity peak around 8 pm, from the rest of the night when activity is mainly constant and low. Activity of group *Pipistrellus* middle frequency in September (Appendix 3; 10) was distributed from 7.30 pm to 6 am. It is clearly separated higher activity period from 7.40 pm to 8.50 pm that includes activity peak from 7.30 pm to 8 pm, from the rest of the night when activity is mainly constant and very low. Species *P. kuhlii* in September (Appendix 3; 11) was distributed from 7.30 pm to 6 am. It is clearly separated higher activity period from 7.40 pm to 8.50 pm that includes activity peak from 7.40 pm to 8 pm, from the rest of the night when activity is very low and occasionally interrupted. Activity of species *H. savii* in September (Appendix 3; 12) was very low and only sporadic.

4. Analysis of bat activity in relation to the wind speed

For analysis of bat activity in relation to the wind speed we took the activity data from batcorder device placed near wind turbine O.U.01 (5.4) and related wind speed data from the same wind turbine and also the activity data from batcorder device placed near wind turbine O.U.18 (1.3) and related wind speed data from the same wind turbine. We analyzed these data for the same bat species as for activity, which is for total activity of all bat species in each month and for species/groups which made the highest activity and mortality share (group *Pipistrellus* middle frequency, species *P. kuhlii*, *H. savii).*

Batcorder windturbine O.U.01 (5.4)

June 2016

In June to the wind speed of 5 m/s more than 60% of total bat activity was recorded (Appendix 4; 1), and 80% activity was recorded at the wind speed slightly above 6.5 m/s. Bat activity was recorded to the wind speed slightly below 12 m/s. To the wind speed of 5 m/s 65% activity of group *Pipistrellus* middle frequency was recorded (Appendix 4; 2), and 80% activity of this group was recorded at wind speed slightly below 6.5 m/s. To the wind speed of 5 m/s slightly more than 70% activity of

species *P. kuhlii* was recorded (Appendix 4; 3), and 80% activity was recorded at wind speed slightly above 6.0 m/s. To the wind speed of 5 m/s 55% activity of species *H. savii* was recorded (Appendix 4; 4), and 80% activity of this species was recorded at wind speed slightly below 8.0 m/s.

July 2016

In July to the wind speed of 5 m/s 55% of total bat activity was recorded (Appendix 4; 5), and 80% activity was recorded at the wind speed to 7.5 m/s. Bat activity was recorded to 12 m/s wind speed. To the wind speed of 5 m/s slightly more than 60% activity of group *Pipistrellus* middle frequency was recorded (Appendix 4; 6), and 80% activity of this group was recorded to the wind speed slightly below 7.5 m/s. To the wind speed of 5 m/s slightly more than 55% activity of species *P. kuhlii* was recorded (Appendix 4; 7), and 80% activity of this species was recorded to the wind speed to 7.5 m/s. To the wind speed of 5 m/s 60% activity of species *H. savii* was recorded (Appendix 4; 8), and 80% activity of this species was recorded to the wind speed slightly above 7.0 m/s.

August 2016

In August to the wind speed of 5 m/s around 45% of total bat activity was recorded (Appendix 4; 9), and 80% activity was recorded at the wind speed around 7.5 m/s. Bat activity was recorded to 12 m/s wind speed. To the wind speed of 5 m/s more than 40% activity of group *Pipistrellus* middle frequency was recorded (Appendix 4; 10), and 80% activity of this group was recorded to the wind speed slightly above 7.5 m/s. To the wind speed of 5 m/s 45% activity of species *P. kuhlii* was recorded (Appendix 4; 11), and 80% activity of this species was recorded to the wind speed slightly above 7.5 m/s. To the wind speed of 5 m/s 50% activity of species *H. savii* was recorded (Appendix 4; 12), and 80% of this species activity was recorded to the wind speed slightly above 7.0 m/s.

September 2016

In September to the wind speed of 5 m/s around 50% of total bat activity was recorded (Appendix 4; 13), and 80% activity was recorded to 7.5 m/s wind speed. Bat activity was recorded to 13.5 m/s wind speed. To the wind speed of 5 m/s 55% activity of group *Pipistrellus* middle frequency was recorded (Appendix 4; 14), and

80% activity of this species was recorded to the 7.5 m/s wind speed. To the wind speed of 5 m/s around 45% activity of species *P. kuhlii* was recorded (Appendix 4; 15), and 80% activity of this species was recorded to the wind speed slightly below 8 m/s. To the wind speed of 5 m/s 50% activity of species *H. savii* was recorded (Appendix 4; 16), and 80% activity of this species was recorded to the wind speed slightly above 7.0 m/s.

Batcorder windturbine O.U.18 (1.3)

July 2016

In July to the wind speed of 5 m/s 70% of total bat activity was recorded (Appendix 5; 1), and 80% activity was recorded to the wind speed lower than 6.5 m/s. Bat activity was recorded to 13 m/s wind speed. To the wind speed of 5 m/s 75% activity of group *Pipistrellus* middle frequency was recorded (Appendix 5; 2), and 80% activity of this group was recorded to the wind speed to 6.0 m/s. To the wind speed of 5 m/s 70% activity of species *P. kuhlii* was recorded (Appendix 5; 3), and 80% activity was recorded at wind speed slightly above 6.0 m/s. To the wind speed of 5 m/s 75% activity of species *H. savii* was recorded (Appendix 5; 4), and 80% activity of this species was recorded to 6.0 m/s wind speed.

August 2016

In August to the wind speed of 5 m/s 80% of total bat activity was recorded (Appendix 5; 5). Bat activity was recorded to 12 m/s wind speed. To the wind speed of 5 m/s 75% activity of group *Pipistrellus* middle frequency was recorded (Appendix 5; 6), and 80% activity of this species was recorded at wind speed below 5.5 m/s. To the wind speed of 5 m/s 80% activity of species *P. kuhlii* was recorded (Appendix 5; 7). To the wind speed of 5 m/s 80% activity of species *H. savii* was recorded (Appendix 5; 8).

September 2016

In September to the wind speed of 5 m/s 60% of total bat activity was recorded (Appendix 5; 9), and 80% activity was recorded to 7.0 m/s wind speed. Bat activity was recorded to 15 m/s wind speed. To the wind speed of 5 m/s more than 65% activity of group *Pipistrellus* middle frequency was recorded (Appendix 5; 10), and

80% activity of this group was recorded to 6.5 m/s wind speed. To the wind speed of 5 m/s more than 65% activity of species *P. kuhlii* was recorded (Appendix 5; 11), and 80% activity of this species was recorded slightly below 6.0 m/s. To the wind speed of 5 m/s less than 40% activity of species *H. savii* was recorded (Appendix 5; 12), and 80% activity of this species was recorded to 6.5 m/s wind speed.

5. Analysis of the recorded bat mortality during monitoring in 2013, 2014, 2015 and 2016

When comparing the overall mortality observed at the wind farm „Jelinak“ during four years (2013, 2014, 2015, 2016) it is necessary to take into account the different field management for each year which refers to the different number of turbines with mitigation measure, different periods (date) with implemented measure and different duration of the implemented measure throughout the night (hours). Thus, in 2013 there weren't any mitigation measure. In 2014 mitigation measure was implemented in the period from 1st July to 30th September 2014, in a way that at six turbines cut-in speed was increased from 3 m/s to 5 m/s during four hours (one hour before sunset and three hours after sunset). In 2015 mitigation measure covered two more turbines so that in total eight turbines had mitigation measure in the period from 1st July to 31st August in a way that these eight turbines started at wind speed of 5 m/s in the period from 9 pm to 3 am next morning. In 2016 mitigation measure covered six more turbines so in total fourteen turbines had mitigation measure with cut-in speed 5 m/s. Total period with mitigation measure in 2016 was from 1st July to 31st August but in that period there were two different protocols which differed in whether measure was implemented in part of the night (from 9 pm till 3 am) or it was implemented during complete night. First protocol was conducted in two parts, from 1st July 2016 till 15th July 2016 and from 16th August 2016 till 31st August 2016 when mitigation measure was conducted from 9 pm to 3 am next day. Second protocol was conducted from 16th July 2016 till 15th August 2016 when mitigation measure was conducted during complete night (from half an hour before sunset till half an hour after sunrise).

Also, when comparing data about recorded mortality between years it is necessary to keep in mind significantly different field effort between years but also in

the same year during 2014. During 2013 searches for dead bats were done at all twenty wind turbines twice a month from March to October, in total sixteen times (OIKON). During 2014 in period from March to August searches for dead bats were done twice a month, in total twelve times (OIKON). Additionally, from July to September every day monitoring was done (EURUS) but only at nine chosen turbines, thus losing the information what was going on at the same time on other turbines. In September 2014 the searches was done only by EURUS every day at nine chosen turbines, and in October 2014 nobody was doing searches. During 2015 the searches for dead bats were done from June to October at all twenty turbines (FOKUS). During June, September and October searches included two days searches every seven days, while in July and August every day searches were done. During 2016 we (FOKUS) followed protocol from 2015 (with exception in October because, according to results of three years of monitoring on the site, we concluded that monitoring in October is not necessary, but in order to follow Croatian legislative, the last search was done in the period from 1st - 5th October.)

Although wind farm had different protocol every year and field effort differs significantly between years, wherefore the actual number of found dead bats in 2013 and 2014 is likely higher than recorded, below are given absolute numbers of dead bats found during all four years of monitoring in order to obtain a broader picture for a proposal for further management of wind farm “Jelinak”.

Figure 14 shows total bat mortality recorded during each of the four years of monitoring. In 2013 in total 148 dead bats were recorded, in 2014 in total 70 dead bats, in 2015 in total 54 dead bats and in 2016 in total 30 dead bats were recorded.

Figure 15 shows total bat mortality recorded during each of the four years of monitoring at fourteen turbines that had mitigation measure in some of the years. In 2014 in relation to 2013, at six turbines that had implemented mitigation measure mortality decreased, while at two turbines without measure mortality increased. In 2015 the measure was implemented and on those two turbines, so in 2015 mitigation measure was implemented at in total eight turbines. Comparing 2015 with previous two years, mortality decreased on seven turbines with mitigation measure except on turbine O.U.18. with four dead bats recorded in 2015, and two dead bats recorded in 2014, and in 2013 when this turbine didn’t have mitigation measure sixteen dead

bats were recorded. Comparing 2016 with previous years it is seen that mortality reduced to zero at seven turbines with mitigation measure (on 4 of them measure introduced in 2016). At three turbines mortality decreased comparing with 2015. At two turbines mortality maintain at the same level as in 2015 (one or two bats) what is decreasing comparing with 2014 and 2013. At two turbines mortality increased from zero in 2015 to one bat in 2016. Looking at six turbines that didn't have mitigation measure neither in 2015 nor in 2016 (Figure 16), at five turbine mortality increased, in total from 8 in 2015 to 21 dead bat in 2016, while at one turbine (O.U.19) decreased from 1 to 0.

From a total of 70 dead bats recorded in 2014, 49 (70%) were found on turbines without mitigation measure, and 21 (30%) on turbines with mitigation measure. From a total of 54 dead bats recorded in 2015, 41 (76%) were found on turbines without mitigation measure, and 13 (24%) on turbines with mitigation measure. From a total of 30 dead bats recorded in 2016, 24 (80%) were found on turbines without mitigation measure, and 6 (20%) on turbines with mitigation measure.

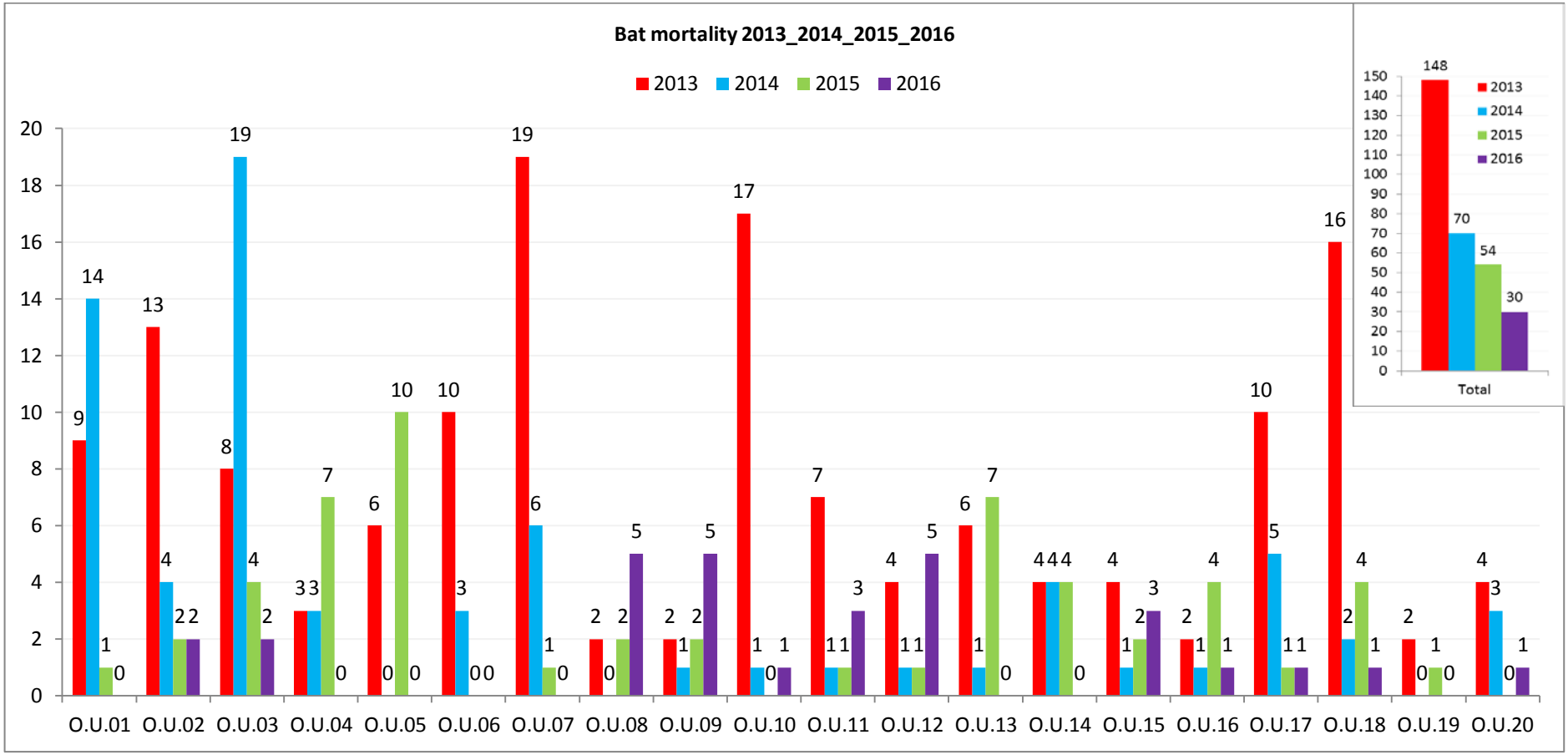


Figure 14. Total recorded bat mortality during 2013, 2014, 2015 and 2016 at location of WF „Jelinak“.

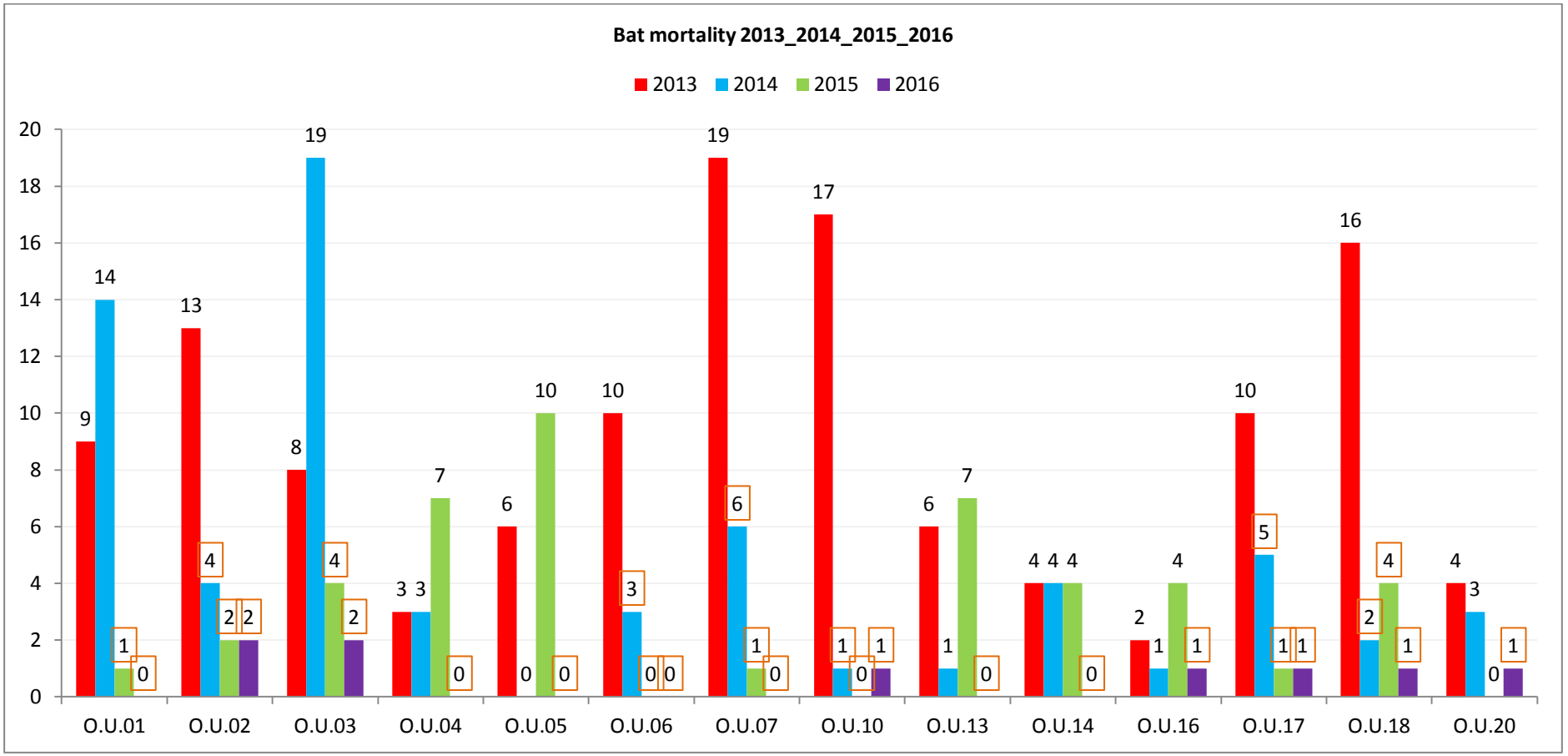


Figure 15. Total recorded bat mortality during 2013, 2014, 2015 and 2016 at fourteen turbines that had mitigation measure in some of the years at location of WF „Jelinak“. (Orange boxes = wind turbines with mitigation measure in particular year).

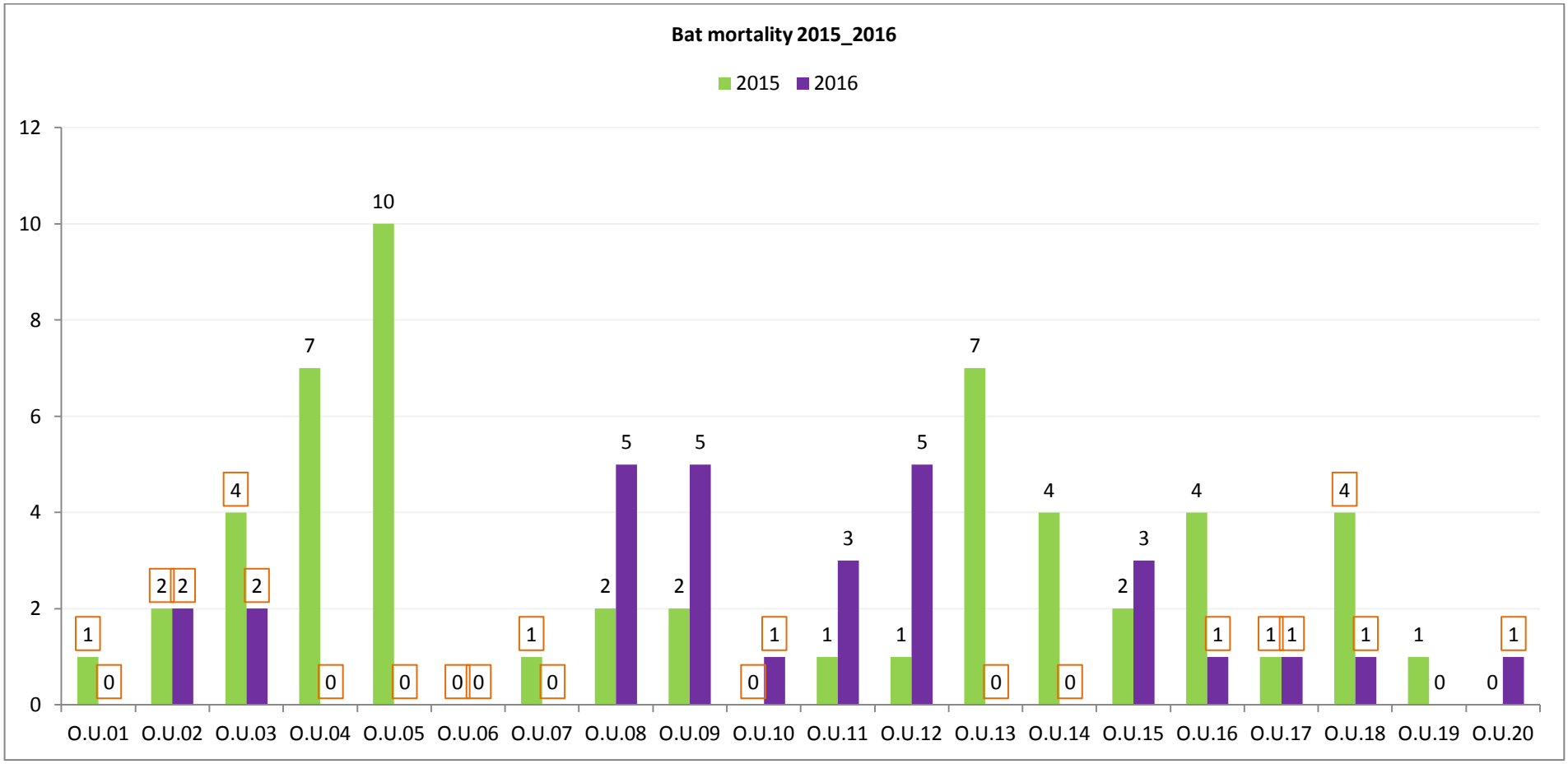


Figure 16. Total recorded bat mortality during 2015 and 2016 at location of WF „Jelinak“. (Orange boxes = wind turbines with mitigation measure in particular year).

6. The proposal of mitigation measures, ways of their implementation and monitoring of their effectiveness

Implementation of mitigation measures in 2016 led to a reduction in mortality but total number of 30 dead bats at wind farm „Jelinak“ still is significant mortality. Further mitigation measures are necessary in order to decrease the negative impact on bats to a minimum.

Analyses of all recorded mortality data in relation to the implemented mitigation measure in 2016 shows that 80% of mortality were recorded at wind turbines at which wasn't and in periods without mitigation measure. This fact and the fact that during the period of every day monitoring 77% mortality was recorded in period from 16.07.2016 to 15.08.2016 when mitigation measure was implemented during complete night, clearly shows that the parameters of implemented measure were properly determined. From four main parameters on which we could possible influence, three are properly determined in 2016 and there is no need to change them in order to decreased bat mortality. These are the cut-in speed (5.0 m/s) with feathering below that speed, time period in which it is necessary to implement the measure (date) and night period during which the measure is implemented (hours). The only parameter that needs to be modified in order to significantly reduce the mortality of bats is to increase the number of wind turbines with implemented measure. It is particularly important to increase the number of wind turbines to the complete field (except O.U.19) from 16.07.2017 to 15.08.2017.

Taking into account all the results and all analysis we give a proposal for mitigation measures modification in order to decrease negative impact on bats at location of wind farm „Jelinak“. Period for mitigation measure is divided in two protocols considering period with highest recorded mortality and the rest of high season (Table 3). In the period from 16th July to 15th August mitigation measure is necessary to implement on nineteen turbines (complete field except O.U.19) in a way that all wind turbines should have cut-in speed at 5 m/s and feathering below that speed during complete night, from half an hour before sunset till half an hour after sunrise. In the period from 1st July to 15th July and from 16th August to 31st August fourteen turbines (all except: O.U.08, O.U.09, O.U.11, O.U.12, O.U.15, O.U.19) should have mitigation measure including cut-in speed at 5 m/s and feathering below that speed from 9 pm till 3 am next morning.

To monitor effectiveness of proposed mitigation measures it is necessary to conduct monitoring program at location of WF „Jelinak“. There are two ways how to conduct monitoring in 2017. First one is to follow monitoring protocol from 2015 and 2016 and be able to directly compare results from previous years. Therefore, in 2017 we propose (Table 4a) to install batcorder device on the site from June to September at the same locations. We propose visual search for dead bats on the site every seven days in June and September, and in July and August every day searches. The last field survey (visual search for dead bats) should be done in the period from 1st October to 5th October.

Based on results of field research in 2015 and 2016 the other way to monitor effectiveness of proposed mitigation measures is to follow protocol in which is reduced number of field visits based on the carcass removal / persistence due to scavengers. In this option we also propose (Table 4b) to install batcorder device on the site from June to September at the same locations. We propose visual search for dead bats on the site every seven days in June and September, and every three days in July and August. The last field survey (visual search for dead bats) should be done in the period from 1st October to 5th October.

Based on the analysis and results of monitoring in 2017, it is necessary to made possibly corrections of mitigation measure and also of proposal for further monitoring program.

Table 3. Proposal of mitigation measures in 2017 at location of WF „Jelinak".

MITIGATION MEASURE IN 2017 AT WF "JELINAK"			
Period: 1.7.2017. - 15.7.2017.			
Wind turbine	**Cut-in speed**	**Feathering**	**Timing**
Mitigation measure at fourteen turbines (except of: O.U.08; O.U.09, O.U.11, O.U.12, O.U.15, O.U.19)	5.0 m/s	yes	9 pm – 3 am
Period: 16.7.2017. - 15.8.2017.			
Wind turbine	**Cut-in speed**	**Feathering**	**Timing**
Mitigation measure on the complete field (except O.U.19))	5.0 m/s	yes	*complete night
* from half an hour before sunset till half an hour after sunrise			
Period: 16.8.2017. - 31.8.2017.			
Wind turbine	**Cut-in speed**	**Feathering**	**Timing**
Mitigation measure at fourteen turbines (except of: O.U.08; O.U.09, O.U.11, O.U.12, O.U.15, O.U.19)	5.0 m/s	yes	9 pm – 3 am

Table 4a. Proposal for a monitoring program in 2017 at location of WF „Jelinak".

MONITORING IN 2017 AT WF "JELINAK"		
Period: June – October 2017		
Month	**Field work**	**Date**
JUNE	• visual search for dead bats on the site • installation of batcorder on the site (June-September)	every 7 days
JULY	• visual search for dead bats on the site	every day
AUGUST	• visual search for dead bats on the site	every day
SEPTEMBER	• visual search for dead bats on the site	every 7 days
OCTOBER	• visual search for dead bats on the site	2 days (1st – 5th October)

Table 4b. Proposal for a monitoring program in 2017 at location of WF „Jelinak".

MONITORING IN 2017 AT WF "JELINAK"		
Period: June – October 2017		
Month	**Field work**	**Date**
JUNE	• visual search for dead bats on the site • installation of batcorder on the site (June-September)	every 7 days
JULY	• visual search for dead bats on the site	every 3 days
AUGUST	• visual search for dead bats on the site	every 3 days
SEPTEMBER	• visual search for dead bats on the site	every 7 days
OCTOBER	• visual search for dead bats on the site	2 days (1st – 5th October)

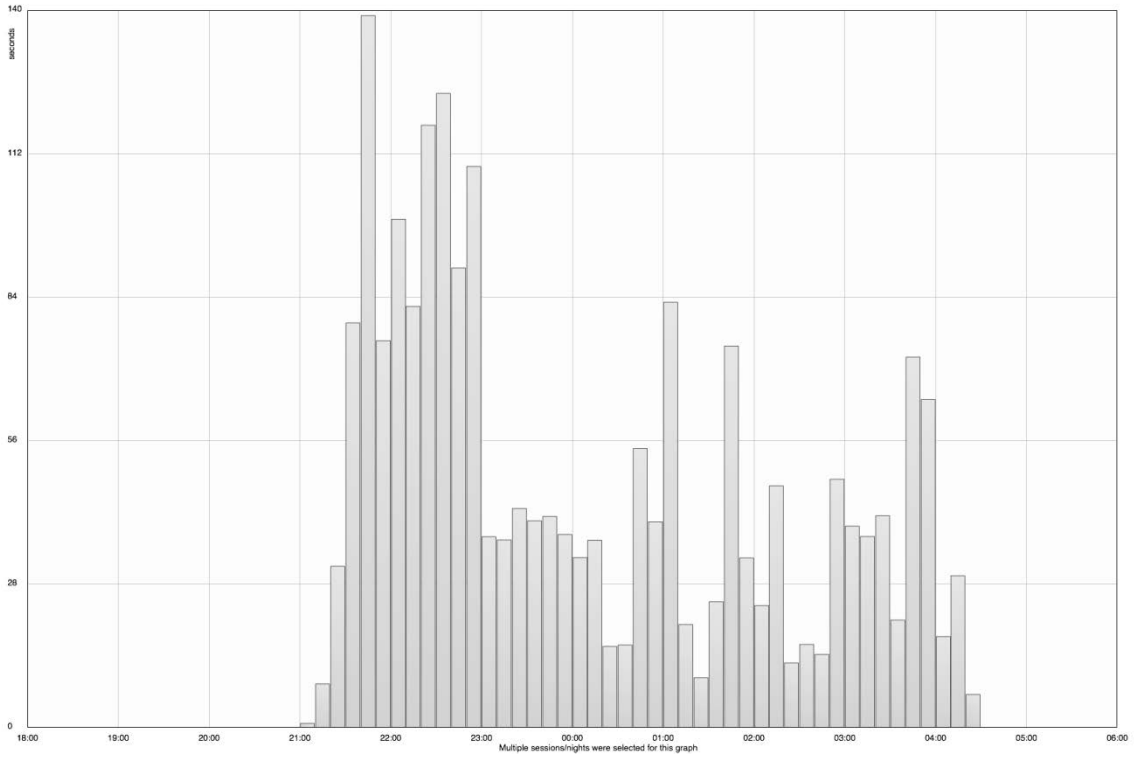
7. Appendix

Appendix 1. Table of total recorded mortality during monitoring in June, July, August and September 2016.

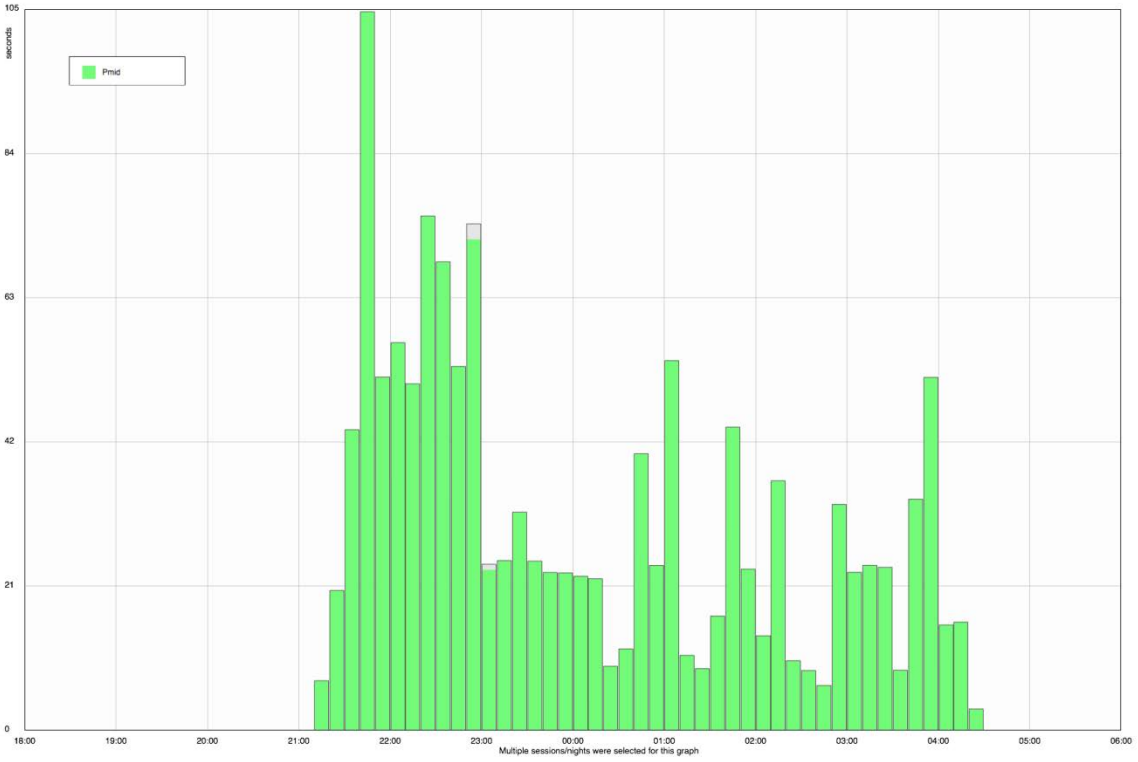
Mortality_monitoring_WF_Jelinak_June_July_August_September_2016.					
No.	**Date**	**Species**	**Sex**	**Turbine**	**note**
1	2016.06.12.	*Hypsugo savii*	H	O.U.03	
2	2016.06.26.	*Hypsugo savii*	M	O.U.12	
3	2016.07.08.	*Pipistrellus kuhlii*	H	O.U.12	female with breasts
4	2016.07.10.	*Pipistrellus kuhlii*	M	O.U.02	
5	2016.07.16.	*Pipistrellus kuhlii*	H	O.U.10	
6	2016.07.25.	*Hypsugo savii*	H	O.U.08	female with breasts
7	2016.07.26.	*Pipistrellus kuhlii*	I	O.U.08	
8	2016.07.27.	*Hypsugo savii*	H	O.U.15	
9	2016.07.28.	*Hypsugo savii*	I	O.U.09	
10	2016.07.29.	*Pipistrellus kuhlii*	M	O.U.09	
11	2016.07.29.	*Hypsugo savii*	H	O.U.09	female with breasts
12	2016.07.29.	*Hypsugo savii*	I	O.U.12	
13	2016.07.29.	*Hypsugo savii*	H	O.U.20	
14	2016.07.31.	*Hypsugo savii*	H	O.U.09	female with breasts
15	2016.07.31.	*Pipistrellus kuhlii*	H	O.U.09	female with breasts
16	2016.07.31.	*Pipistrellus kuhlii*	M	O.U.12	
17	2016.07.31.	*Hypsugo savii*	I	O.U.15	
18	2016.08.01.	*Pipistrellus kuhlii*	H	O.U.11	
19	2016.08.04.	*Hypsugo savii*	H	O.U.08	
20	2016.08.04.	*Pipistrellus kuhlii*	I	O.U.08	
21	2016.08.06.	*Hypsugo savii*	M	O.U.02	
22	2016.08.09.	*Pipistrellus kuhlii*	H	O.U.12	female with breasts
23	2016.08.10.	*Pipistrellus kuhlii*	I	O.U.11	
24	2016.08.15.	*Hypsugo savii*	H	O.U.08	
25	2016.08.16.	*Pipistrellus kuhlii*	I	O.U.11	
26	2016.08.16.	*Pipistrellus kuhlii*	I	O.U.18	
27	2016.08.19.	*Hypsugo savii*	H	O.U.15	
28	2016.08.30.	*Hypsugo savii*	M	O.U.17	
29	2016.09.17.	*Pipistrellus pygmaeus*	I	O.U.03	
30	2016.09.17.	*Tadarida teniotis*	M	O.U.16	

(Sex: M=male, H=female, I=indefinite.)

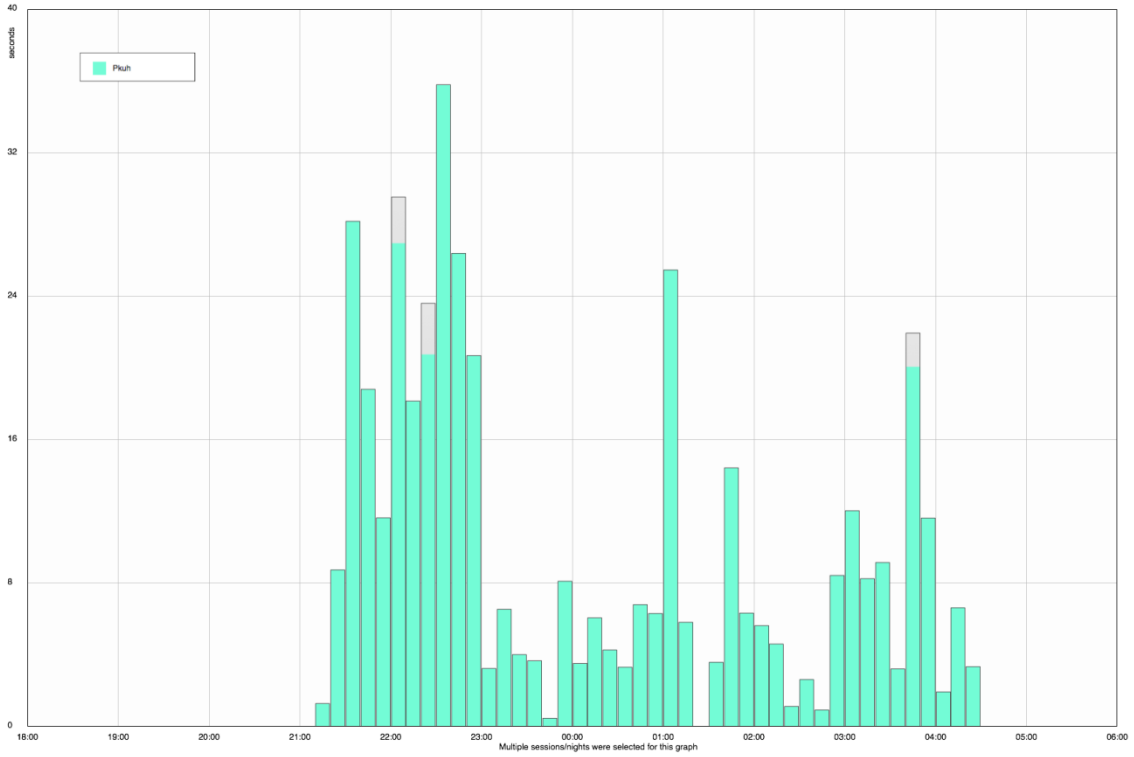
Appendix 2. Batcorder wind turbine O.U.01 (5.4).



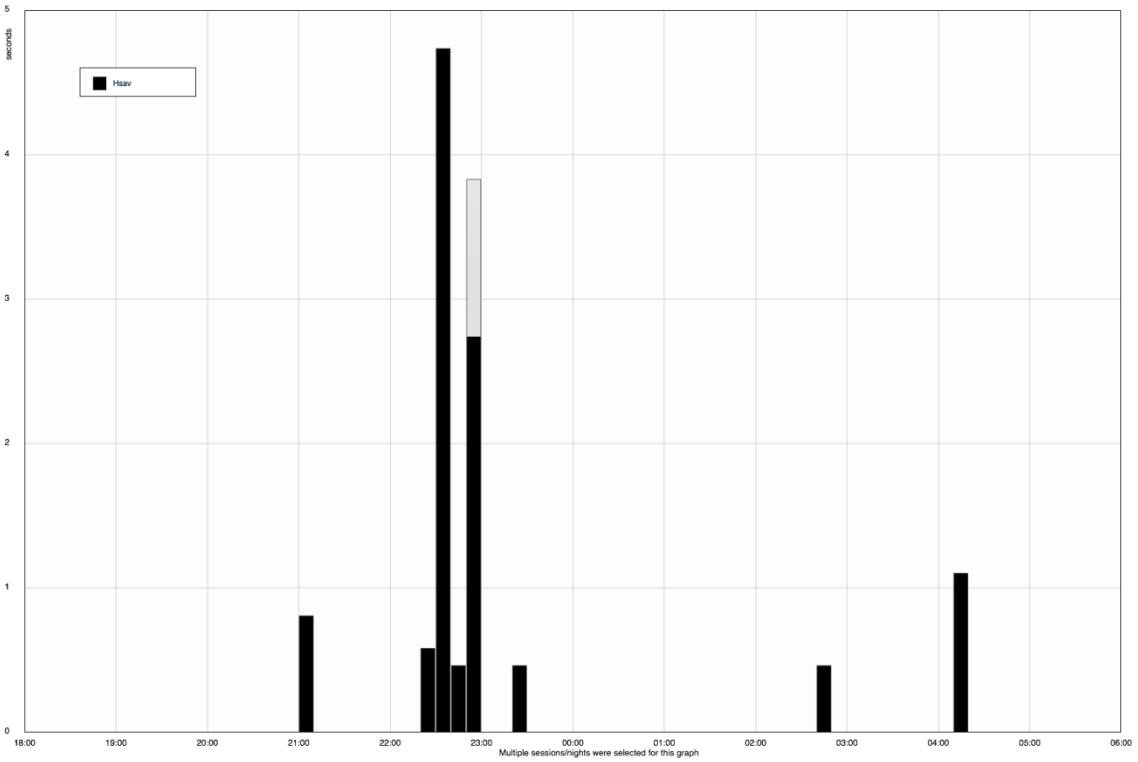
1. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 5th – 30th June 2016 at location of WF „Jelinak".



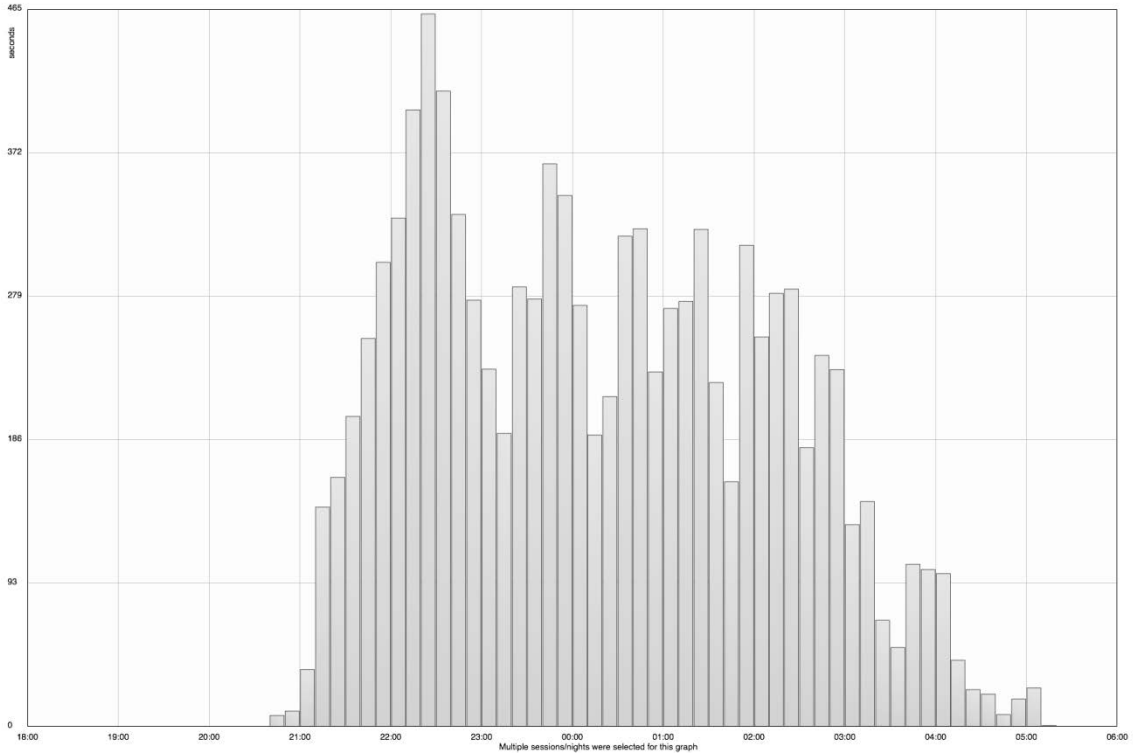
2. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in period 5th – 30th June 2016 at location of WF „Jelinak".



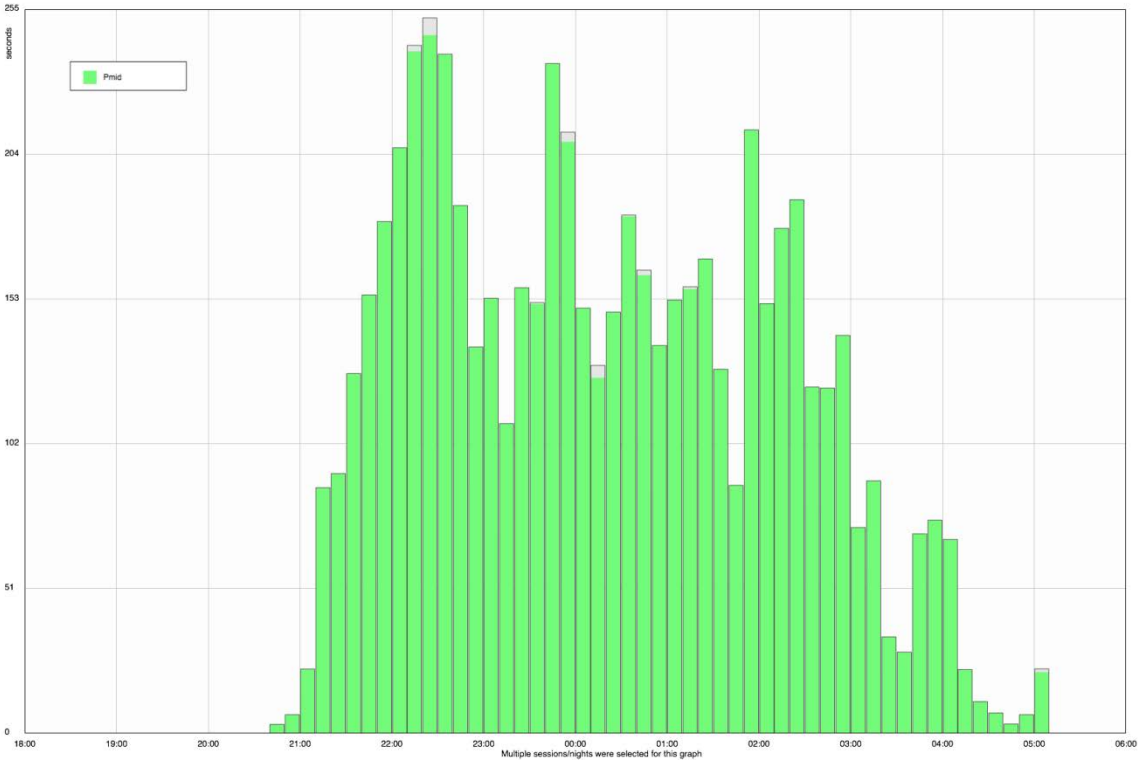
3. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 5th – 30th June 2016 at location of WF „Jelinak".



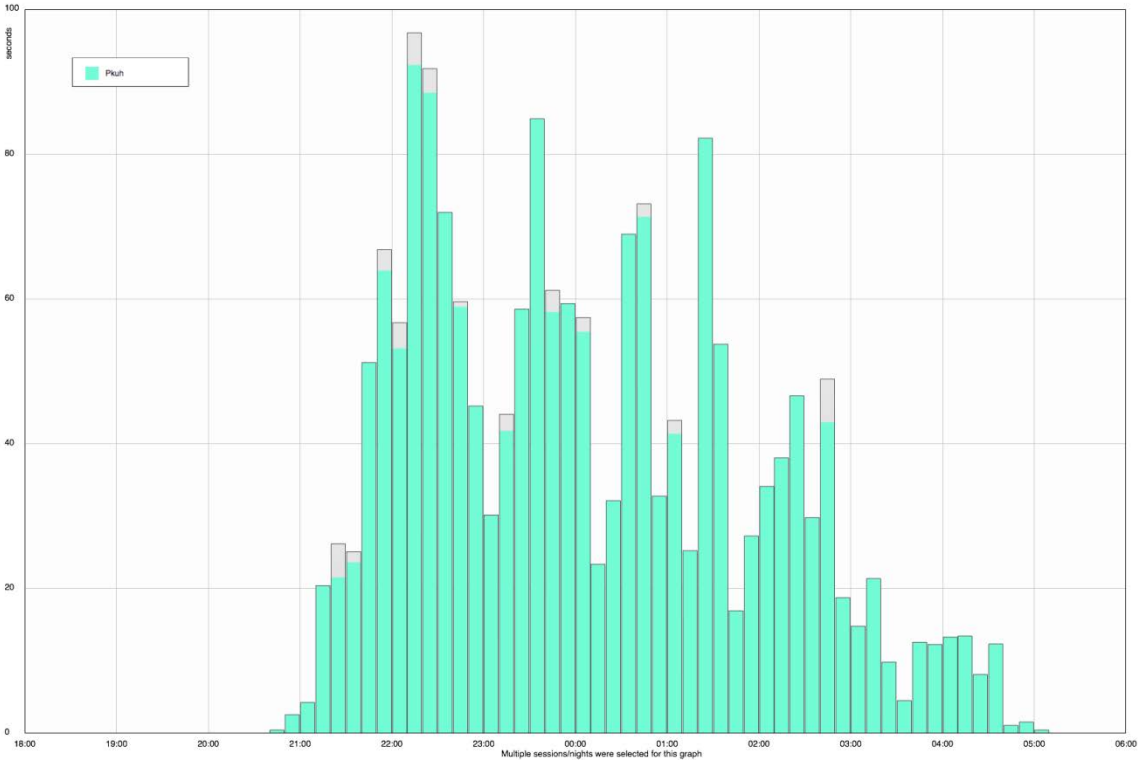
4. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 5th – 30th June 2016 at location of WF „Jelinak".



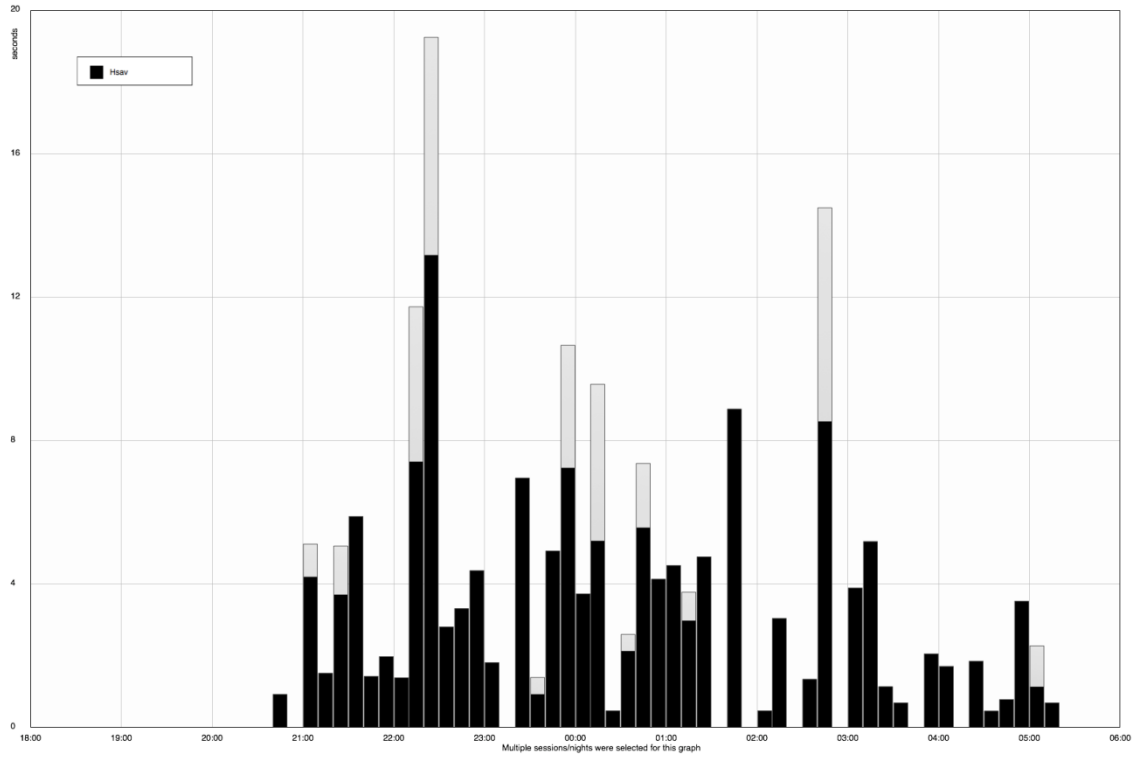
5. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 31st July 2016 at location of WF „Jelinak“.



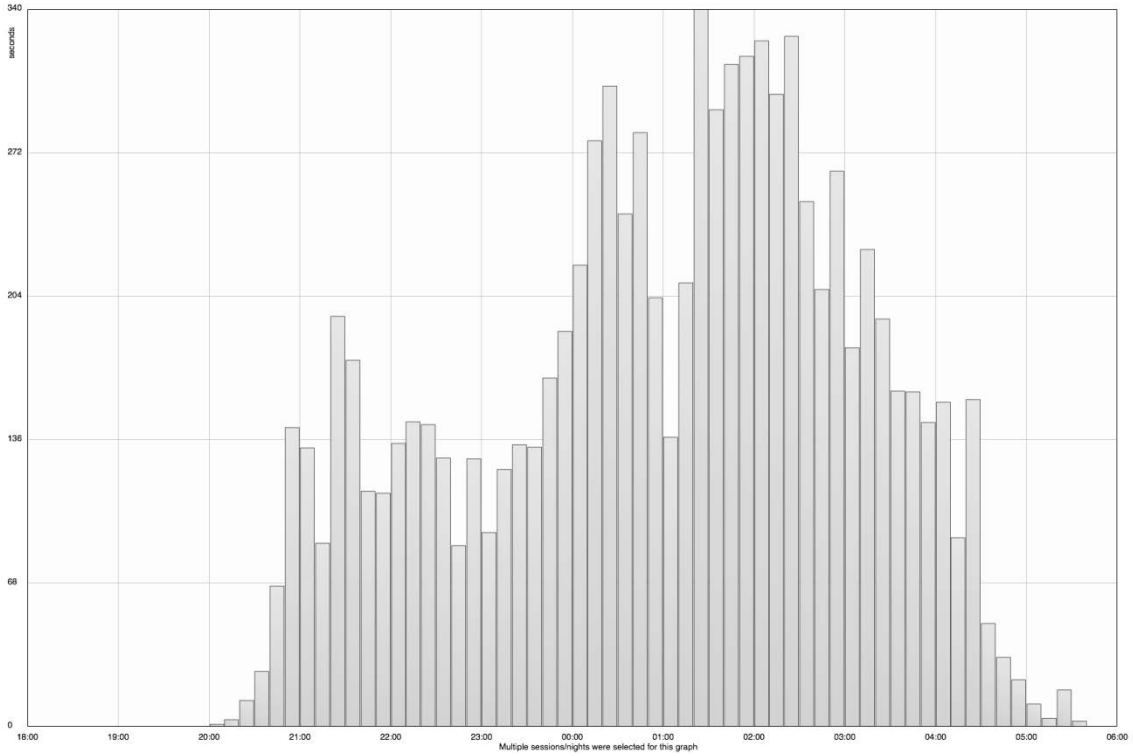
6. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in period 1st – 31st July 2016 at location of WF „Jelinak“.



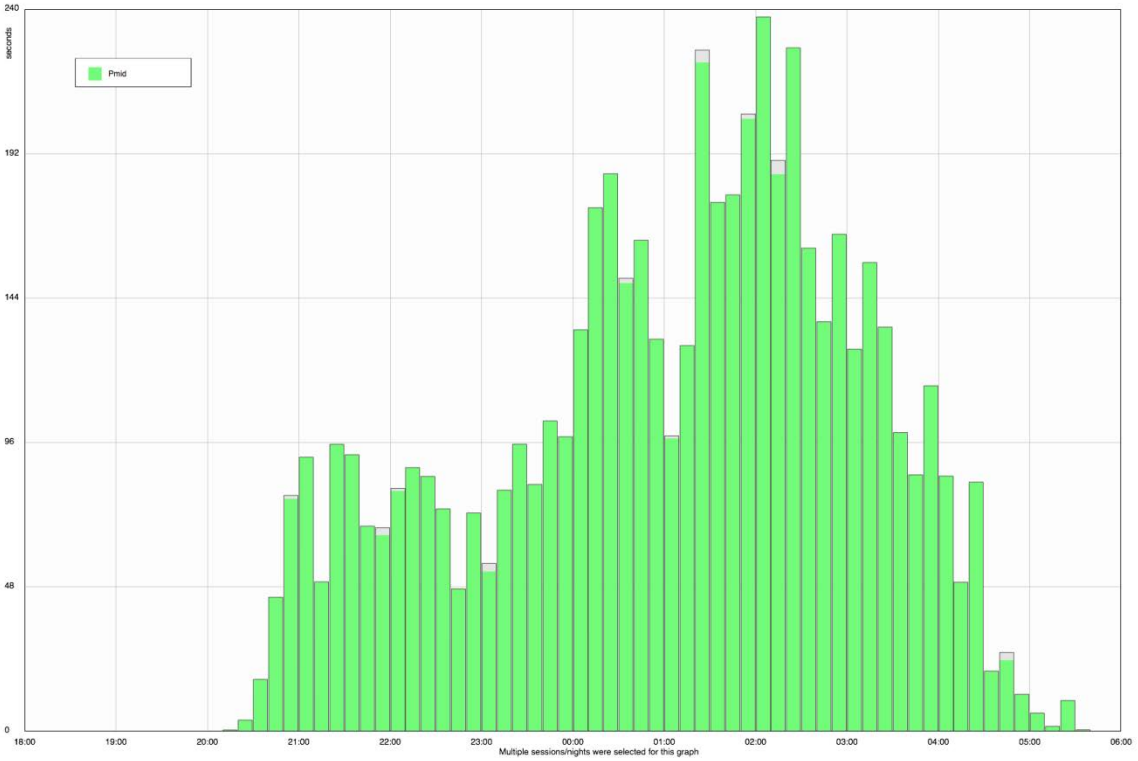
7. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 31st July 2016 at location of WF „Jelinak“.



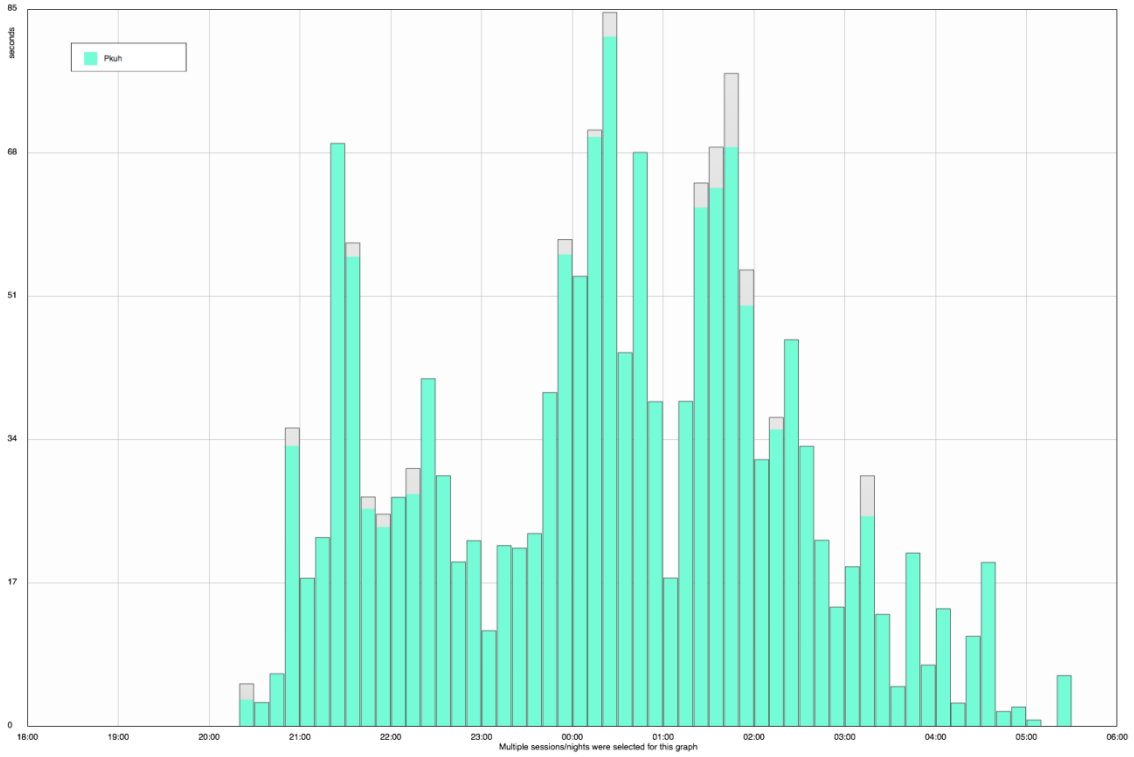
8. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 1st – 31st July 2016 at location of WF „Jelinak“.



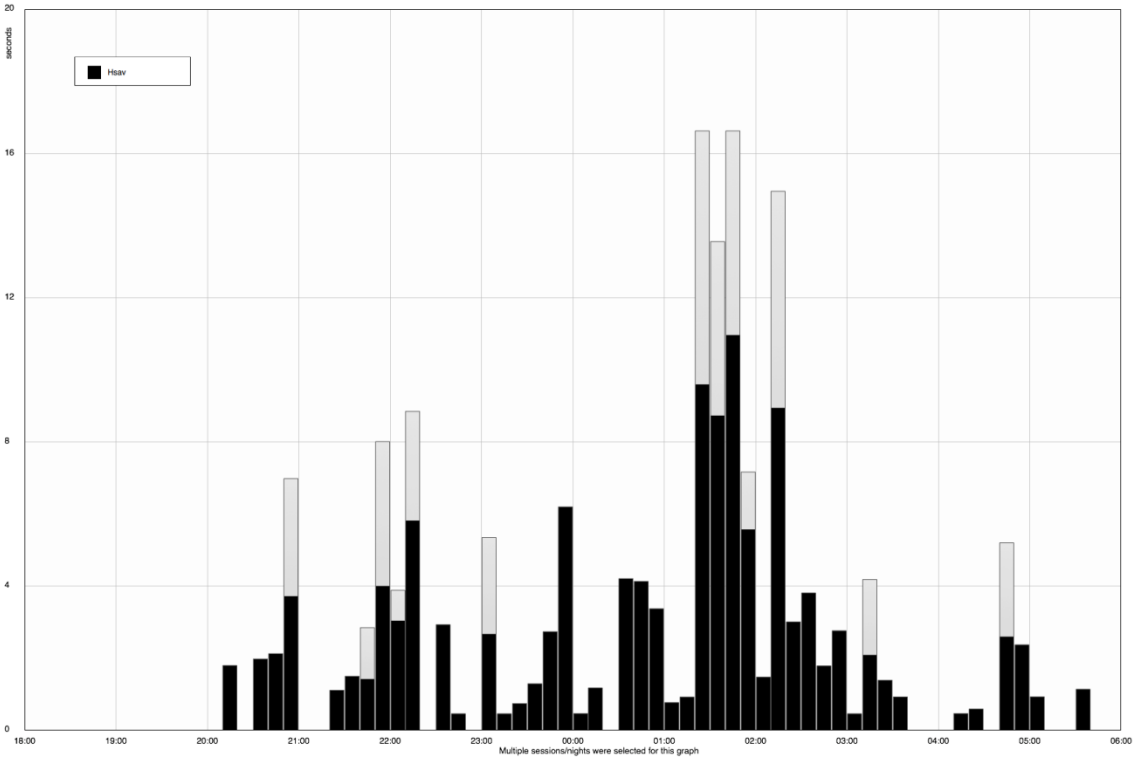
9. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 31st August 2016 at location of WF „Jelinak".



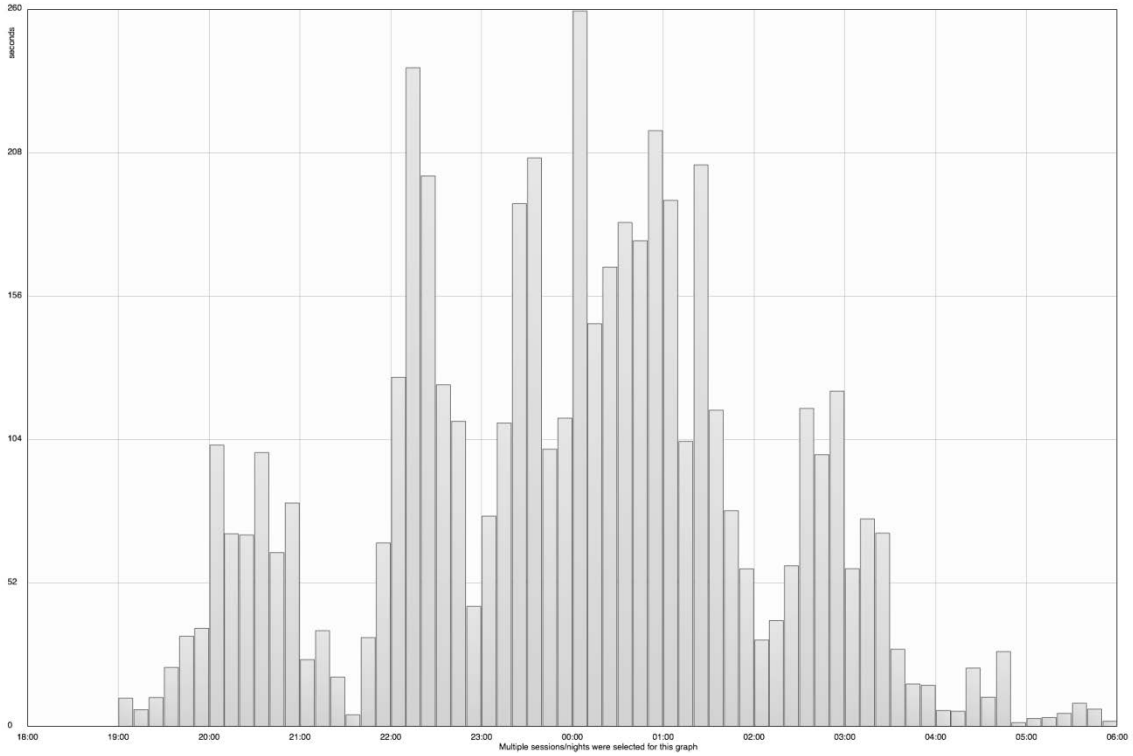
10. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in period 1st – 31st August 2016 at location of WF „Jelinak".



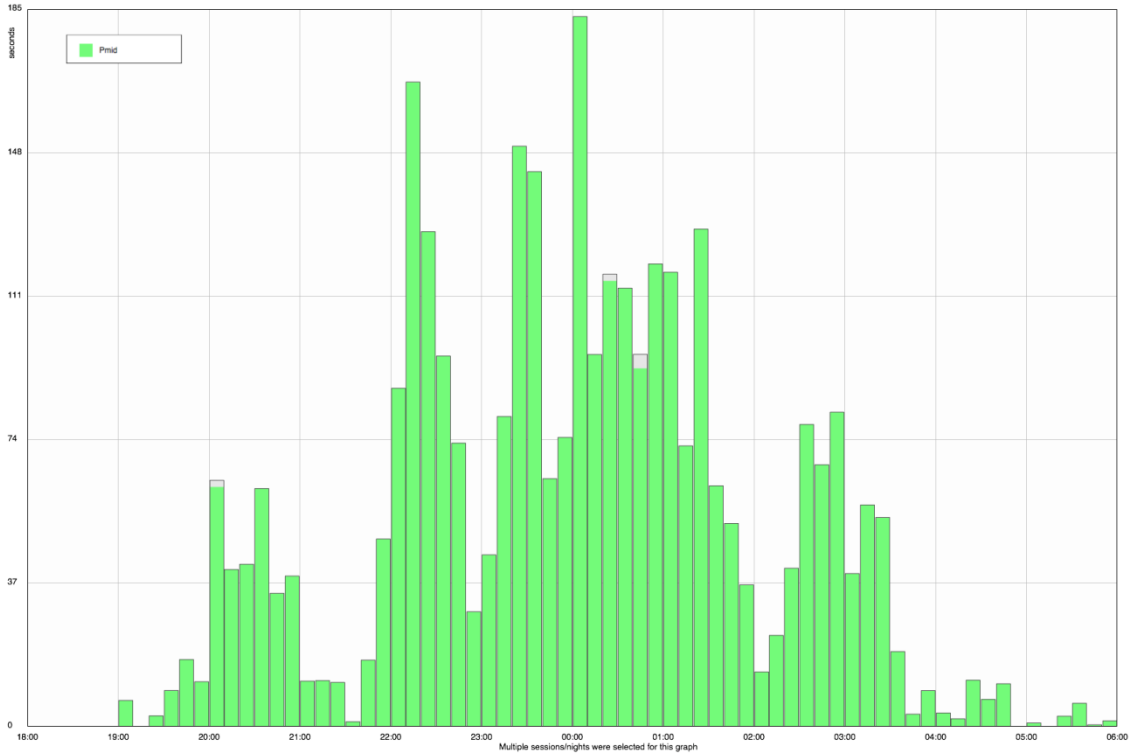
11. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 31st August 2016 at location of WF „Jelinak“.



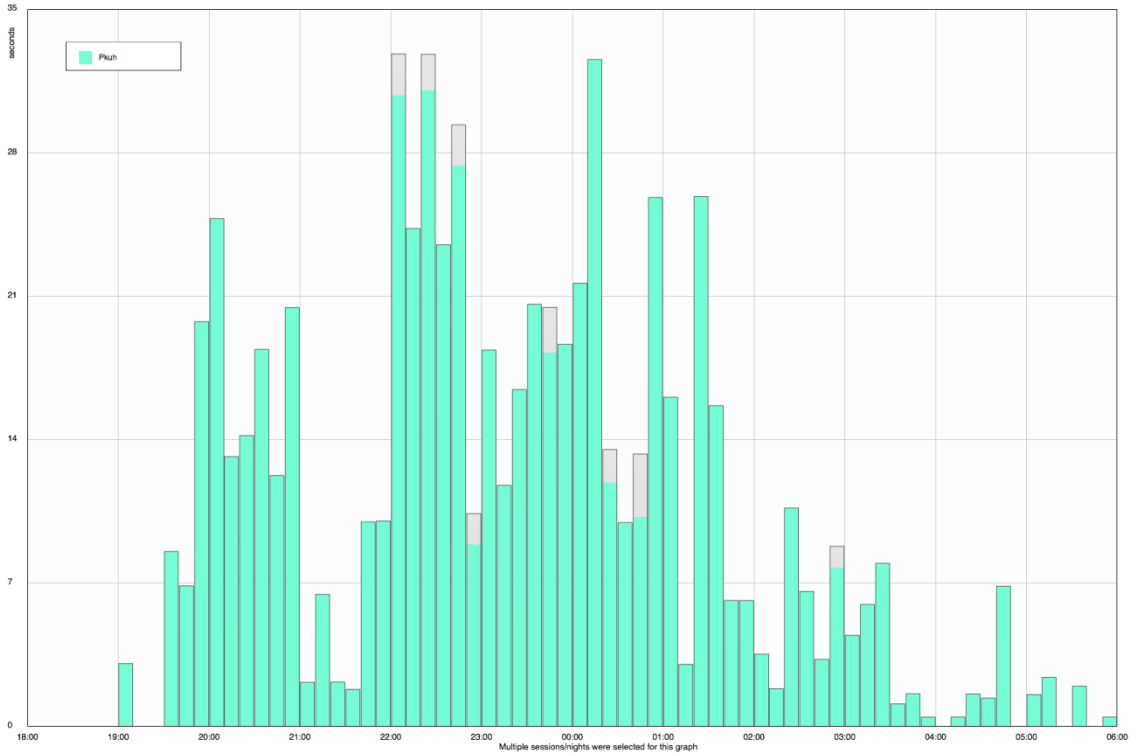
12. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 1st – 31st August 2016 at location of WF „Jelinak“.



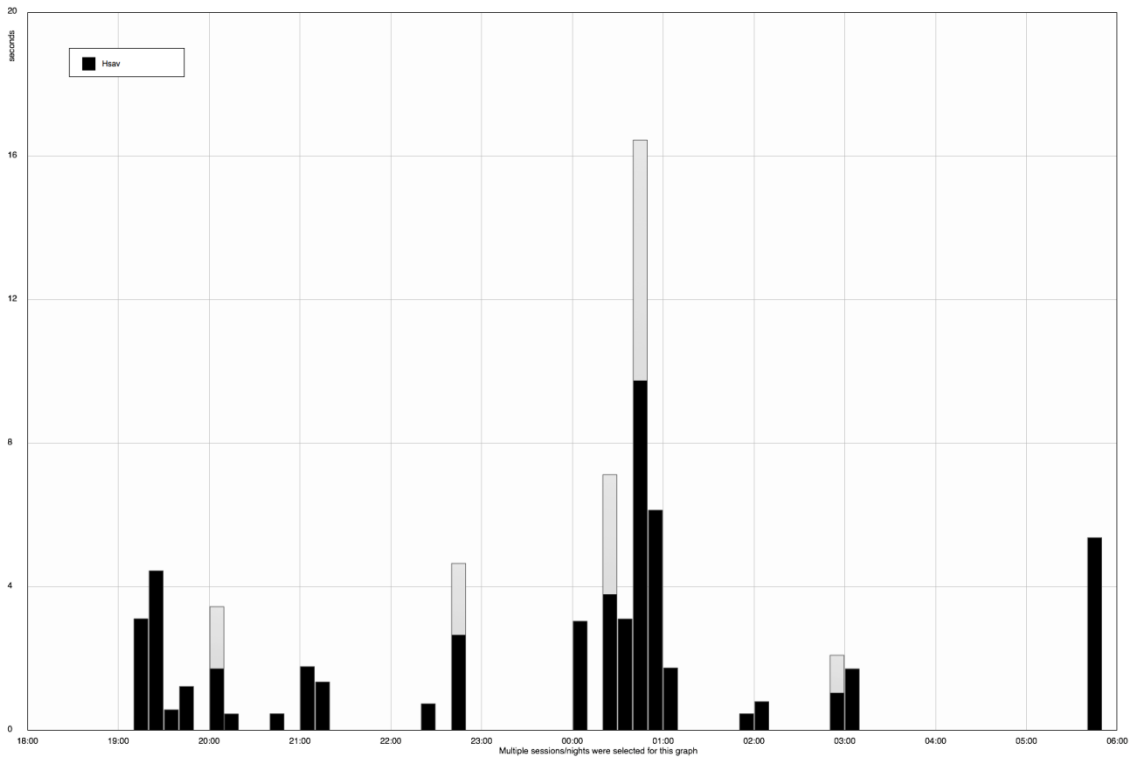
13. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 30th September 2016 at location of WF „Jelinak".



14. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.01 in period 1st – 30th September 2016 at location of WF „Jelinak".

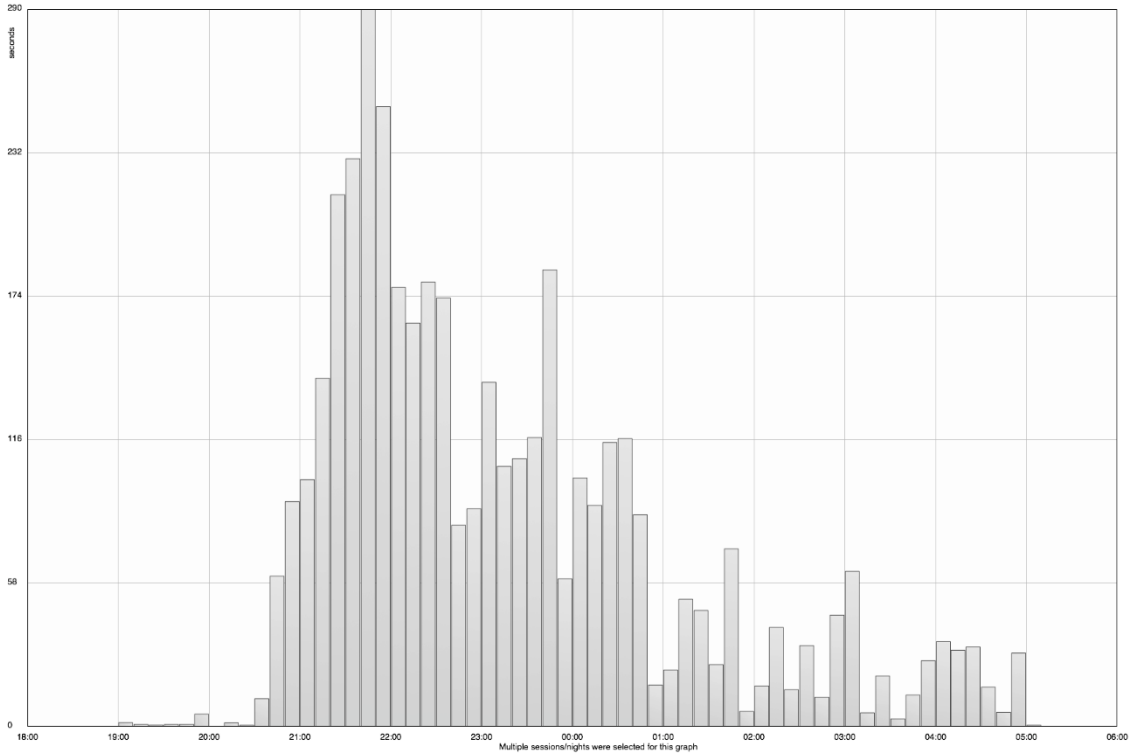


15. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 30th September 2016 at location of WF „Jelinak“.

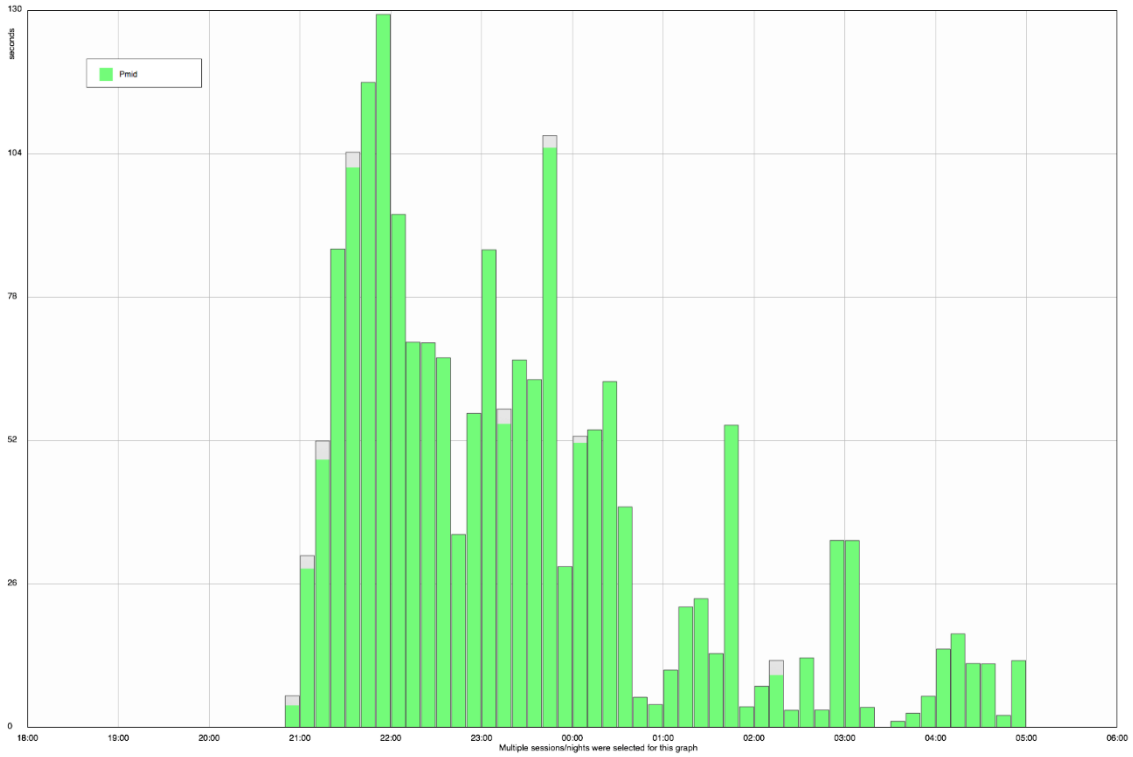


16. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 1st – 30th September 2016 at location of WF „Jelinak“.

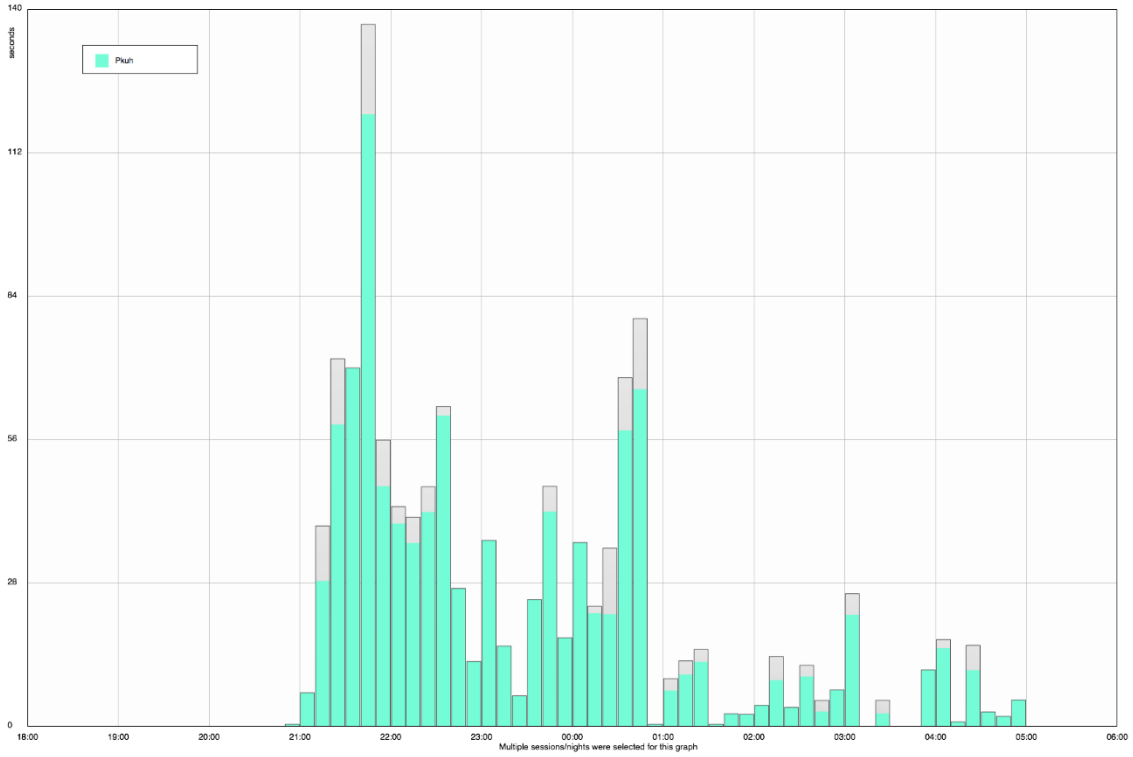
Appendix 3. Batcorder wind turbine O.U.18 (1.3).



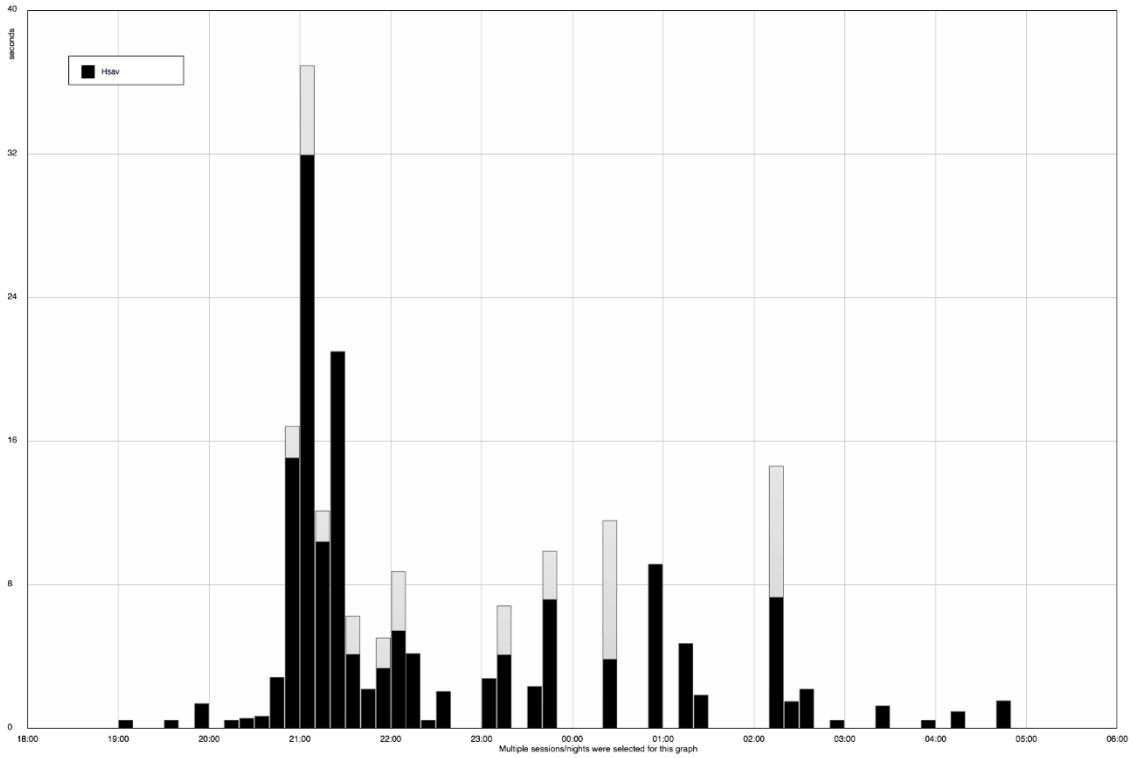
1. Total activity of all recorded bat species during entire nights at wind turbine O.U.18 in period 12th – 31st July 2016 at location of WF „Jelinak".



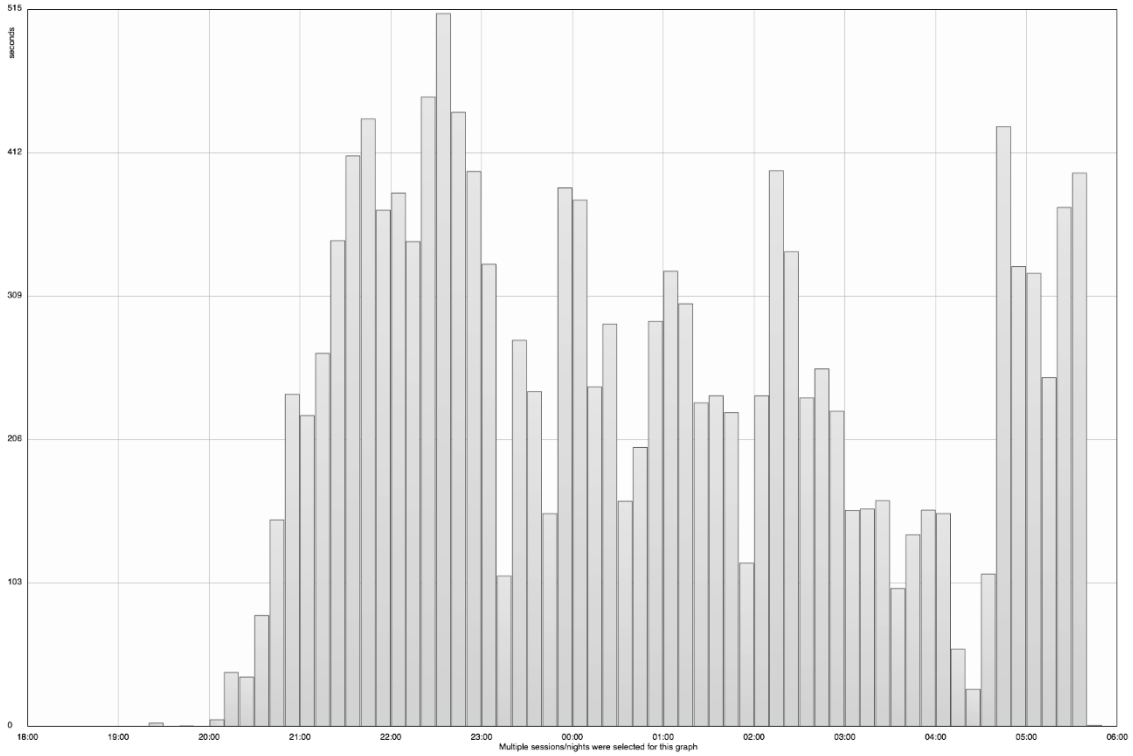
2. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.18 in period 12th – 31st July 2016 at location of WF „Jelinak".



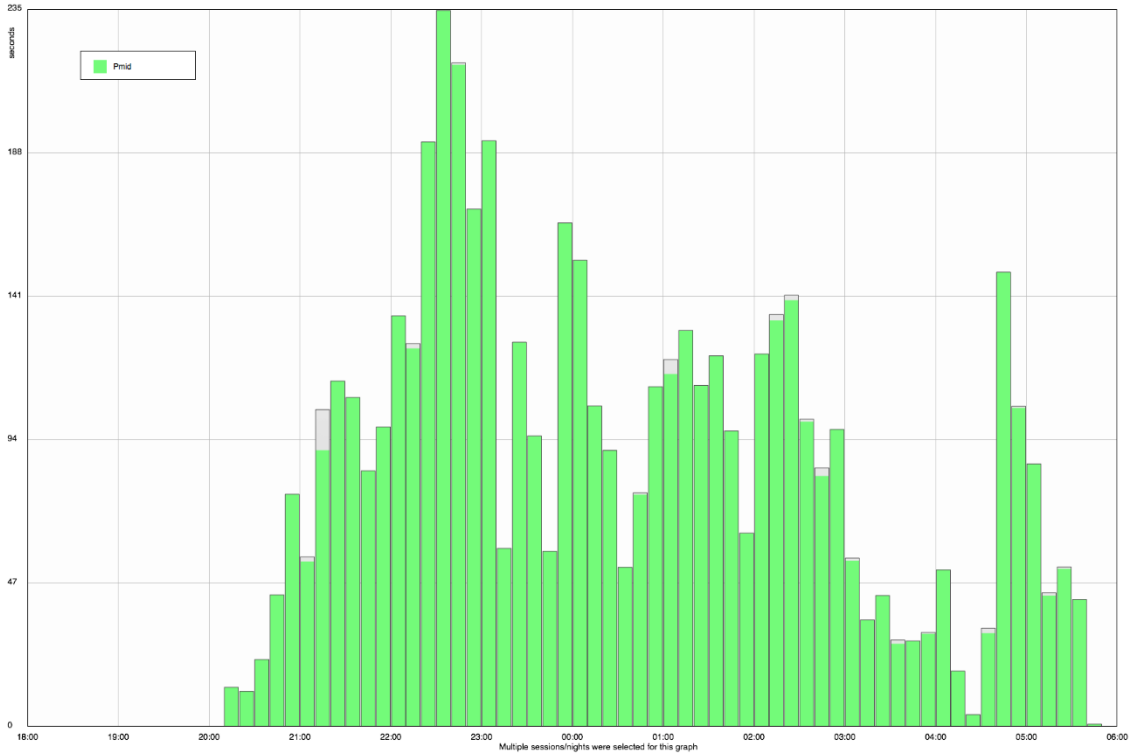
3. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.18 in period 12th – 31st July 2016 at location of WF „Jelinak".



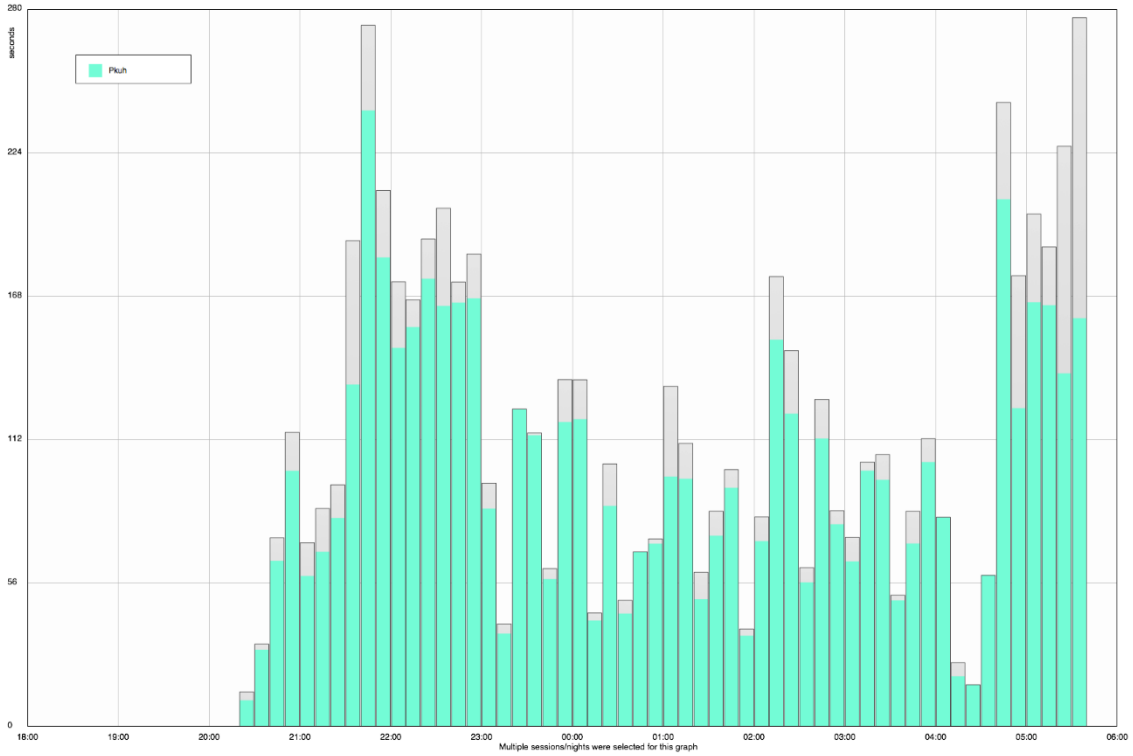
4. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.18 in period 12th – 31st July 2016 at location of WF „Jelinak".



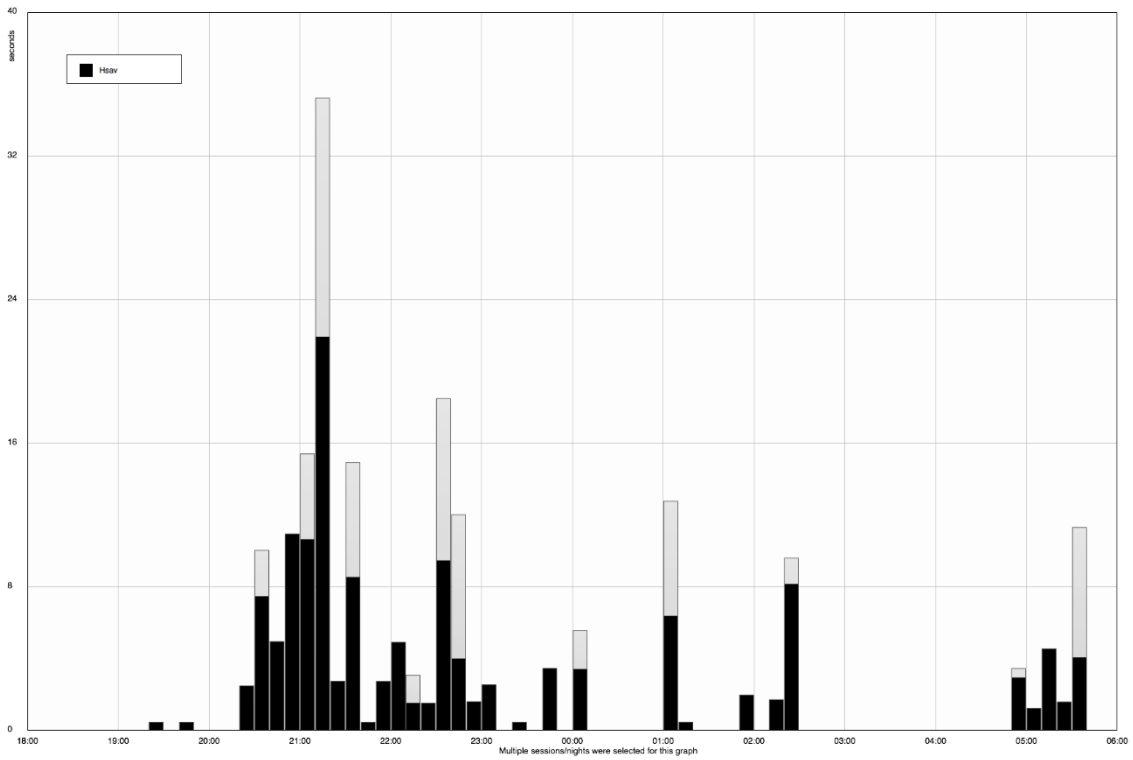
5. Total activity of all recorded bat species during entire nights at wind turbine O.U.18 in period 1st – 31st August 2016 at location of WF „Jelinak".



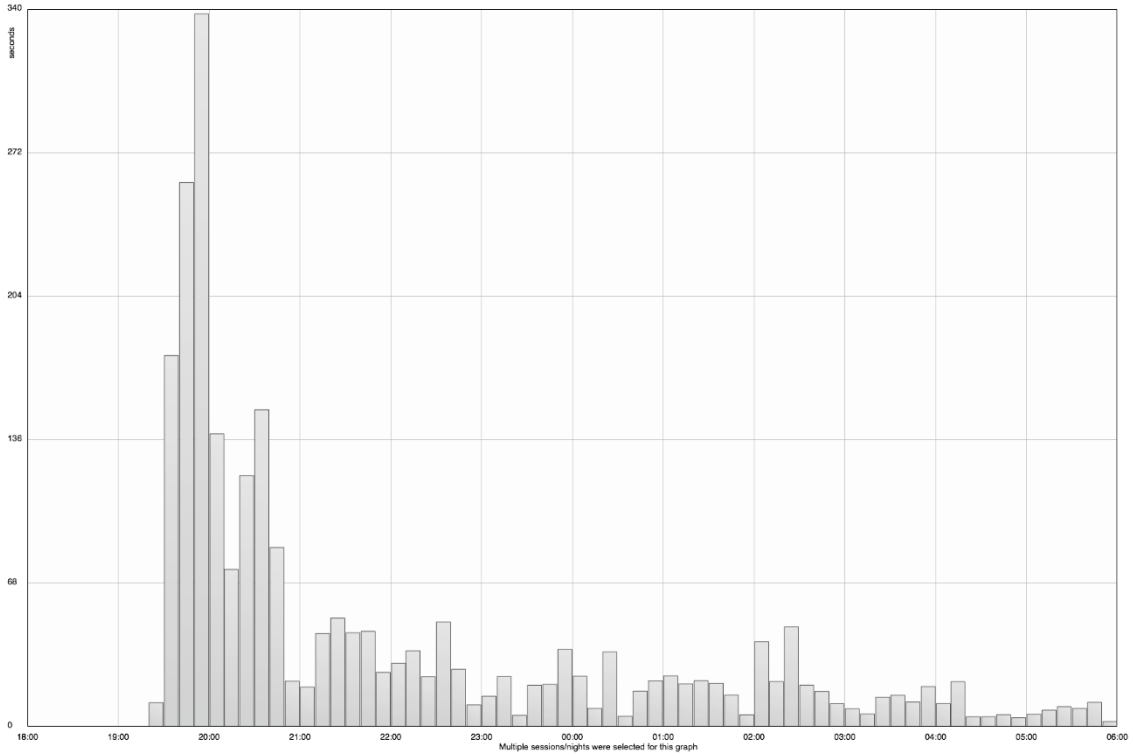
6. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.18 in period 1st – 31st August 2016 at location of WF „Jelinak".



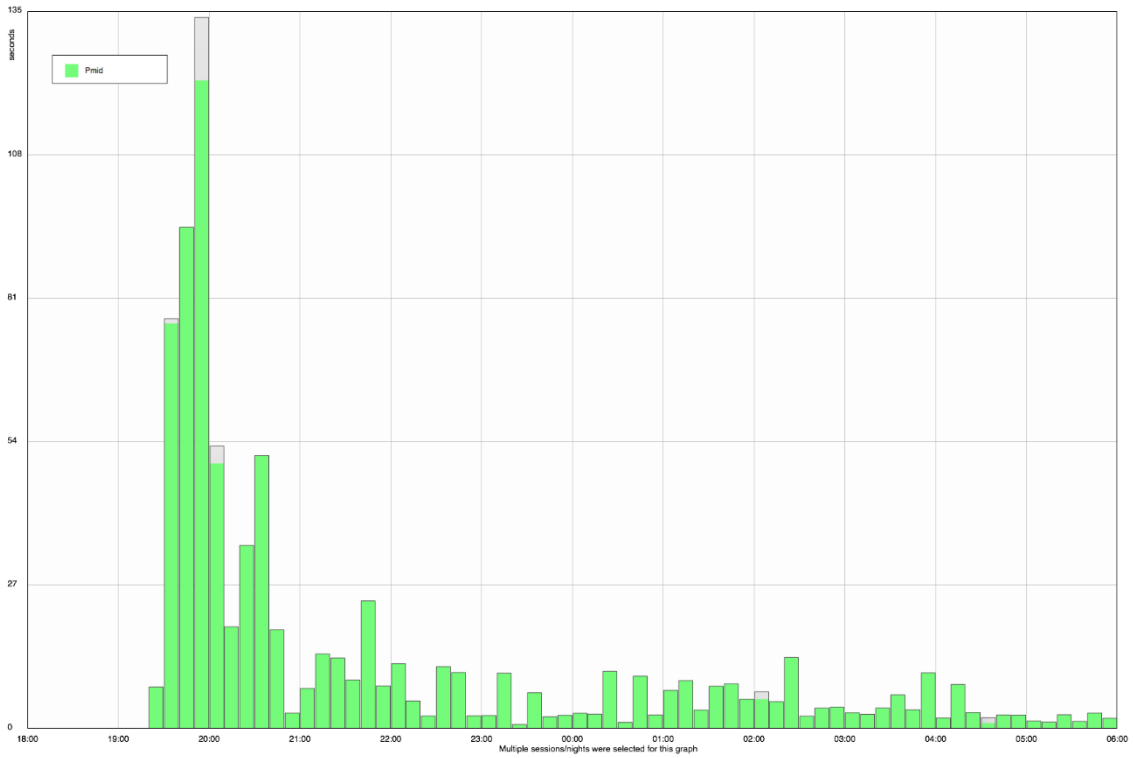
7. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.18 in period 1st – 31st August 2016 at location of WF „Jelinak".



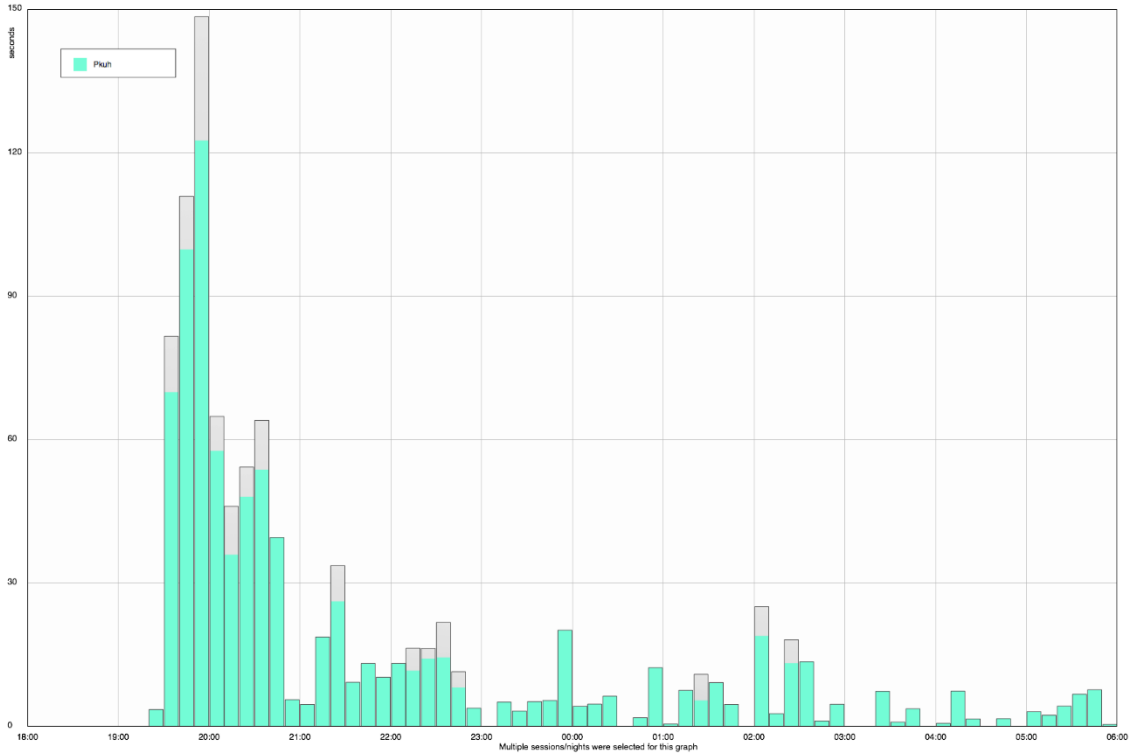
8. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.18 in period 1st – 31st August 2016 at location of WF „Jelinak".



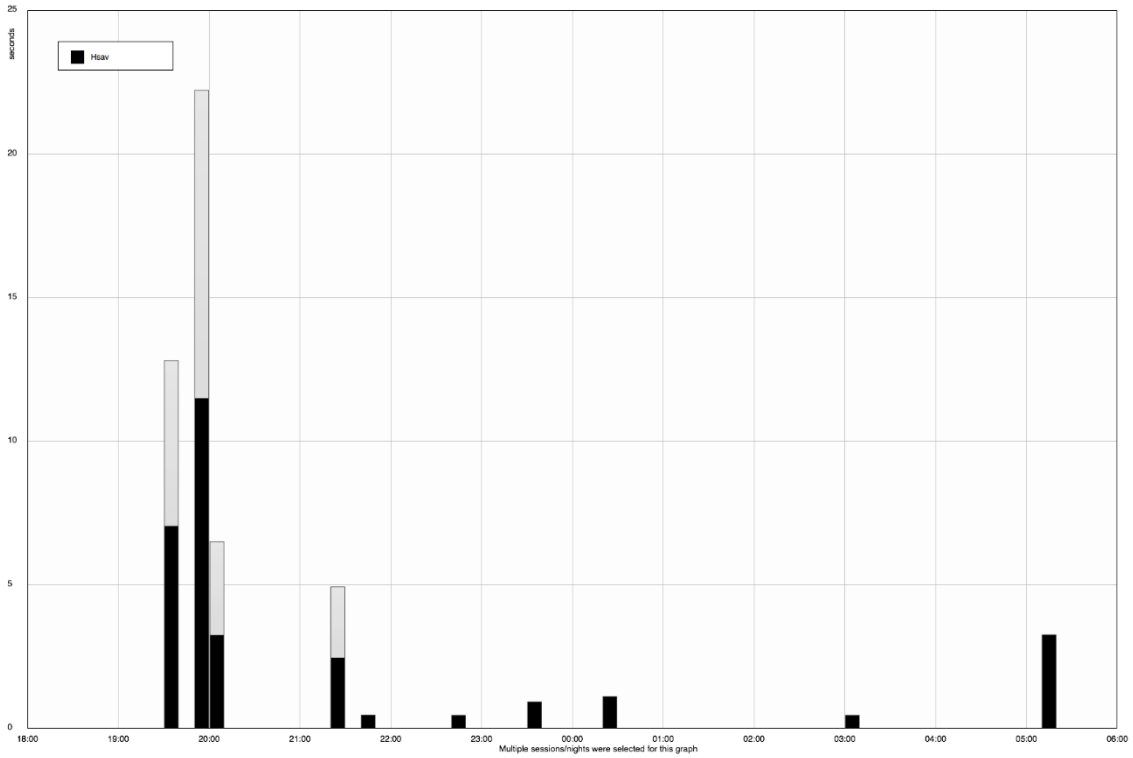
9. Total activity of all recorded bat species during entire nights at wind turbine O.U.18 in period 1st – 23rd September 2016 at location of WF „Jelinak“.



10. Total activity of group *Pipistrellus* middle frequency during entire nights at wind turbine O.U.18 in period1st – 23rd September 2016 at location of WF „Jelinak“.

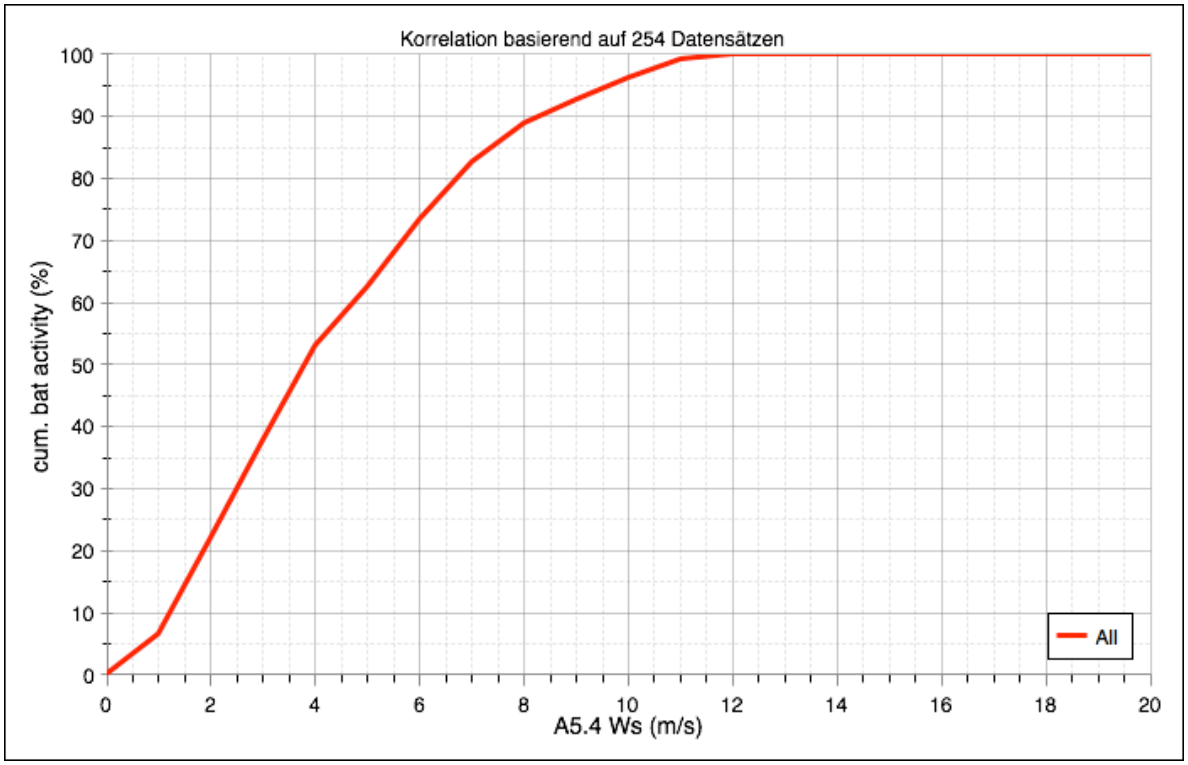


11. Total activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.18 in period 1st – 23rd September 2016 at location of WF „Jelinak“.

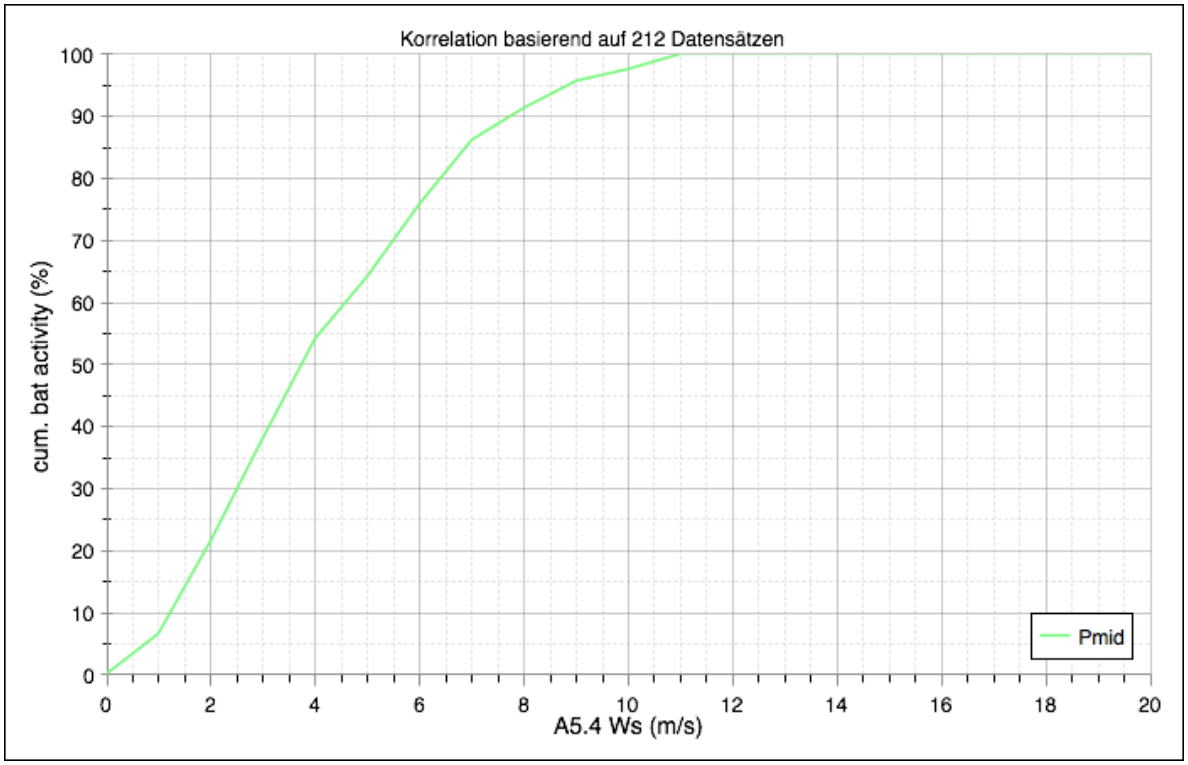


12. Total activity of species *Hypsugo savii* during entire nights at wind turbine O.U.18 in period 1st – 23rd September 2016 at location of WF „Jelinak“.

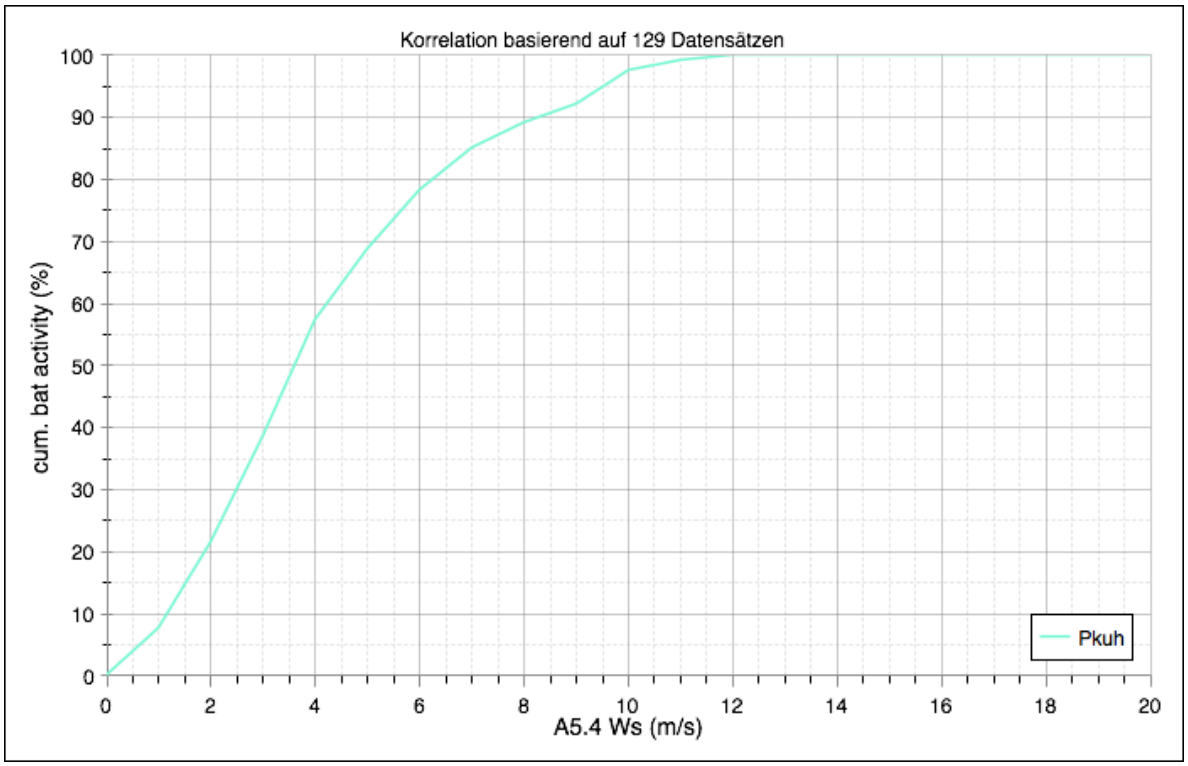
Appendix 4. Bat activity in relation to the wind speed - Batcorder wind turbine O.U.01 (5.4).



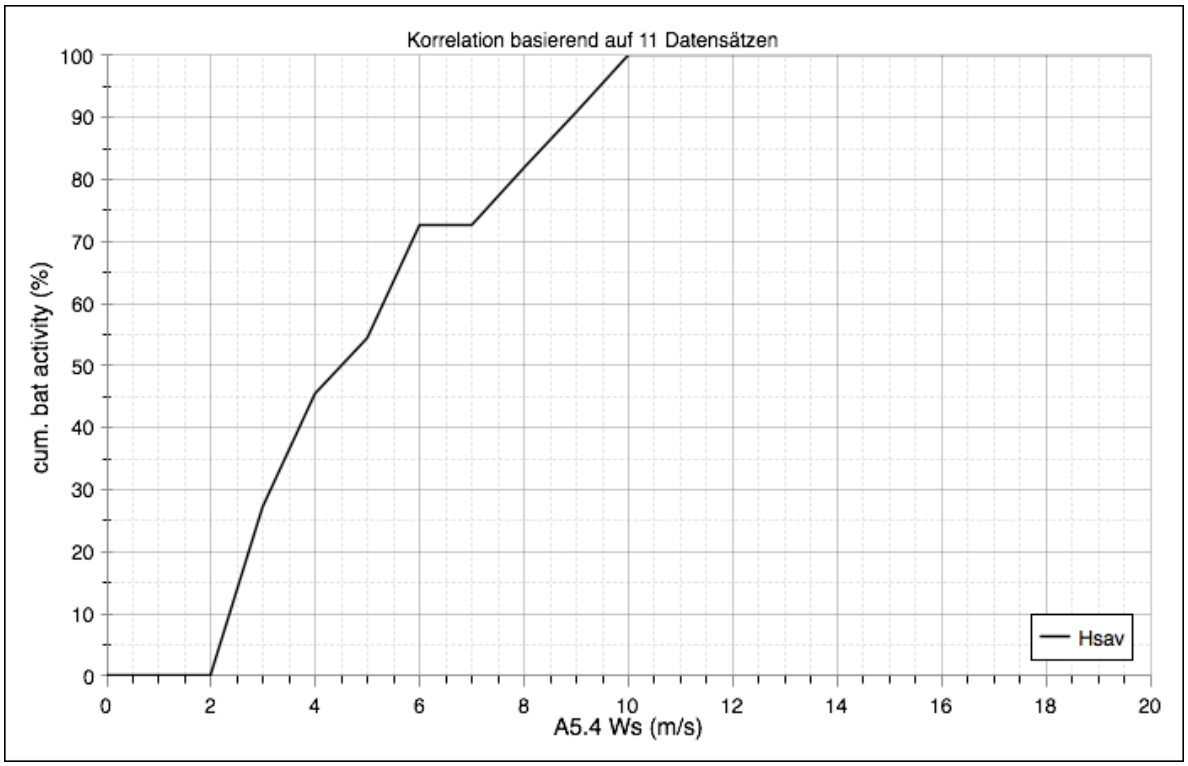
1. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in June 2016 at location of WF „Jelinak“.



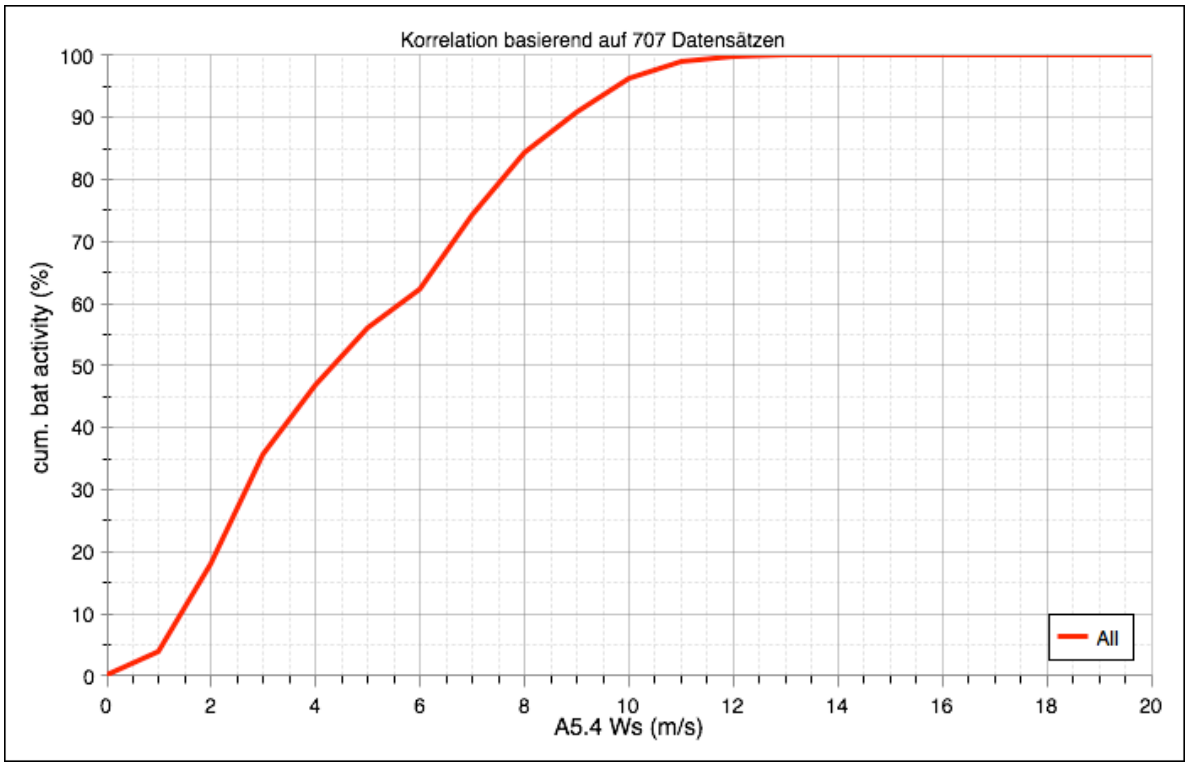
2. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.01 in June 2016 at location of WF „Jelinak“.



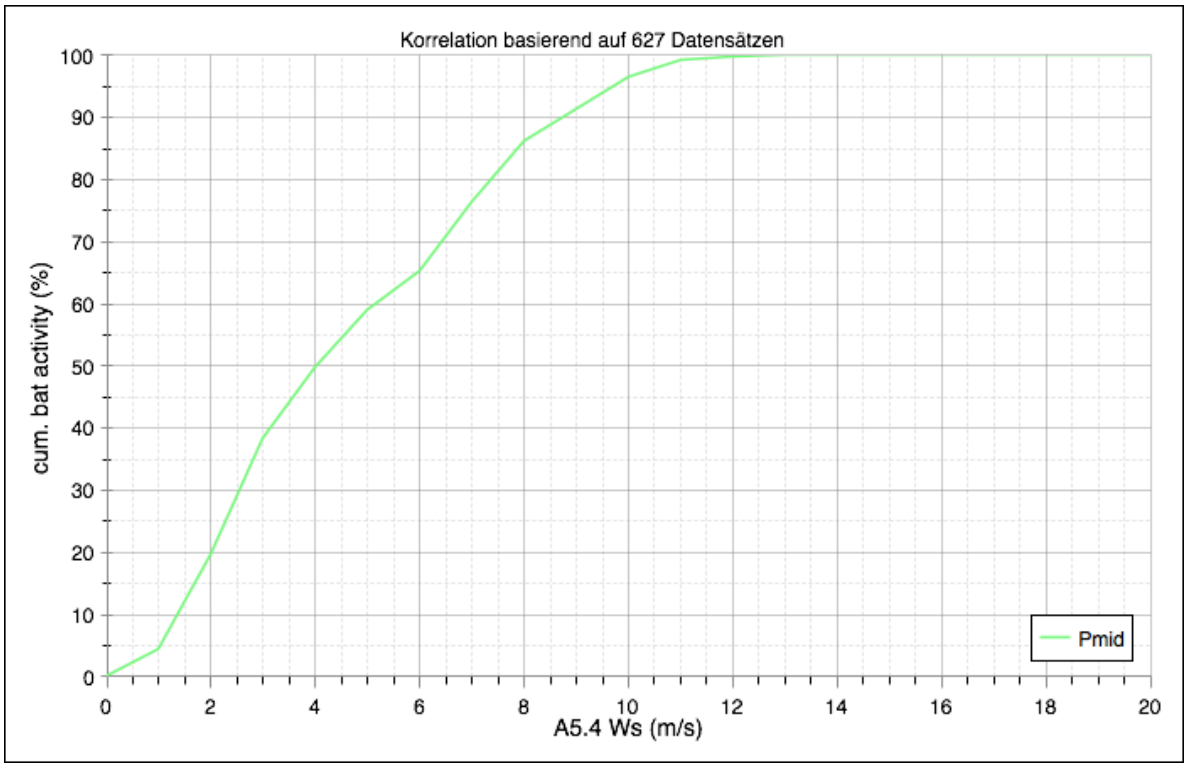
3. Total activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in June 2016 at location of WF „Jelinak“.



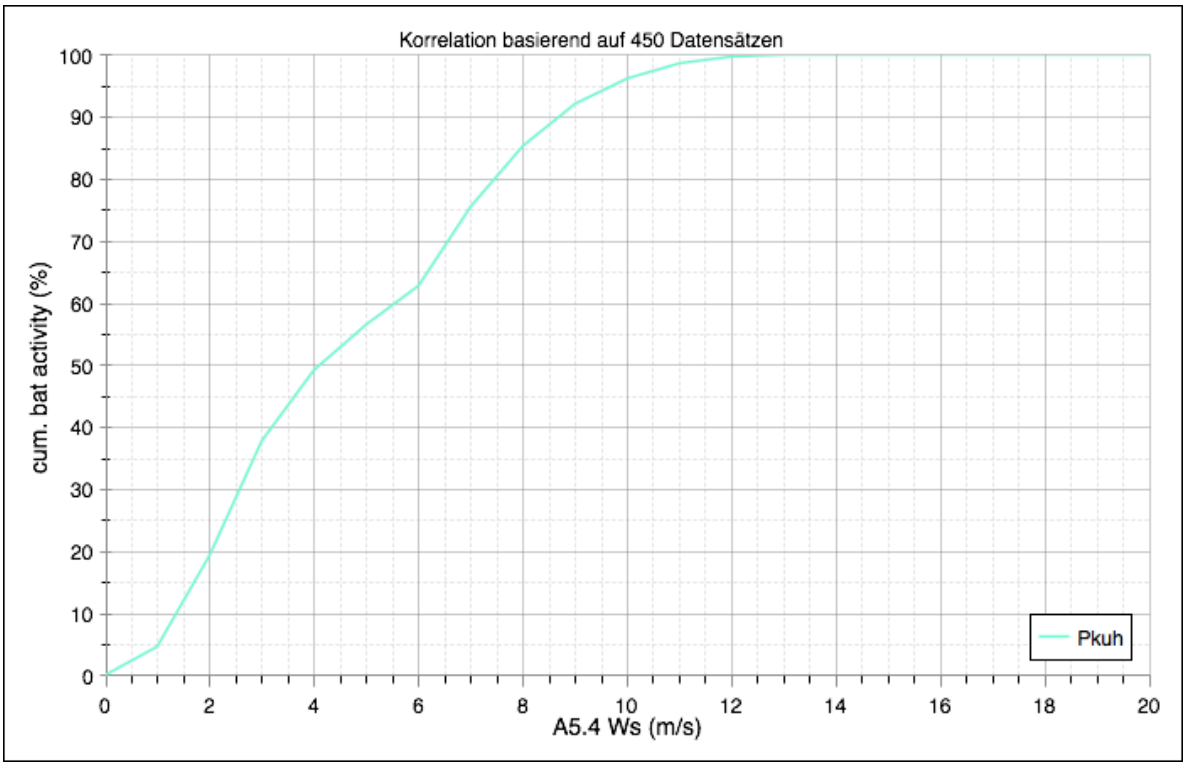
4. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in June 2016 at location of WF „Jelinak“.



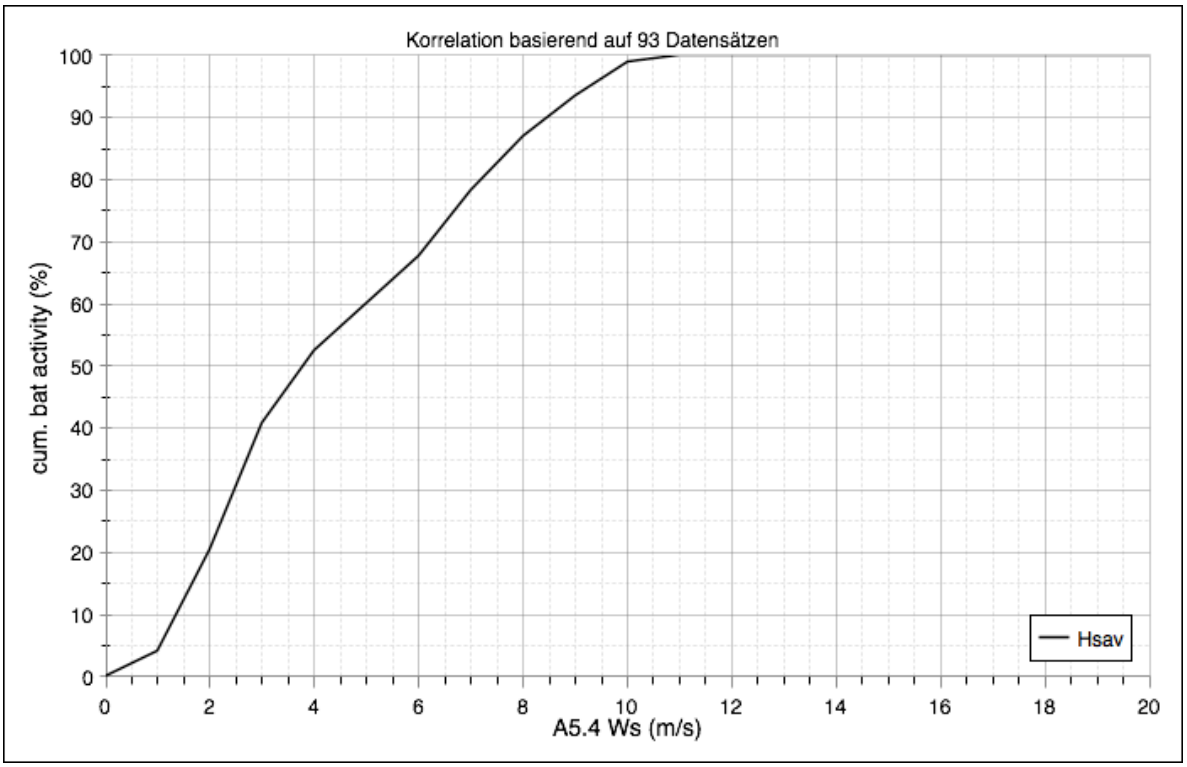
5. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in July 2016 at location of WF „Jelinak“.



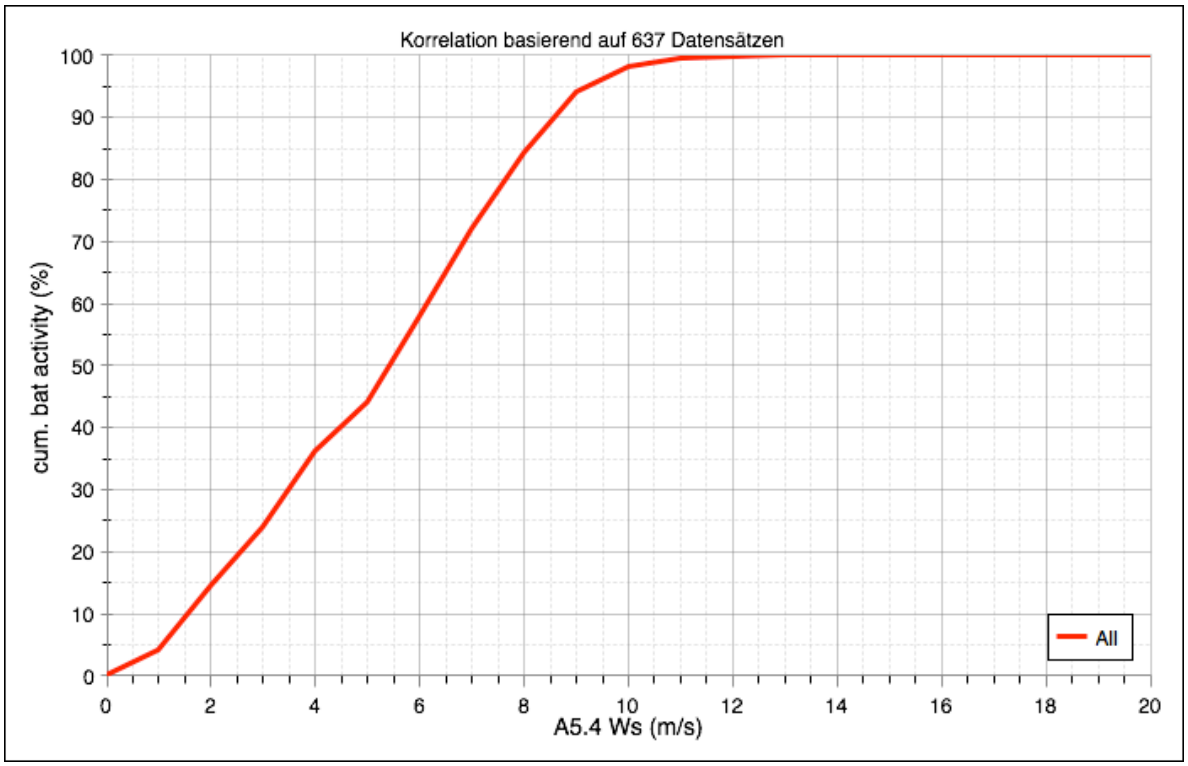
6. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.01 in July 2016 at location of WF „Jelinak“.



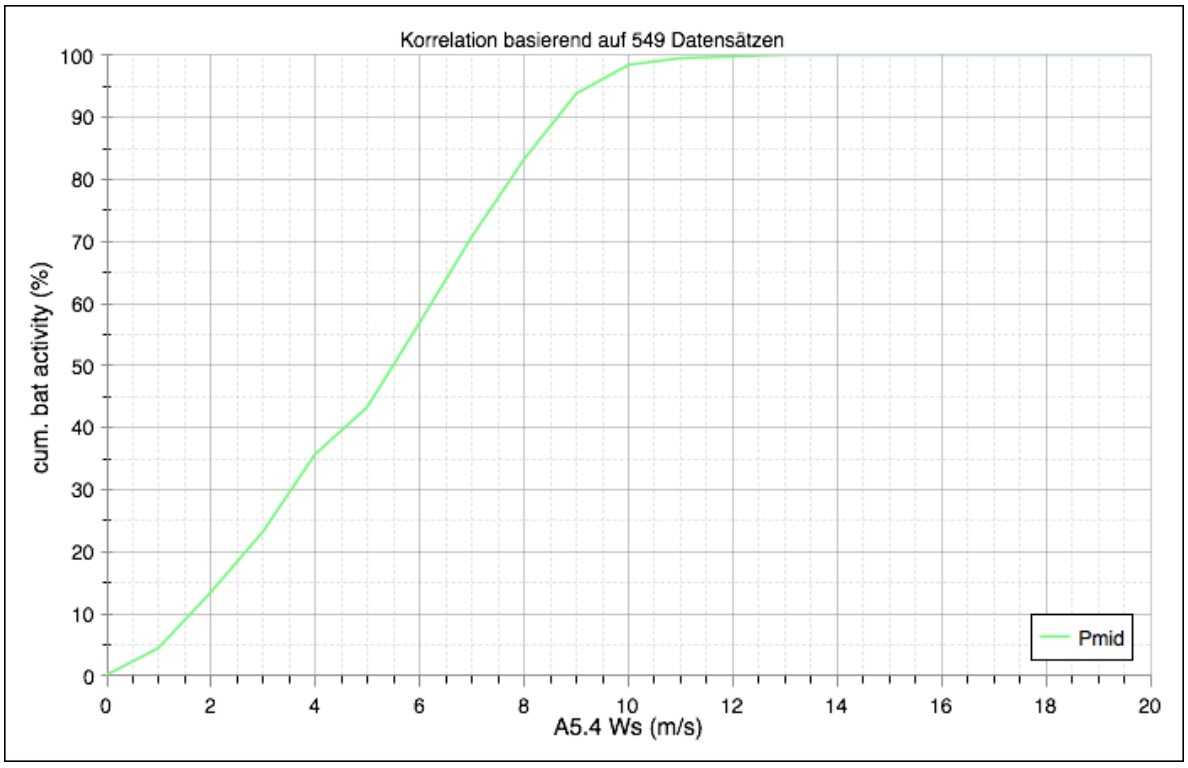
7. Total activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in July 2016 at location of WF „Jelinak“.



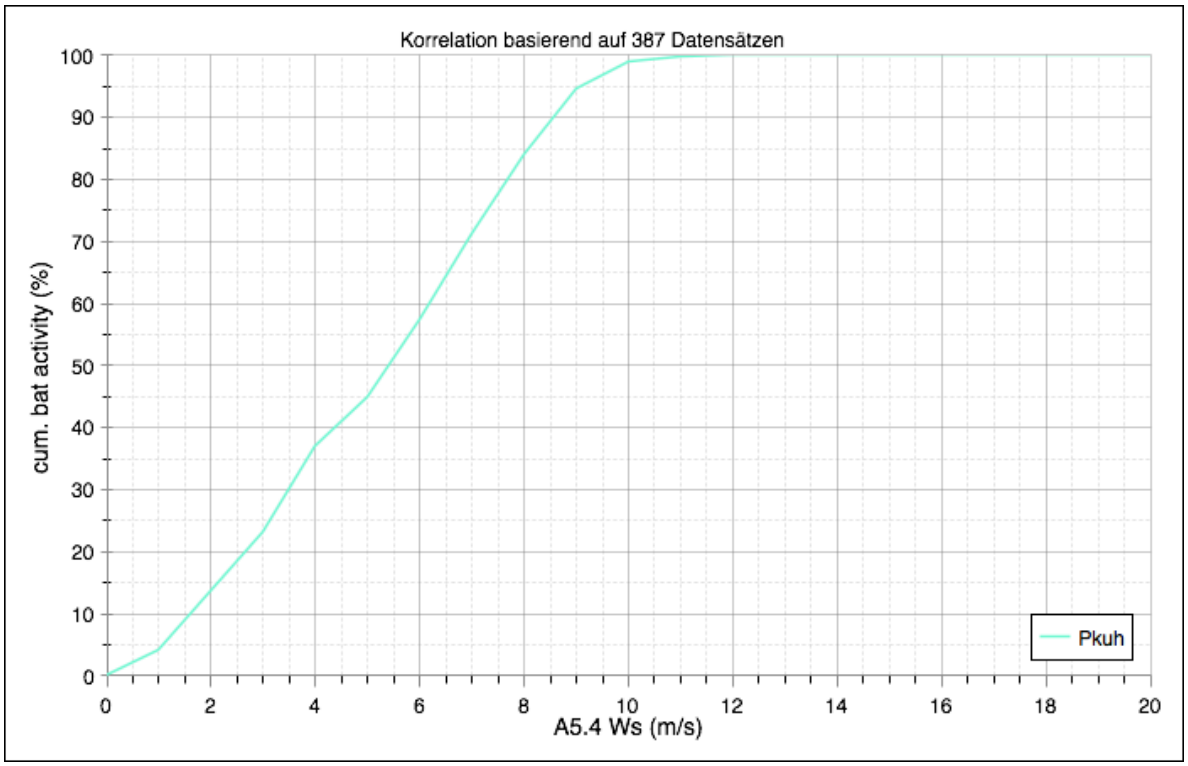
8. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in July 2016 at location of WF „Jelinak“.



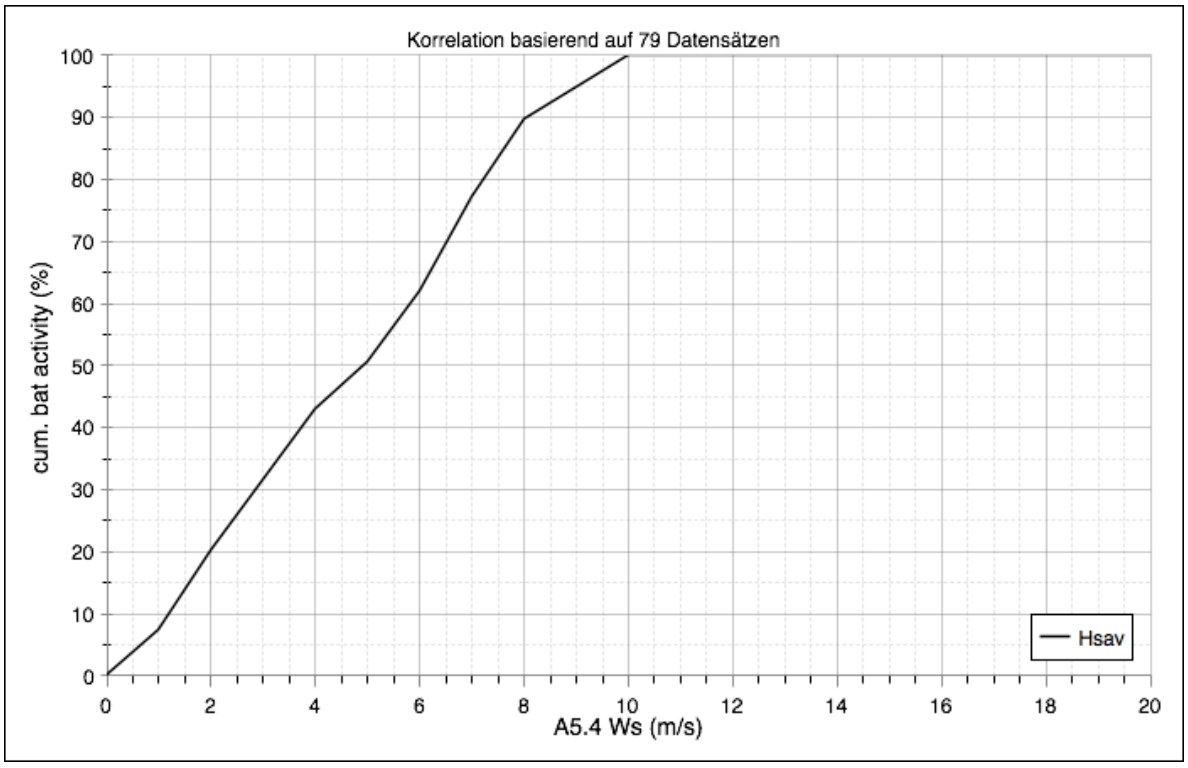
9. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in August 2016 at location of WF „Jelinak“.



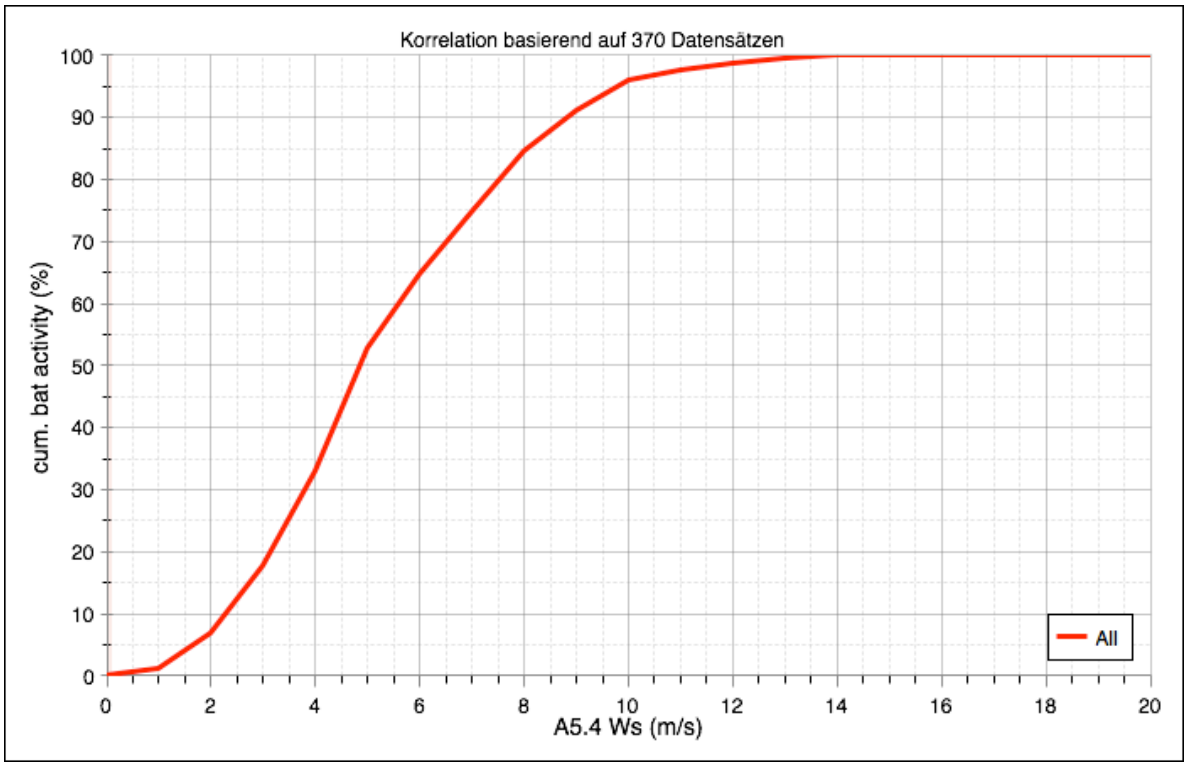
10. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.01 in August 2016 at location of WF „Jelinak“.



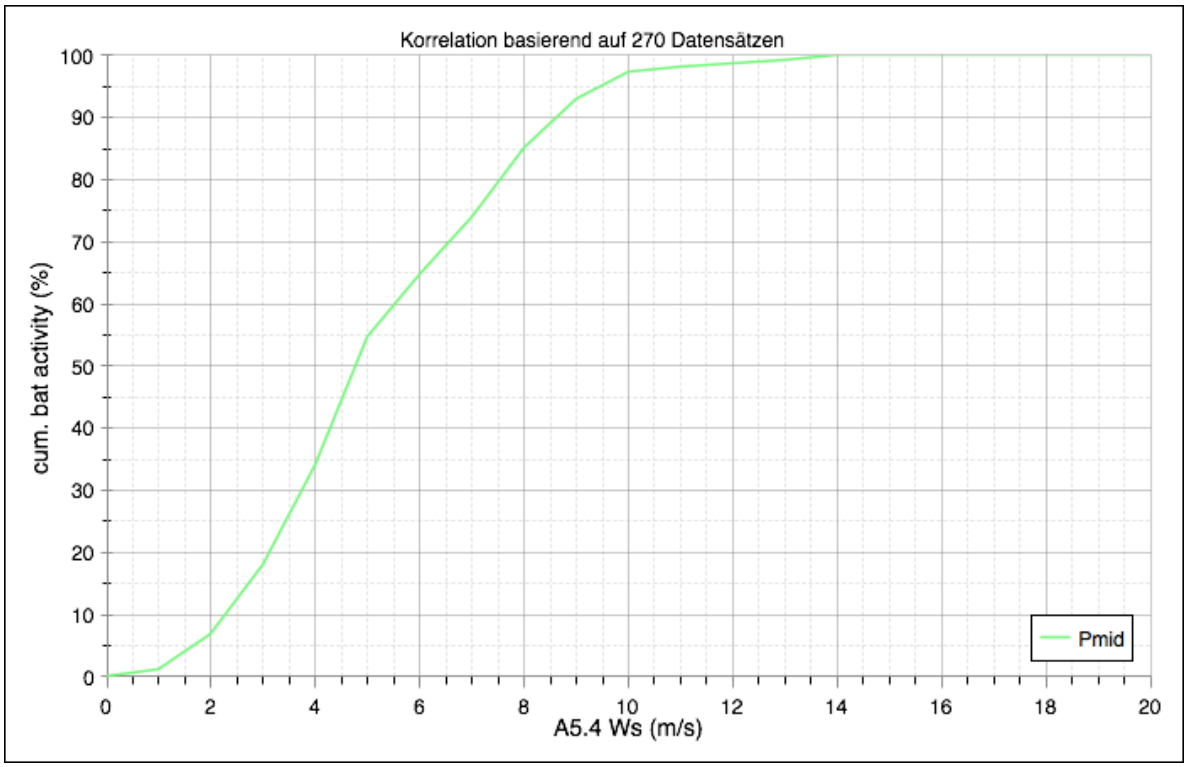
11. Total activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in August 2016 at location of WF „Jelinak“.



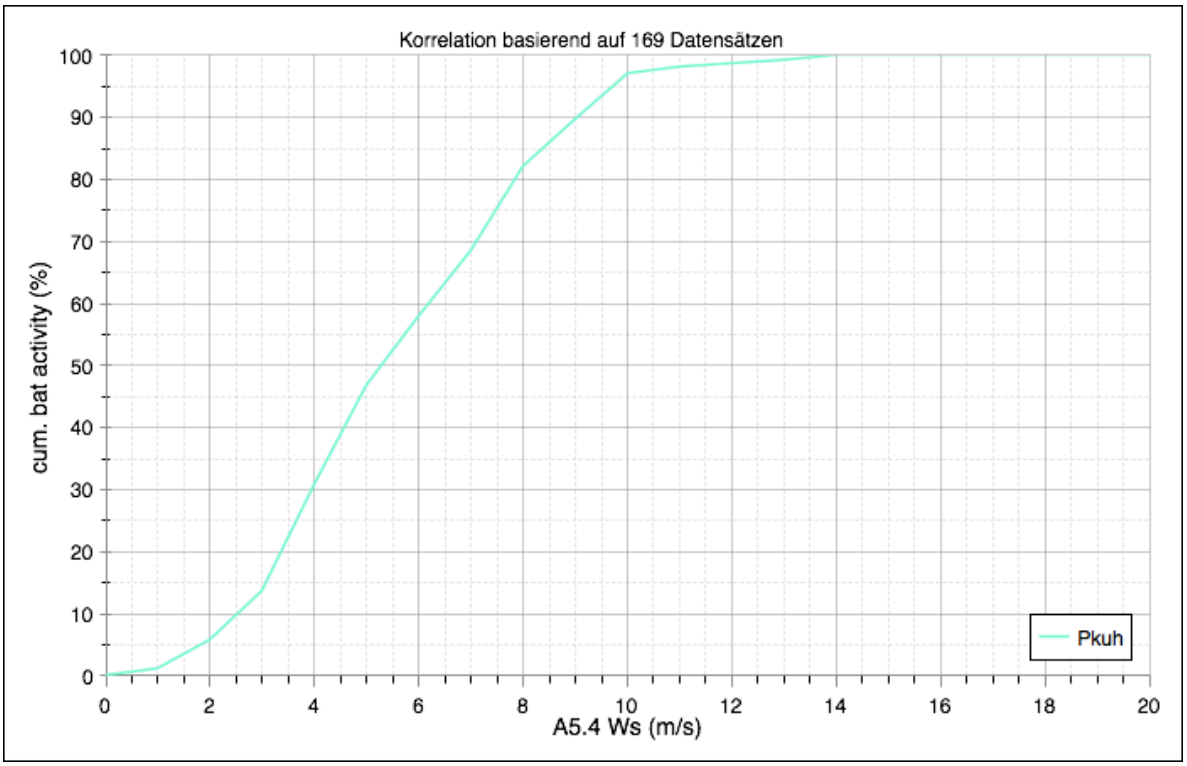
12. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in August 2016 at location of WF „Jelinak“.



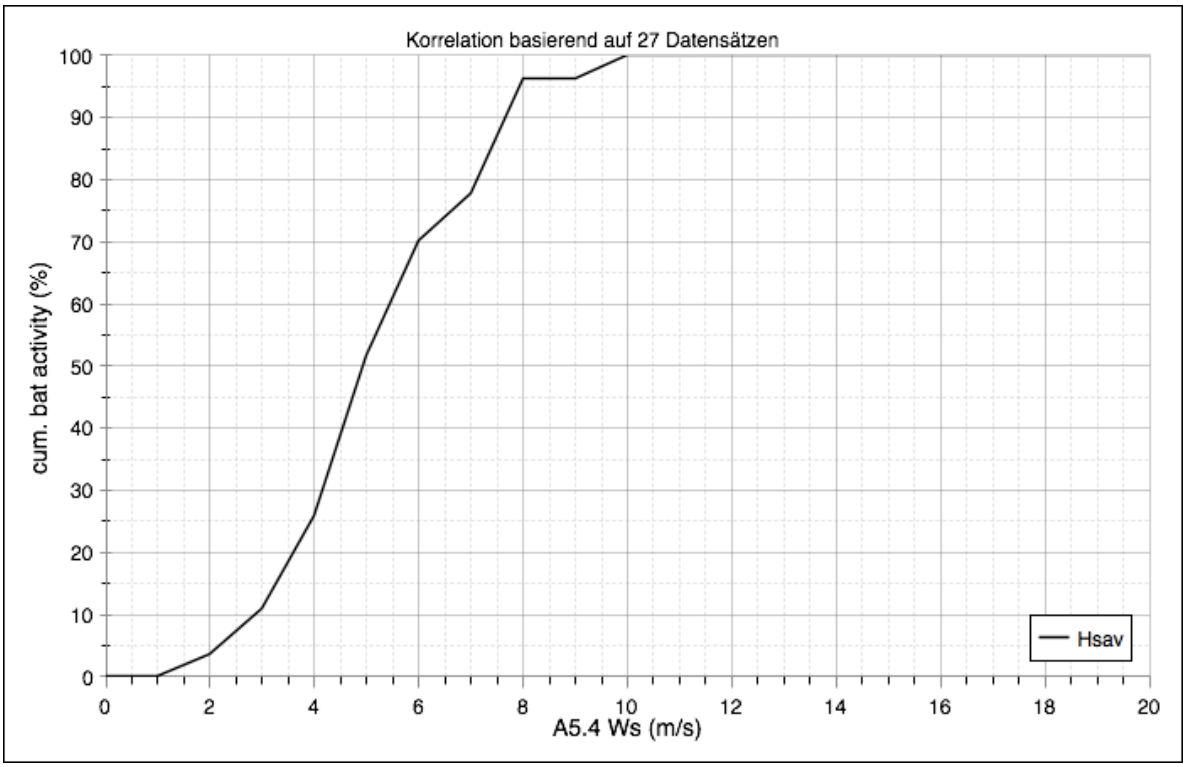
13. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in September 2016 at location of WF „Jelinak“.



14. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.01 in September 2016 at location of WF „Jelinak“.

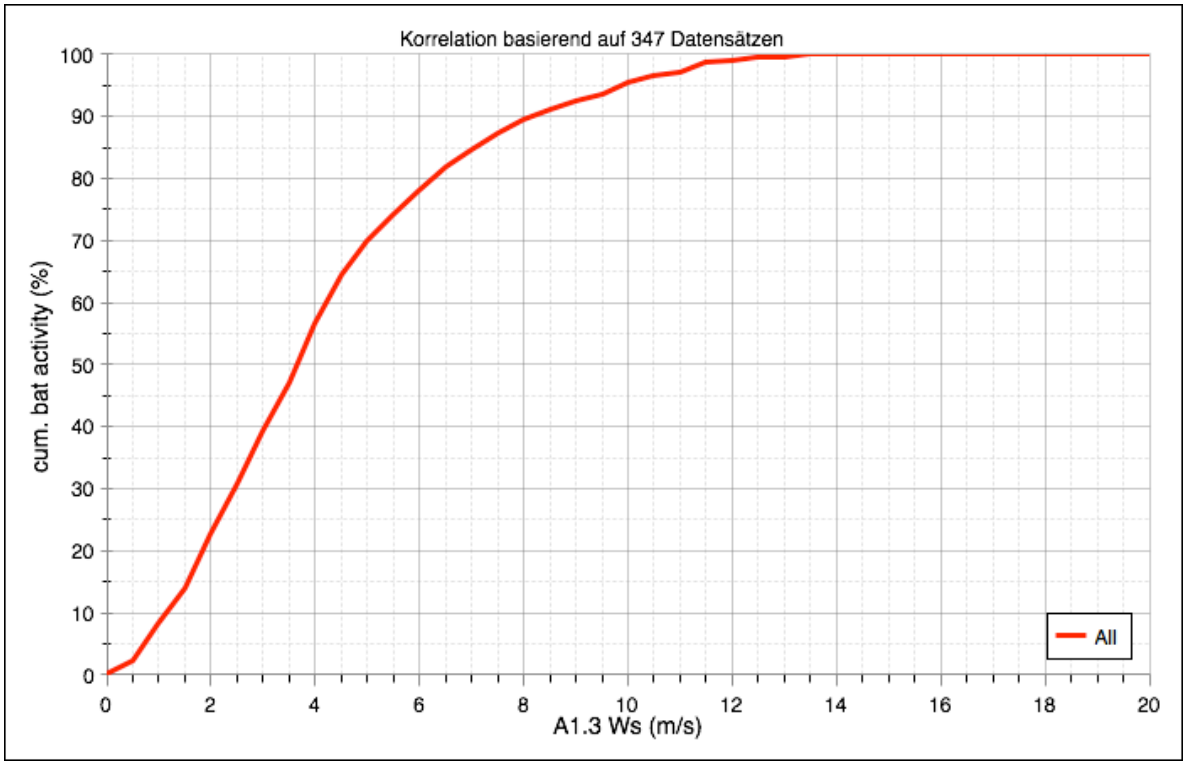


15. Total activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in September 2016 at location of WF „Jelinak“.

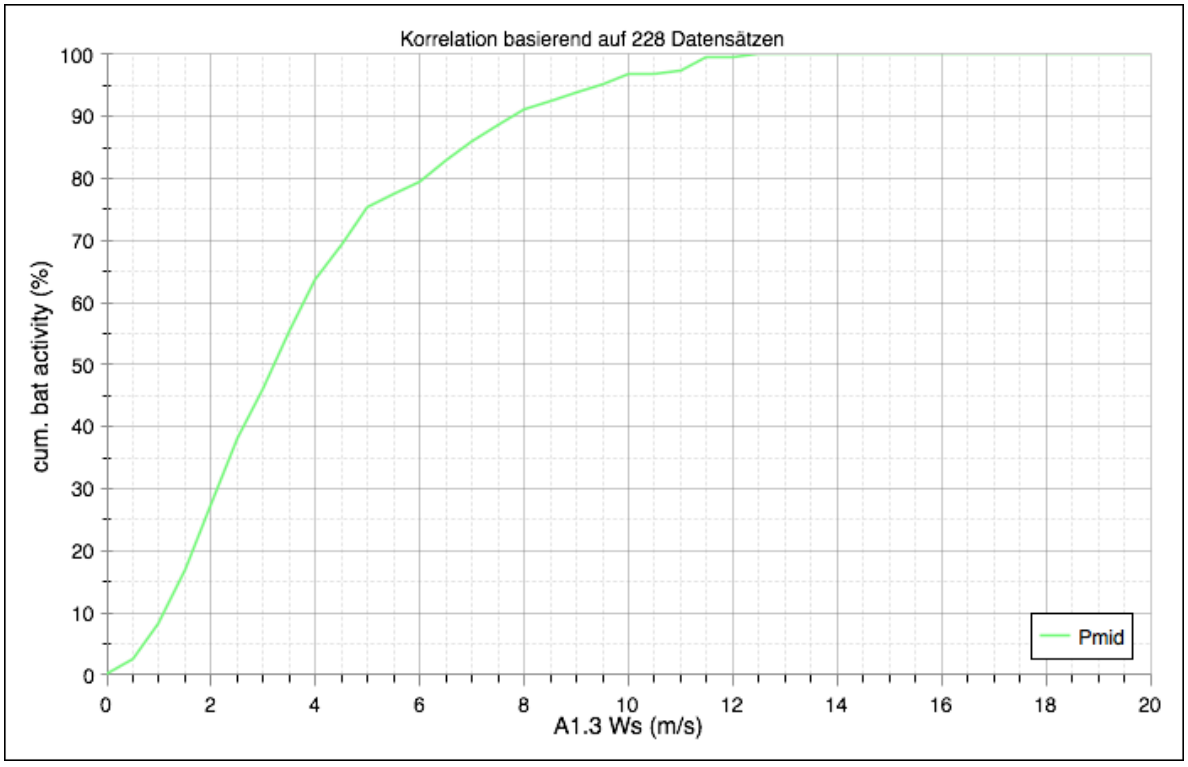


16. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in September 2016 at location of WF „Jelinak“.

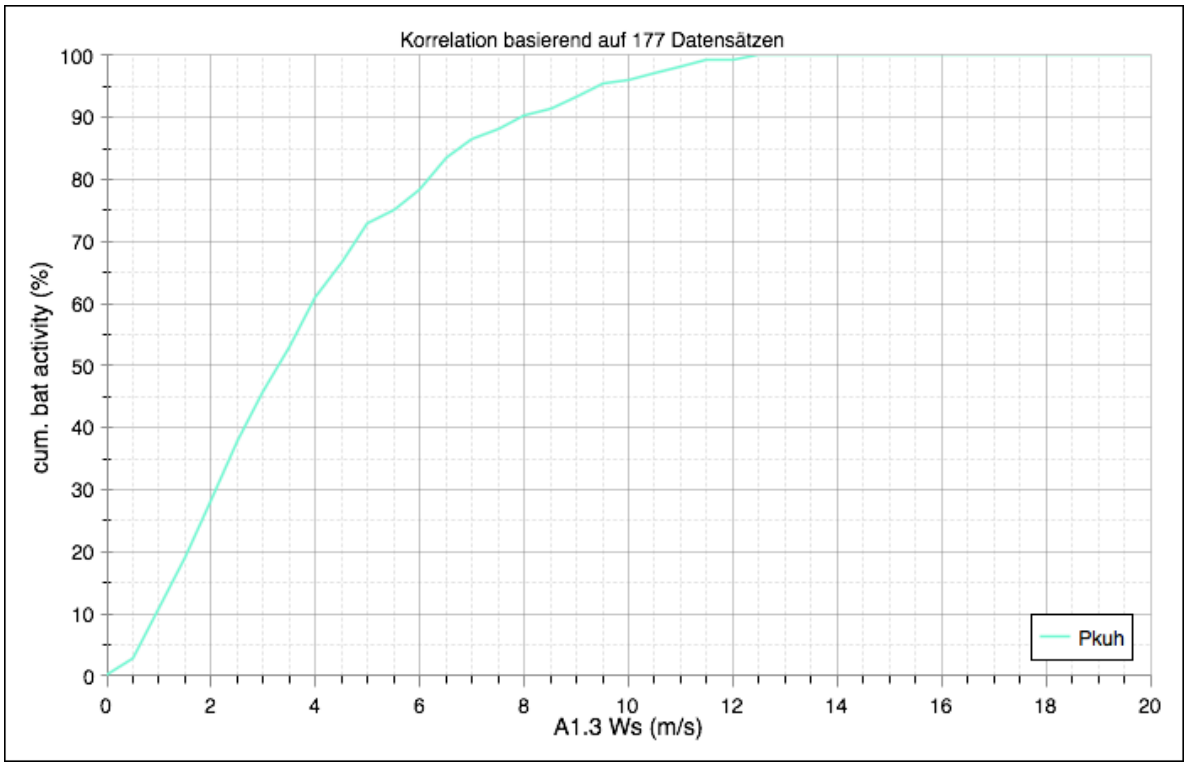
Appendix 5. Bat activity in relation to the wind speed - Batcorder wind turbine O.U.18 (1.3).



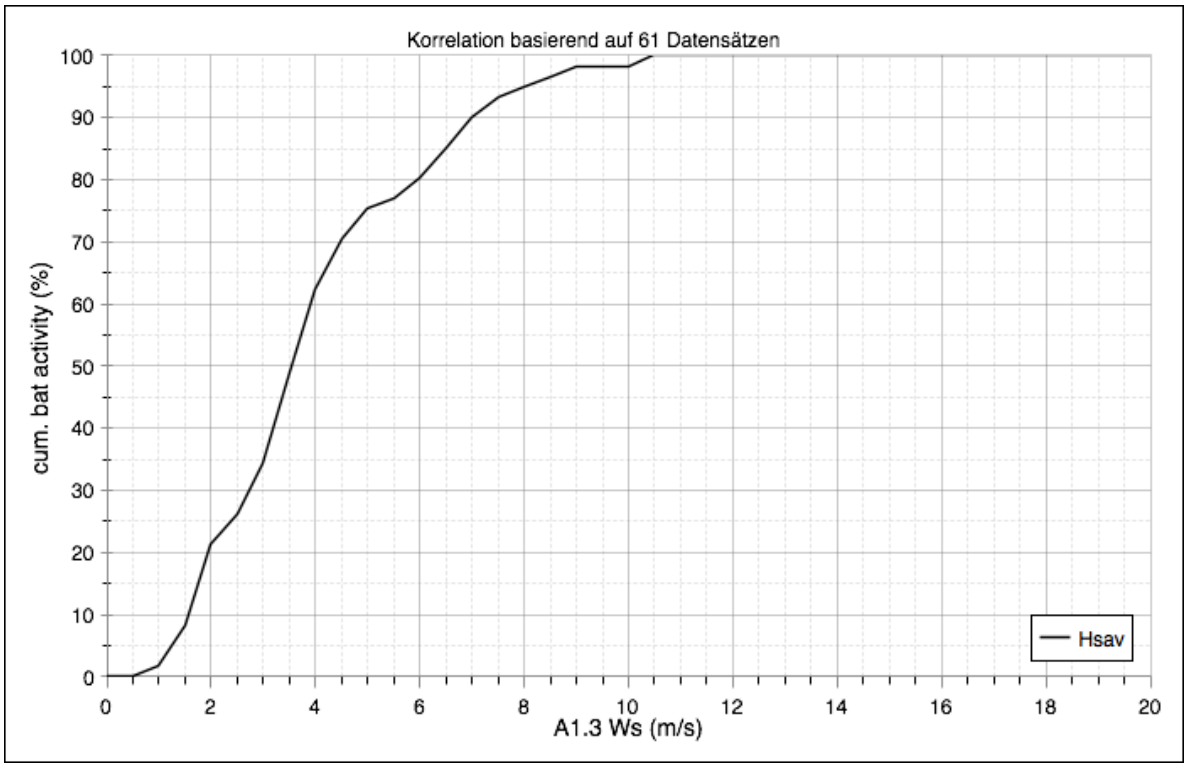
1. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.18 in July 2016 at location of WF „Jelinak“.



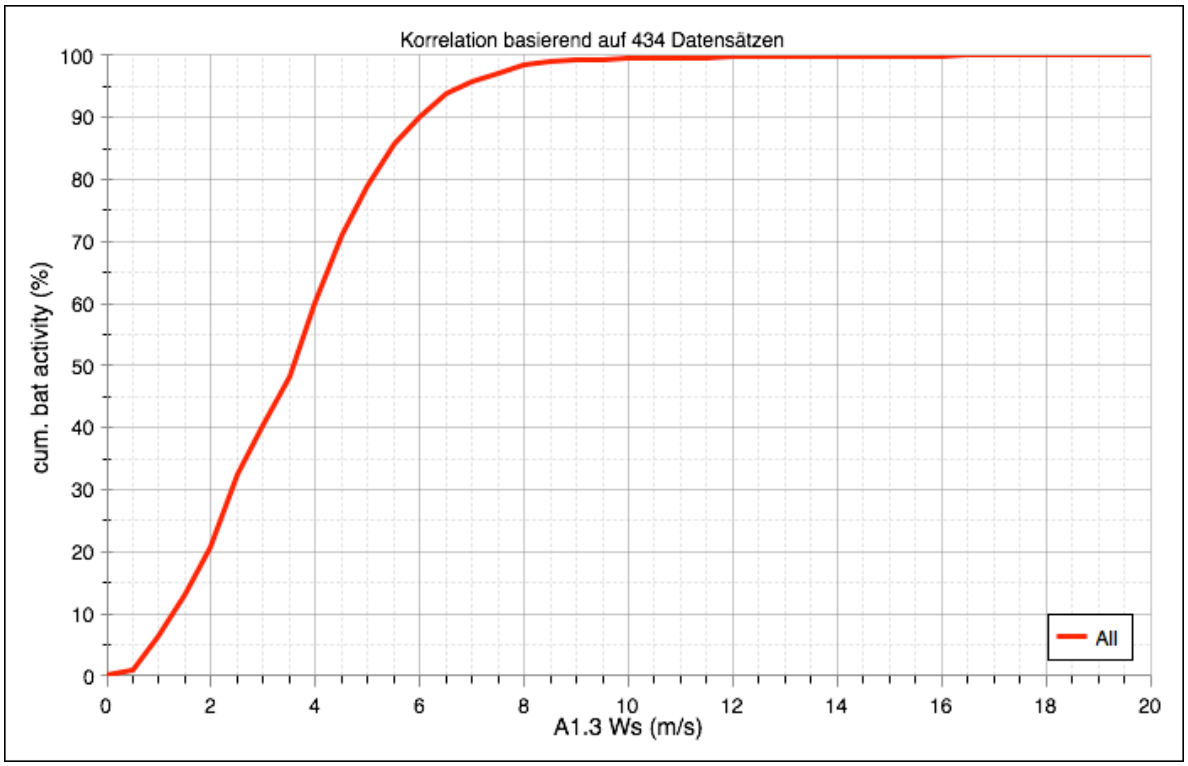
2. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.18 in July 2016 at location of WF „Jelinak“.



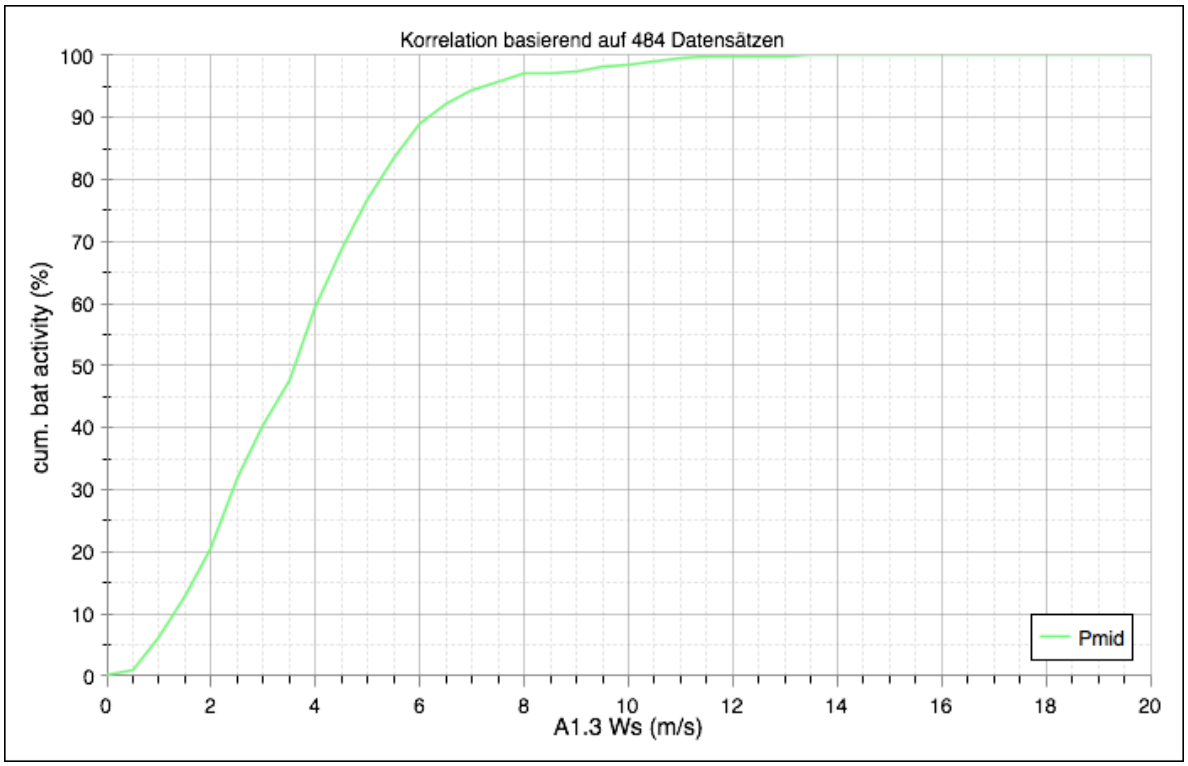
3. Total activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.18 in July 2016 at location of WF „Jelinak".



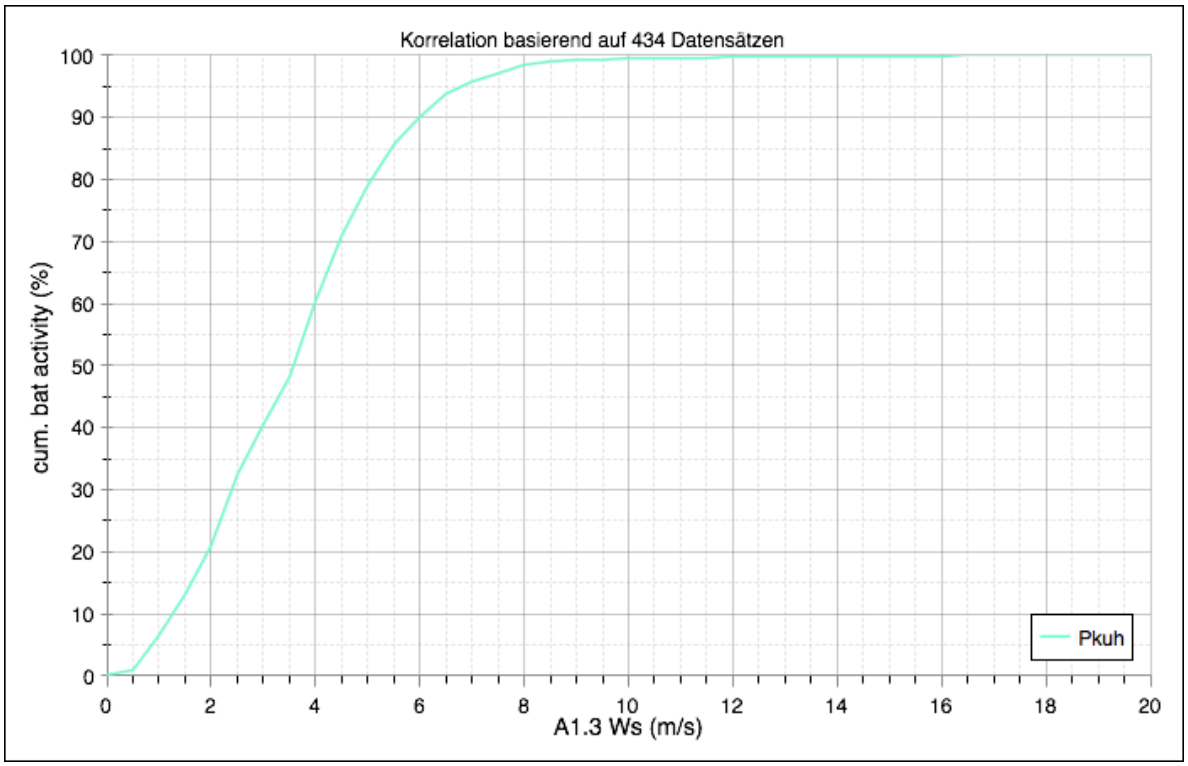
4. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.18 in July 2016 at location of WF „Jelinak".



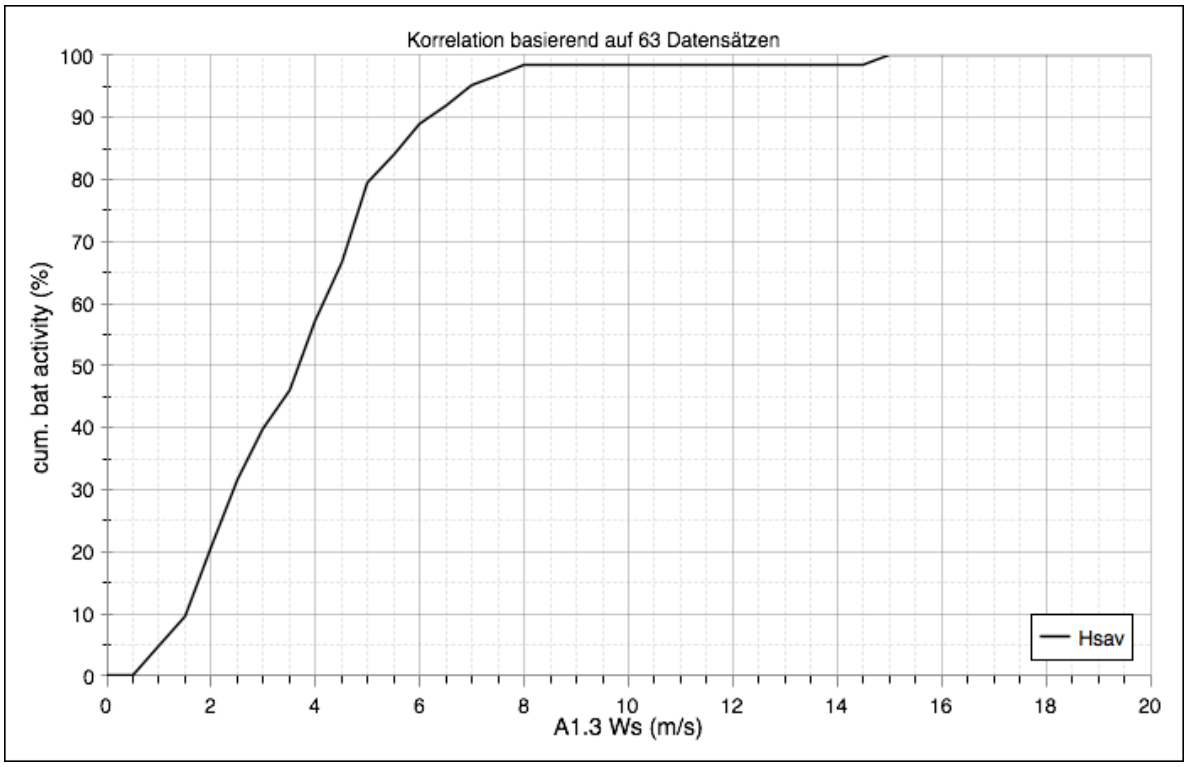
5. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.18 in August 2016 at location of WF „Jelinak“.



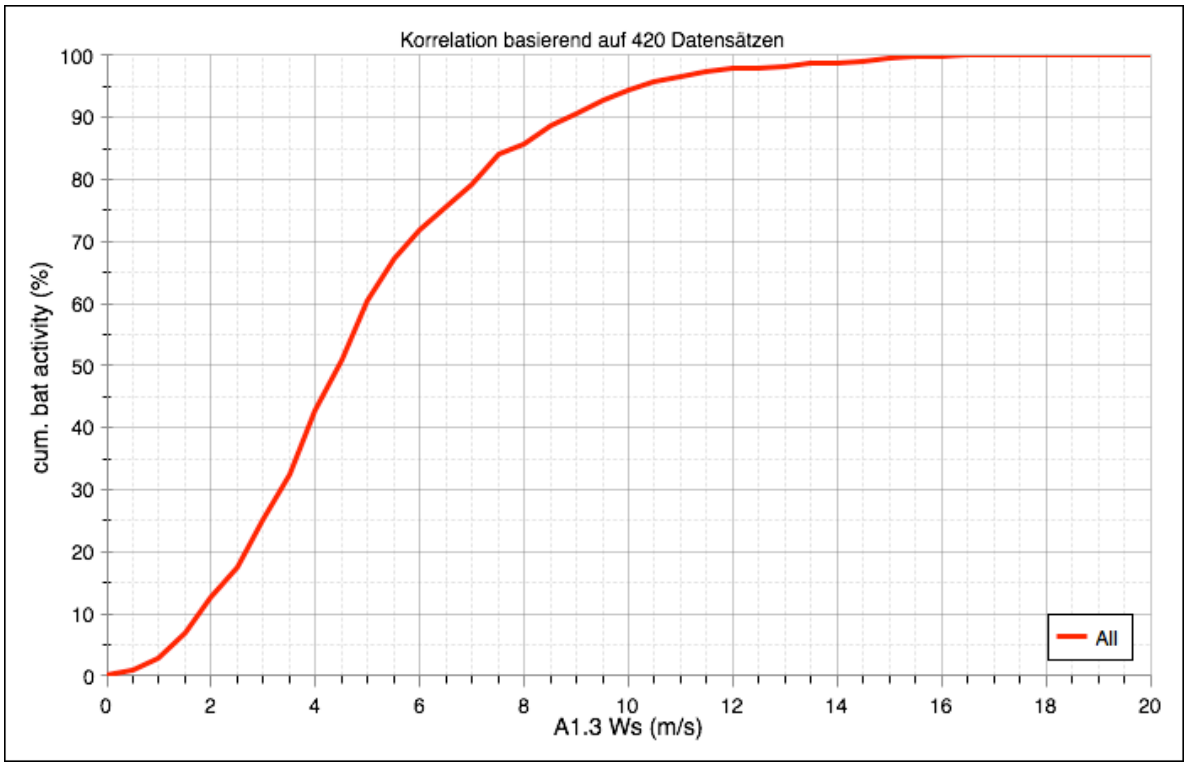
6. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.18 in August 2016 at location of WF „Jelinak“.



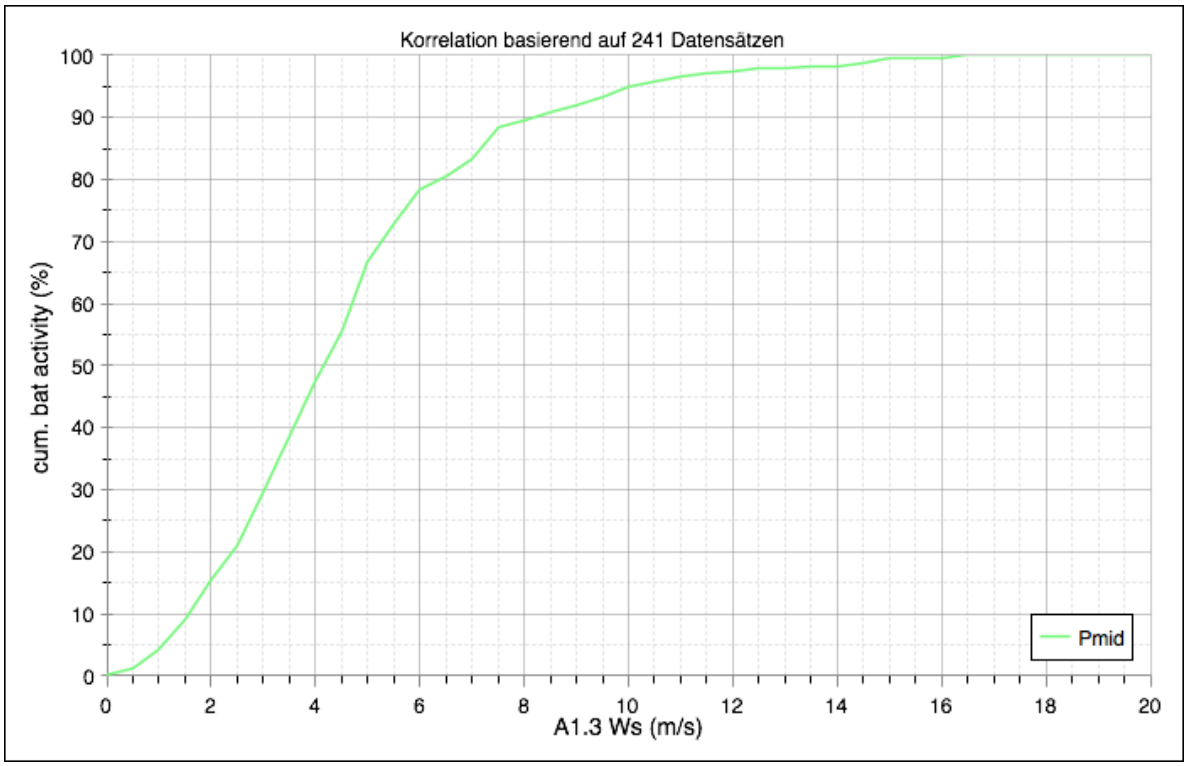
7. Total activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.18 in August 2016 at location of WF „Jelinak“.



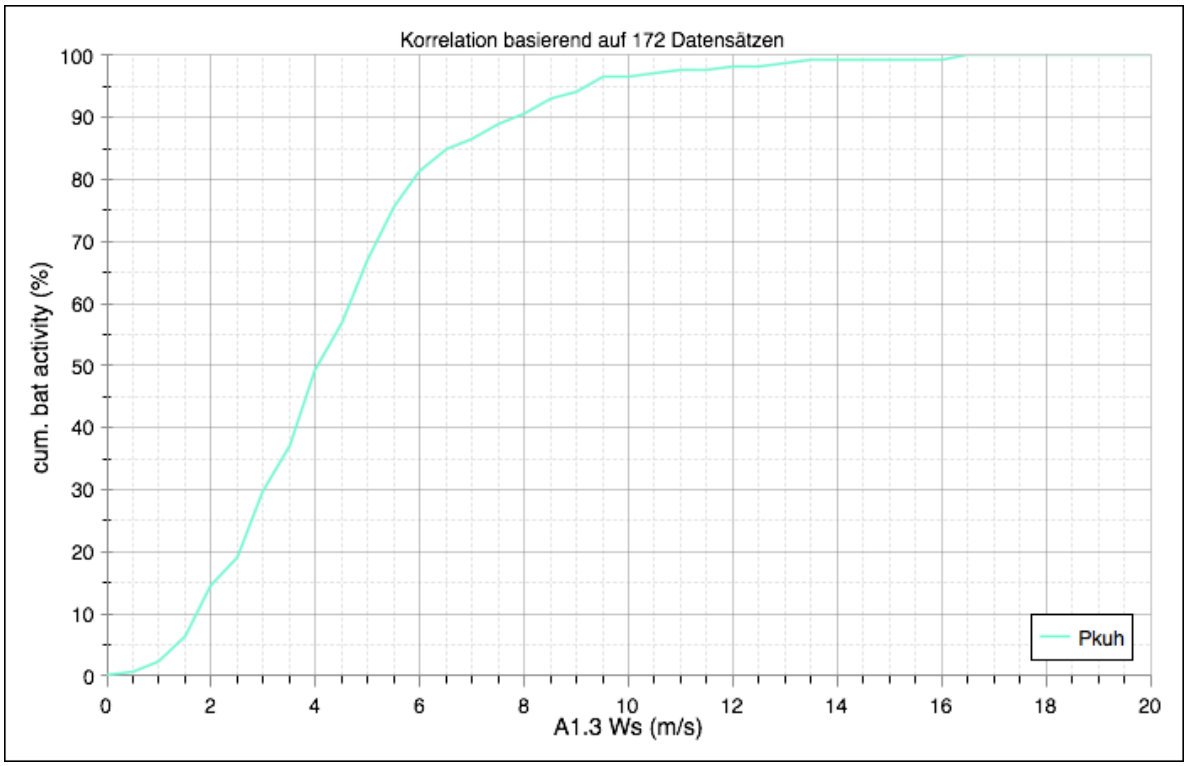
8. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.18 in August 2016 at location of WF „Jelinak“.



9. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.18 in September 2016 at location of WF „Jelinak“.



10. Total activity of group *Pipistrellus* middle frequency in relation to the wind speed at wind turbine O.U.18 in September 2016 at location of WF „Jelinak“.



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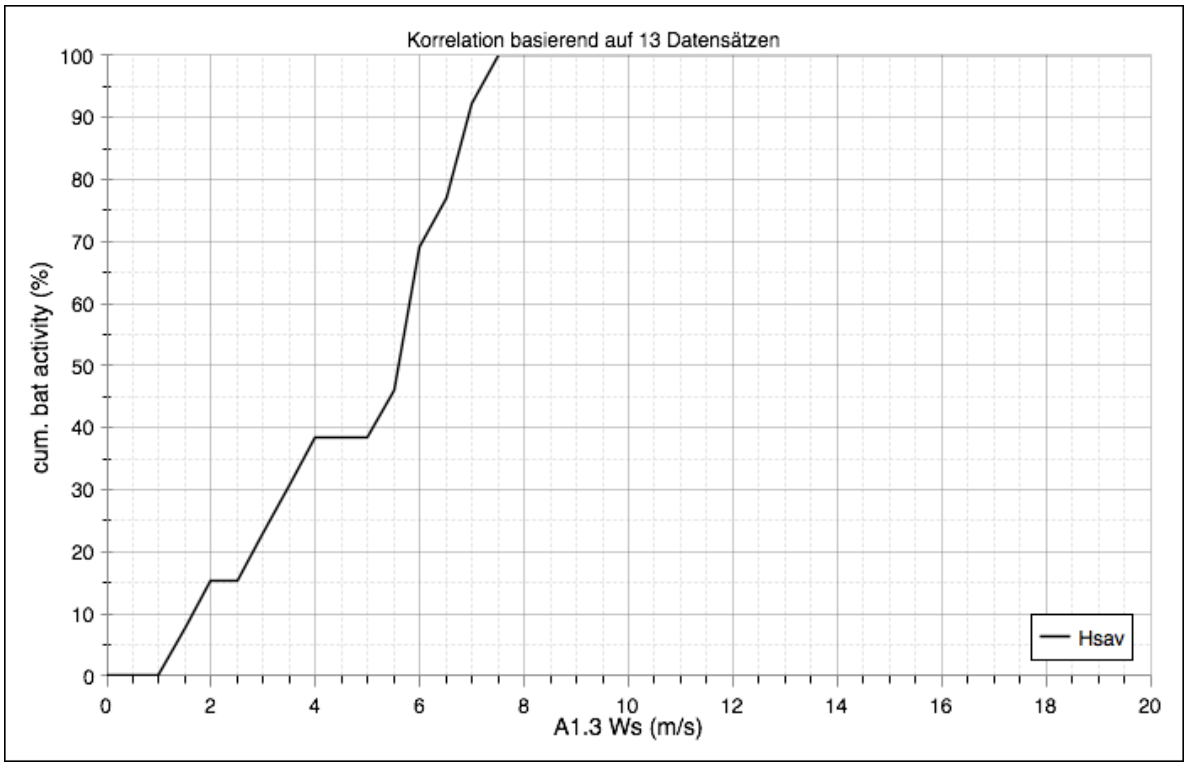


12. Total activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.18 in September 2016 at location of WF „Jelinak“.

BAT MONITORING AT THE LOCATION OF WINDFARM JELINAK DURING 2017.

- Final report (period June - October 2017) -

FOKUS ECOLOGY d.o.o.
Zagreb

Igor Pavlinić, PhD

Maja Đaković, PhD

Zagreb, 5.3.2018.

CONTENTS

1. Introduction

According to the Purchase Order (Purchase Order Number: 3100511987) the bat monitoring at the Wind Farm Jelinak locality started on 2nd June 2017 and lasted till 10th October 2017. The monitoring was conducted on the complete field, at all twenty turbines. Visual search for dead bats on the site included visits every seven days during June and September, every three day search during July and August, and last search from 1st to 5th October. Bat activity was monitored on the site from 2nd June to 10th October with batcorder system that automatically record bat calls.

During June and September mitigation measure wasn't implemented. There were two different protocols of mitigation measure in July and August which differed in whether measure was implemented in part of the night (from 9 pm till 3 am) or it was implemented during complete night, and it also differed in number of turbines with measure. First protocol was conducted in two parts. From 1st July 2017 till 15th July 2017 mitigation measure was conducted at fourteen wind turbines (O.U.01, O.U.02, O.U.03, O.U.04, O.U.05, O.U.06, O.U.07, O.U.10, O.U.13, O.U.14, O.U.16¸ O.U.17, O.U.18, O.U.20) from 9 pm to 3 am next day with cut-in speed 5.0 m/s and with feathering below that wind speed. The same mitigation protocol was conducted from 16th August 2017 till 31st August 2017. Second protocol was conducted from 16th July 2017 till 15th August 2017 in a way that mitigation measure was conducted at ninetheen wind turbines (all turbines exept O.U.19) during complete night (from half an hour before sunset till half an hour after sunrise) with cut-in speed 5.0 m/s and with feathering below that wind speed.

All monthly Reports and Final Report are written in Croatian and English language.

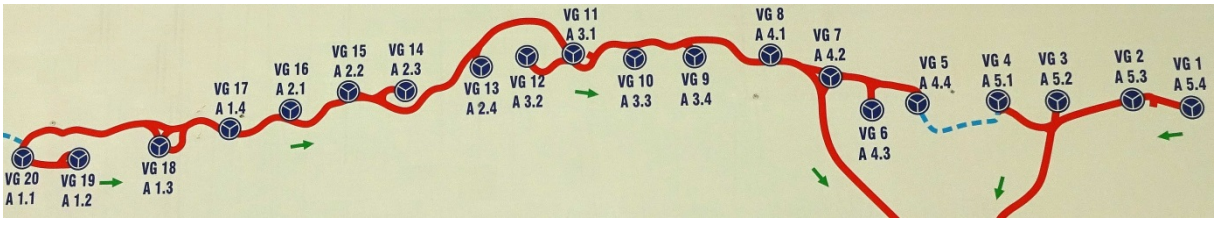


Figure 1. Layout view of wind turbines at the location of WF Jelinak.

2. Methods

2.1. Methods for bat collision monitoring

Monitoring of bat collision at wind farm Jelinak during 2017 started in the beginning of June and was carried out till the 5th October. The search for dead bats included every seven days search during June and September, every three days search during July and August and last search from 1st to 5th October. At every visit we searched the area around each of the twenty wind turbines within a radius of no less than 70 meters. The search involved a minimum of two people. The search generally started early in the morning in order to find bats in the best possible condition, before being eaten by insects. Track was recorded during the entire duration of the search with mobile applications MotionX-GPS and OruxMaps, and with Garmin GPS watch. In the case of finding a dead bat, species, sex, age, in the case of female presence/absence of breasts (indication if she had a young this season), condition of corpse and type of injury was recorded. GPS coordinates were taken for each found bat and each was photographed.

2.2. Methods for bat activity monitoring

Bat activity was monitored from 2nd June to 10th October 2017 using device for automatic recording of bat calls, Batcorder 3.0 which was placed at wind turbine O.U.01 (5.4) at six meters high.

3. Results of field surveys

Field research included monitoring of bat collision and monitoring of bat activity at wind farm Jelinak. This Final report contains results for June, July, August, September and October 2017. Bat mortality data for 2017 are presented per periods of implementation different mitigation measure protocols.

3.1. Bat collision monitoring results

During monitoring in 2017 at WF Jelinak location in total 20 dead bats were recorded (Appendix 1). During field visits in June one dead bat was found (5%) (Figure 2, Table 1). From 1st July till 15th July 2017 eight dead bats were found (40%), five on turbine with implemented mitigation measure and three on turbine without measure (Figure 2, Table 1).

From 16th July till 15th August 2017 six dead bats were found (30%), all six on turbines with implemented mitigation measure (Figure 2, Table 1). From 16th August till 31st August 2017 four dead bats were found (20%), three on turbines with implemented mitigation measure and one on turbine without measure (Figure 2, Table 1). During field visits in September one dead bat was found (5%), while during visits in October no dead bats were found (Figure 2, Table 1).

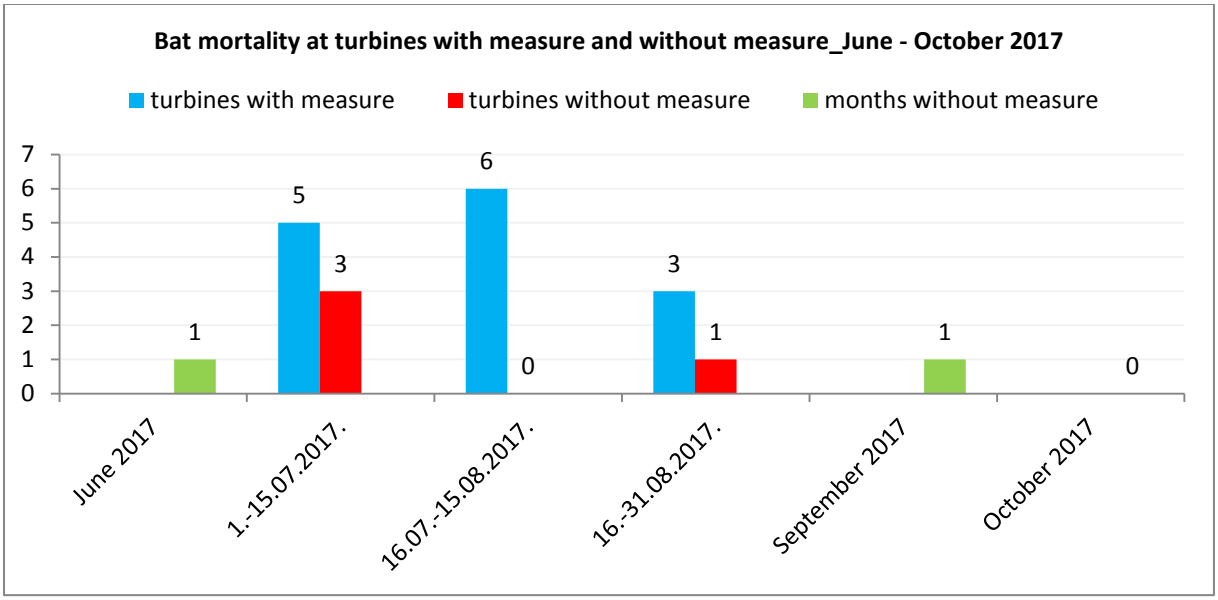


Figure 2. Total bat mortality during June, July, August, September and October 2017 at location of WF Jelinak.

Figure 3 shows the total recorded bat mortality during 2017 per periods of different mitigation measure protocols and per wind turbines. Numbers in the orange boxes indicate the wind turbines with mitigation measure implemented in certain periods (uncoloured box = protocol from 21 pm to 3 am, coloured box = protocol complete night). The most bats were killed at wind turbines O.U.03, O.U.09, O.U.13 and O.U.18, each with 3 dead bats. At these three wind turbines 12 bats were killed which makes 60% of total mortality. Ten out of these twelwe bats were killed while turbine had mitigation measure. Mortality was also recorded at 8 more turbines (O.U.01, O.U.02, O.U.5, O.U.6, O.U.10, O.U.15, O.U.17 and O.U.20), each with 1 dead bat. During entire investigated period at eight wind turbines there weren't any dead bats (O.U.04, O.U.07, O.U.08, O.U.11, O.U.12, O.U.14, O.U.16 i O.U.19).

From fourteen wind turbines with implemented mitigation measure, in period with measure (July - August) mortality was recorded at nine wind turbines (O.U.01, O.U.02, O.U.03, O.U.5, O.U.6, O.U.9, O.U.13, O.U.17 and O.U.18), each of O.U.03, O.U.13 and O.U.18 with three dead bats, and each of other with 1 dead bat.

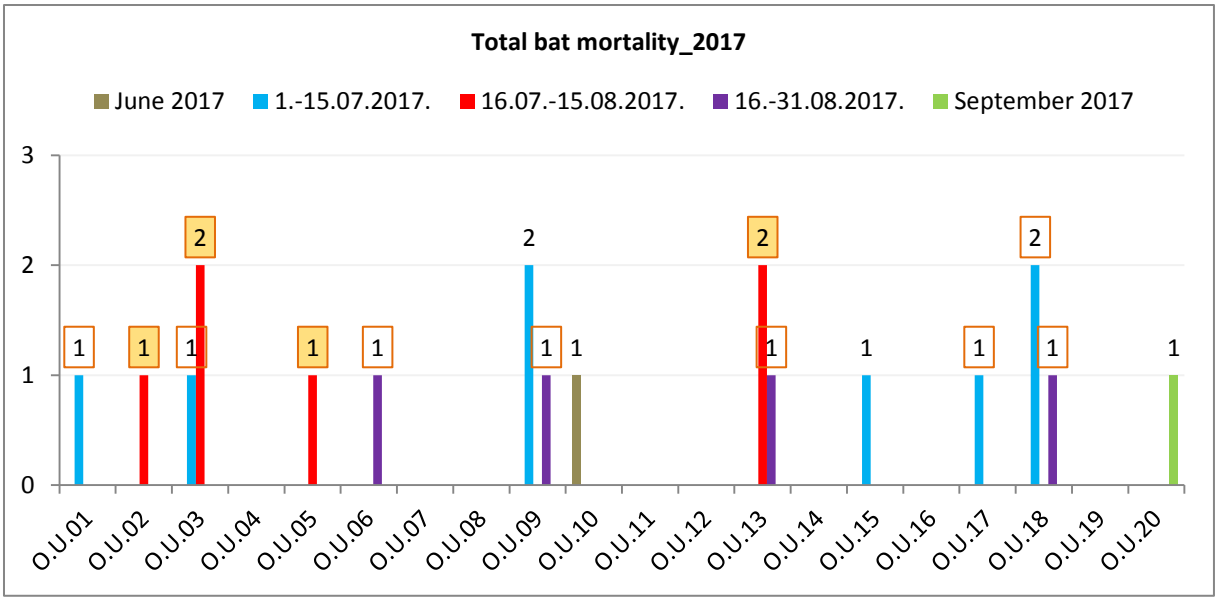


Figure 3. Bat mortality recorded during 2017 per wind turbines and per months at location of WF Jelinak. July and August are divided according to conducting two mitigation measure protocols (1.-15.07.2017., 16.07.-15.08.2017. and 16.08.-31.08.2017.) (Orange boxes = wind turbines with mitigation measure in certain period; coloured boxes = protocol from 9 pm to 3 am, coloured boxes = protocol complete night).

In June when mitigation measure wasn't implemented individual mortality was recorded at only one wind turbine, O.U.10. In September when mitigation measure wasn't implemented individual mortality was recorded at only one wind turbine O.U.20. In total in periods and at wind turbines when mitigation measure wasn't implemented 5 dead bats were found which makes 25% of total mortality in 2017.

Table 1. Number and percentage of dead bats per wind turbine in 2017. June and September refers to complete month, while July and August are divided according to conducting two mitigation measure protocols (1.-15.07.2017., 16.07.-15.08.2017. and 16.08.-31.08.2017.) at location of WF Jelinak. (Orange = wind turbines with mitigation measure in certain period.)

WT	June '17.		1.-15.07.'17.		16.07.-15.08.'17.		16.-31.08.'17.		September '17.		TOTAL	
	number of dead bats	%	number of dead bats	%	number of dead bats	%	number of dead bats	%	number of dead bats	%	number of dead bats	%
O.U.01	0	0	1	12,5	0	0	0	0	0	0	1	5
O.U.02	0	0	0	0	1	17	0	0	0	0	1	5
O.U.03	0	0	1	12,5	2	33	0	0	0	0	3	15
O.U.04	0	0	0	0	0	0	0	0	0	0	0	0
O.U.05	0	0	0	0	1	17	0	0	0	0	1	5
O.U.06	0	0	0	0	0	0	1	20	0	0	1	5
O.U.07	0	0	0	0	0	0	0	0	0	0	0	0
O.U.08	0	0	0	0	0	0	0	0	0	0	0	0
O.U.09	0	0	2	25	0	0	1	20	0	0	3	15
O.U.10	1	100	0	0	0	0	0	0	0	0	1	5
O.U.11	0	0	0	0	0	0	0	0	0	0	0	0
O.U.12	0	0	0	0	0	0	0	0	0	0	0	0
O.U.13	0	0	0	0	2	33	1	20	0	0	3	15
O.U.14	0	0	0	0	0	0	0	0	0	0	0	0
O.U.15	0	0	1	12,5	0	0	0	0	0	0	1	5
O.U.16	0	0	0	0	0	0	0	0	0	0	0	0
O.U.17	0	0	1	12,5	0	0	0	0	0	0	1	5
O.U.18	0	0	2	25	0	0	1	20	0	0	3	15
O.U.19	0	0	0	0	0	0	0	0	0	0	0	0
O.U.20	0	0	0	0	0	0	0	0	1	100	1	5
total	**1**	**5%**	**8**	**40%**	**6**	**30%**	**4**	**20%**	**1**	**5%**	**20**	

Figure 4 shows mortality recorded during monitoring in 2017 shown per periods of different protocols of mitigation measure and total bat mortality per species.

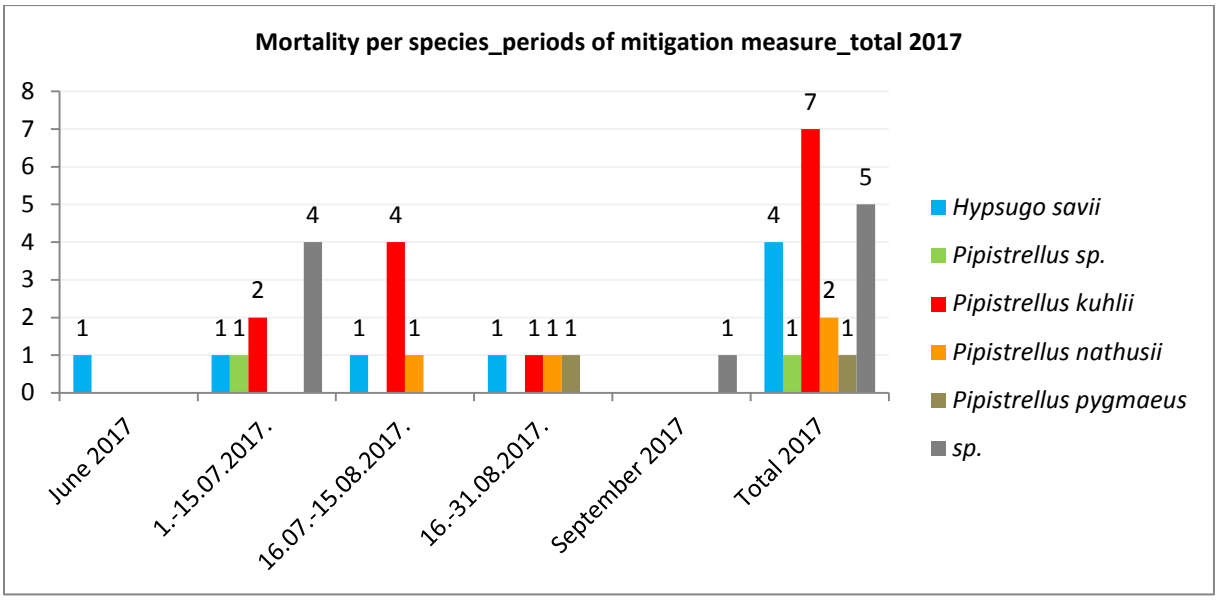


Figure 4. Bat mortality per periods of mitigation measure protocols in 2017 per species at location of WF Jelinak.

In total 35% of dead bats during 2017 belongs to species *P. kuhlii* (7 bats), 20% of dead bats belongs to species *H. savii* (4 bats), 10% of dead bats belongs to species *P. nathusii* (2 bats), and 5% of dead bats belongs to species *P. pygmaeus* (1 bat). For 25% of dead bats was not possible to determine species because of state of corpses, which is result of every three days searches in July (4 *sp*. bats), or every seven day searches in September (1 *sp*. bat). The rest of 5% is individual dead bats for which, because of state of corpse, was possible to determine only to genus *Pipistrellus sp.* (Figure 4). Dead bat from June belong to species *H. savii*. During the first mitigation period two dead bats of *P. kuhlii* species were found, 1 *H. savii*, 1 bat from genus *Pipistrellus sp*., and 4 bats without determination of species or genus. During second mitigation measure period 4 dead bats belongs to species *P. kuhlii*, and 1 to *H. savii* and *P. nathusii*. During third mitigation period 1 dead bat of species *H. savii*, *P. kuhlii*, *P. nathusii* and *P. pygmaeus* were recorded. For dead bat recorded in September it was not possible to determine species.

From 20 found dead bats, 8 were females, 2 males and 10 bats with indefinite sex (because of the state of corpse). For 1 out of 8 females was possible to determine that she had young this season.

Figure 5 shows the mortality recorded during every three days of July and August 2017.

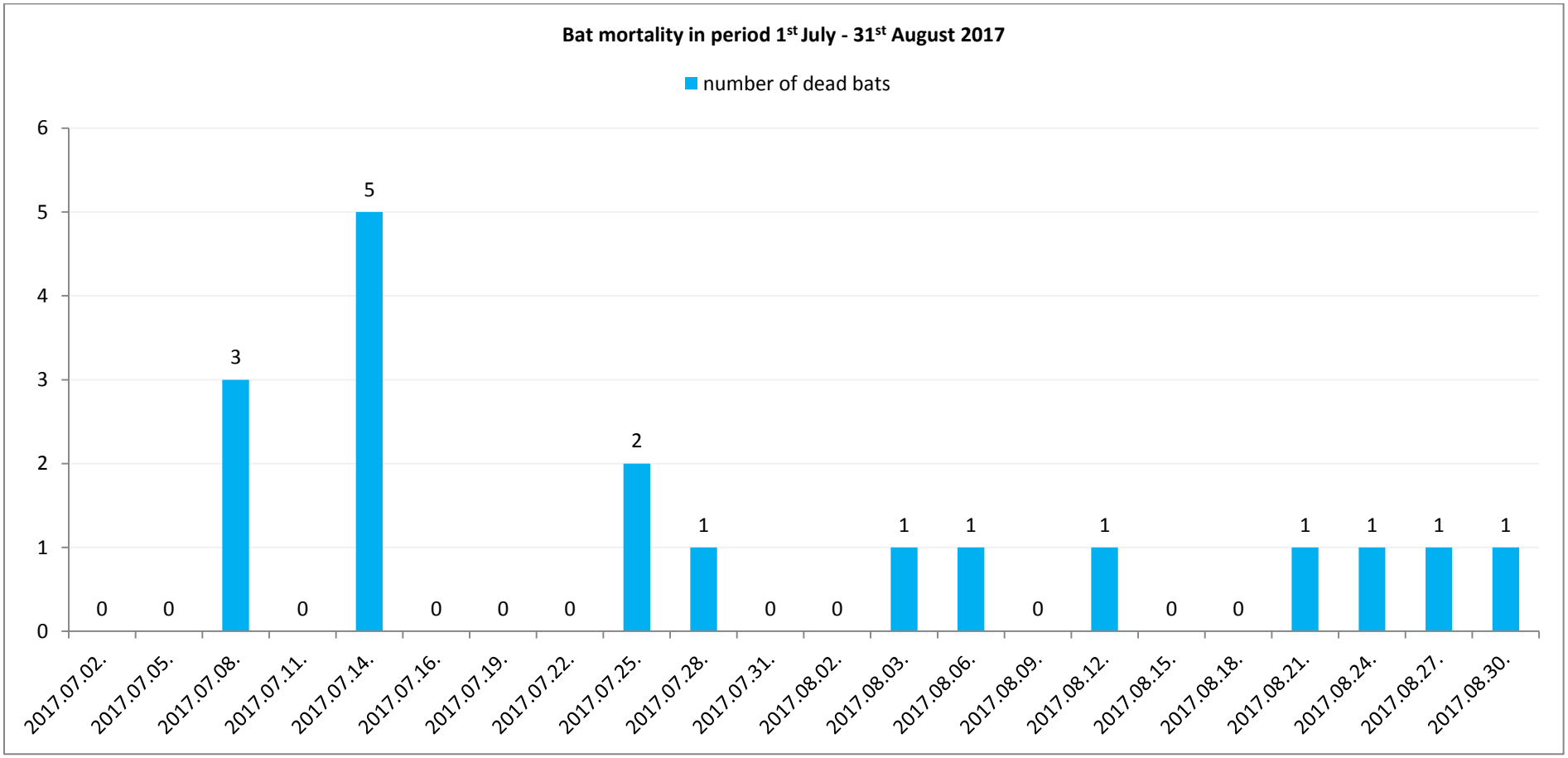


Figure 5. Number of dead bats during every three day visits in July and August 2017 at location of WF Jelinak.

In June, when searches for dead bats were carried out every 7 days, one dead bat was found. In period from 1st to 15th July eight dead bats were recorded. In period from 16th July to 15th August six dead bats were recorded. In period from 16th August to 31st August four dead bats were found. In September one dead bat was found. Data from 2016 and 2015 (obtained with every day searches during July and August) has shown that bat mortality peak period at WF Jelinak is in period from 16th July to 15th August so that's why in that period in 2017 mitigation measure was implemented during complete night at all wind turbines (except O.U.19 which still doesn't have mortality). With measure implemented during complete night at all wind turbines in most critical period, mortality in 2017 was decreased to 6 bats.

Figure 6 shows bat mortality recorded in period with implemented mitigation measure i.e. in July and August, divided per periods of mitigation measure protocols at wind turbines with mitigation measure in relation to wind turbines without measure. It is necessary to emphasise that in period 16.07. – 15.08.2017 all turbines had mitigation measure (except O.U.19 which still doesn't have mortality) during complete night, while in periods 1. – 15.07.2017 and 16. – 31.08.2017 measure was implemented at 14 turbines in period from 9 pm to 3 am. In total 14 dead bats (78%) was recorded at wind turbines with measure, and 4 dead bats (22%) at turbines without measure.

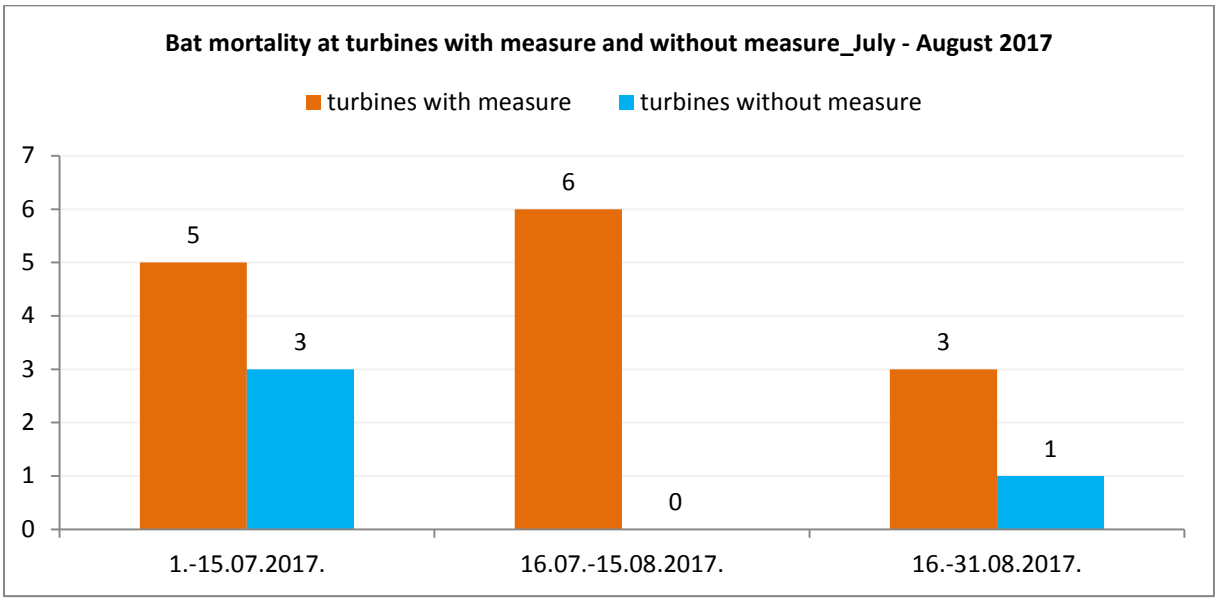


Figure 6. Bat mortality recorded in 2017 during July and August per different periods of mitigation measure protocols at wind turbines with mitigation measure and wind turbines without measure at location of WF Jelinak. In period 16.07. – 15.08.2017 all turbines had mitigation measure (except O.U.19) during complete night, while in periods 1. – 15.07.2017 and 16. – 31.08.2017 measure was implemented at 14 wind turbines in period from 9 pm to 3 am.

3.1.1. Mortality estimators (Shoenfeld and Huso)

For estimating the mortality occurring at the wind farm Jelinak we used two statistical estimators, Schoenfeld and Huso. In order to use such statistical calculations, we tested and established a value for searcher efficiency (percent of bat carcasses found versus not found). Result was 80% searcher efficiency, so we took for mortality estimator's calculation range from 72% – 88% (or 10% below and 10% above obtained value). Also, for each month we tested and established a value for carcass removal/persistence due to scavengers. Average removal time in June was 9 days, in July and August 4 days and in September 6 days.

Both mortality estimators share the same input parameters but use different formula. Used parameters are *t* – average removal time (in days), *p* – searchers efficiency value (values from 0 to 1, result of multiplication of more factors) and *I* – average interval between searches (in days). Considering different time span between searches for dead bats (during June searches every 7 days, *I*=6; during July and August every 3 days searches, *I*=1, during September searches every 7 days, *I*=6), mortality estimators calculations were made separately for June and September and together for July and August (Table 2).

Table 2. Mortality estimators, Shoenfeld and Huso, for months with recorded mortality (June; July and August; September) 2017 at location of WF Jelinak.

Mortality estimators	June 2017		July – August 2017		September 2017	
	min	max	min	max	min	max
Shoenfeld						
mortality per turbine	0,07	0,08	1,21	1,32	0,09	0,10
total	1,46	1,63	24,10	26,37	1,72	1,97
Huso						
mortality per turbine	0,08	0,10	1,30	1,59	0,09	0,11
total	1,56	1,90	25,99	31,77	1,80	2,20

During June at all twenty turbines in total was found 1 dead bat or 0.05 bats per turbine. Shoenfeld estimator for this period estimated mortality ranging from 0.07 to 0.08 bats per turbine. For total number of bats at all 20 turbines estimated range is from 1.46 to 1.63 dead bats. Another used estimator, Huso, estimated the number of dead bats per turbine from 0.08 to 0.10 with total of dead bats from 1.56 to 1.90. Taking into account that searches in June were done every 7 days, it is expected that mortality estimations are higher than the number of really recorded dead bats but we can say that in this period field effort and search efficiency are sufficient. In June the numbers of found dead bats as well as the estimated number of dead bats are small.

During July – August period at all twenty turbines we have found total of 18 dead bats or 0.9 bats per turbine. Estimation of Shoenfeld estimator for this period ranges from 1.21 to 1.32 bats per turbine. For total number of bats at all 20 turbines estimated range is from 24.10 to 26.37 dead bats. Another used estimator, Huso, estimated the number of dead bats per turbine from 1.30 to 1.59 with total of dead bats from 25.99 to 31.77. Both estimators for this period estimated higher mortality than really recorded. In this period, July-August 2017, as opposed to every day searches in 2016 and 2015, searches were done every 3 days, based on in earlier years established removal time, so for this period should take into account that both estimators are suggesting that real mortality is significantly higer than recorded mortality.

During September at all twenty turbines we have found total of 1 dead bat or 0.05 bats per turbine. Shoenfeld estimator for this period estimated mortality ranging from 0.09 to 0.10 dead bats per turbine. For total number of bats at all 20 turbines estimated range is from 1.72 to 1.97 dead bats. Another used estimator, Huso, estimated the number of dead bats per turbine from 0.09 to 0.11 with total of dead bats from 1.80 to 2.20. Taking into account that searches in September were done every 7 days, it is expected that mortality estimations are higher than the number of really recorded dead bats but we can say that in this period field effort and search efficiency are sufficient. In September the numbers of found dead bats as well as the estimated number of dead bats are small.

3.2. Bat activity monitoring results

Batcorder wind turbine O.U.01 (5.4)

June 2017

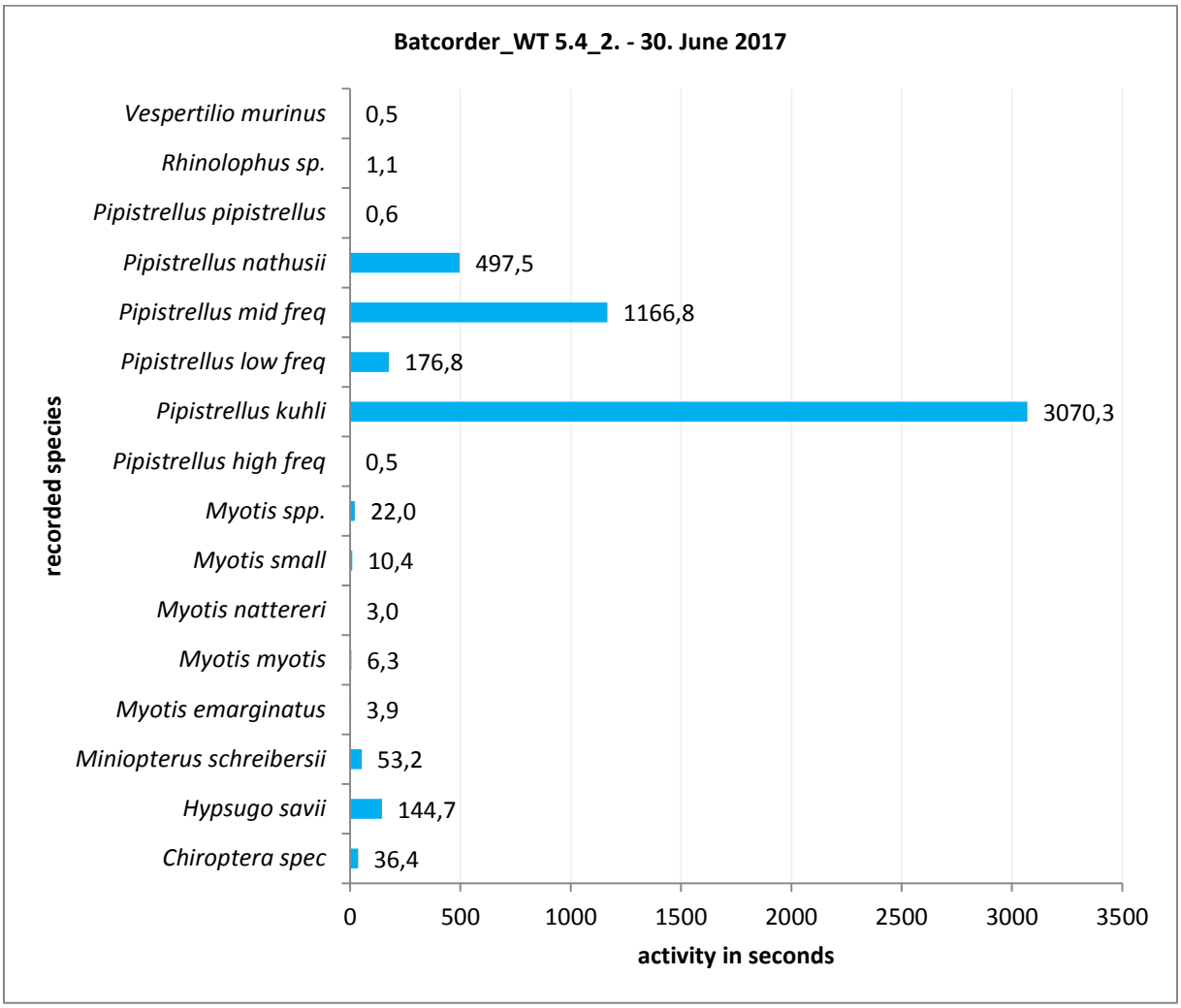


Figure 7. Total activity of all recorded bat species at wind turbine O.U.01 in the period 2nd – 30th June 2017 at location of WF Jelinak.

Figure 7 shows all recorded bat species in the period 2nd – 30th June 2017 at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/group share, the largest share belongs to species *P. kuhlii* (59%). Analysis was also done for species *H. savii* (3%) because of its share in recorded mortality.

Activity of all recorded bats in June (Appendix 2; 1) was distributed from 9 pm to 4.30 am, activity was lowered from 1 am to 4 am. In the same way was distributed activity of species *P. kuhlii* in July (Appendix 2; 2). Activity of species *H. savii* in June (Appendix 2; 3) was low and after 10.40 pm was intermittent and even lower.

July 2017

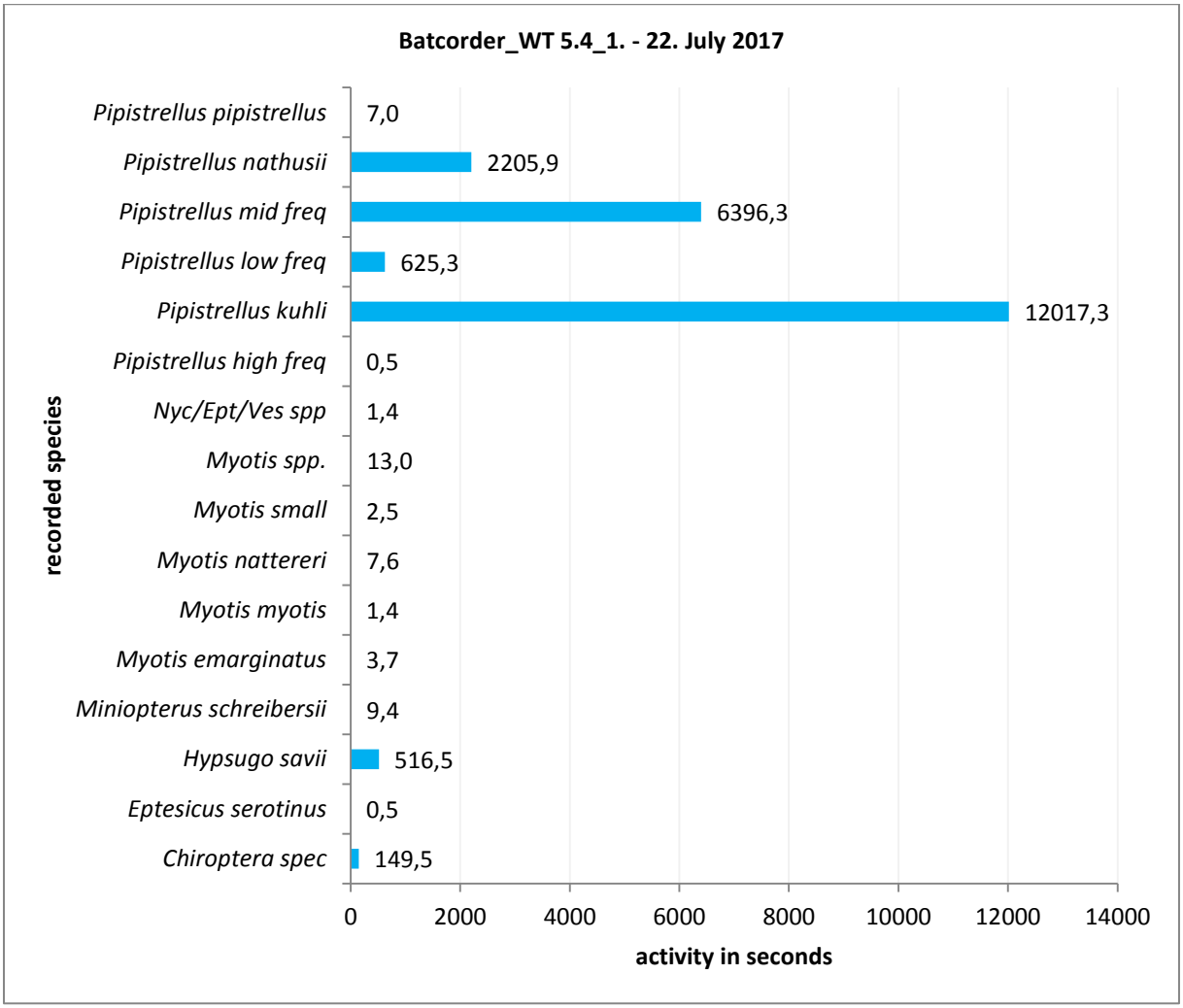


Figure 8. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 22nd July 2017 at location of WF Jelinak.

Figure 8 shows all recorded bat species in the period 1st – 22nd July 2017 at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/groups share, the largest share belongs to species *P. kuhlii* (55%). Analysis was also done for species *H. savii* (2%) because of its share in recorded mortality.

Activity of all recorded bats in July (Appendix 2; 4) was distributed from 9 pm to 4.40 am, with main activity from 10 pm to 00.50 am and with clear activity drop from 00.50 am to 1.30 am and after 3 am. In the same way was distributed activity of species *P. kuhlii* in July (Prilog 2; 5). Activity of species *H. savii* in July (Appendix 2; 6) was low and intermitted, with main activity from 10.40 pm to 11.50 pm.

August 2017

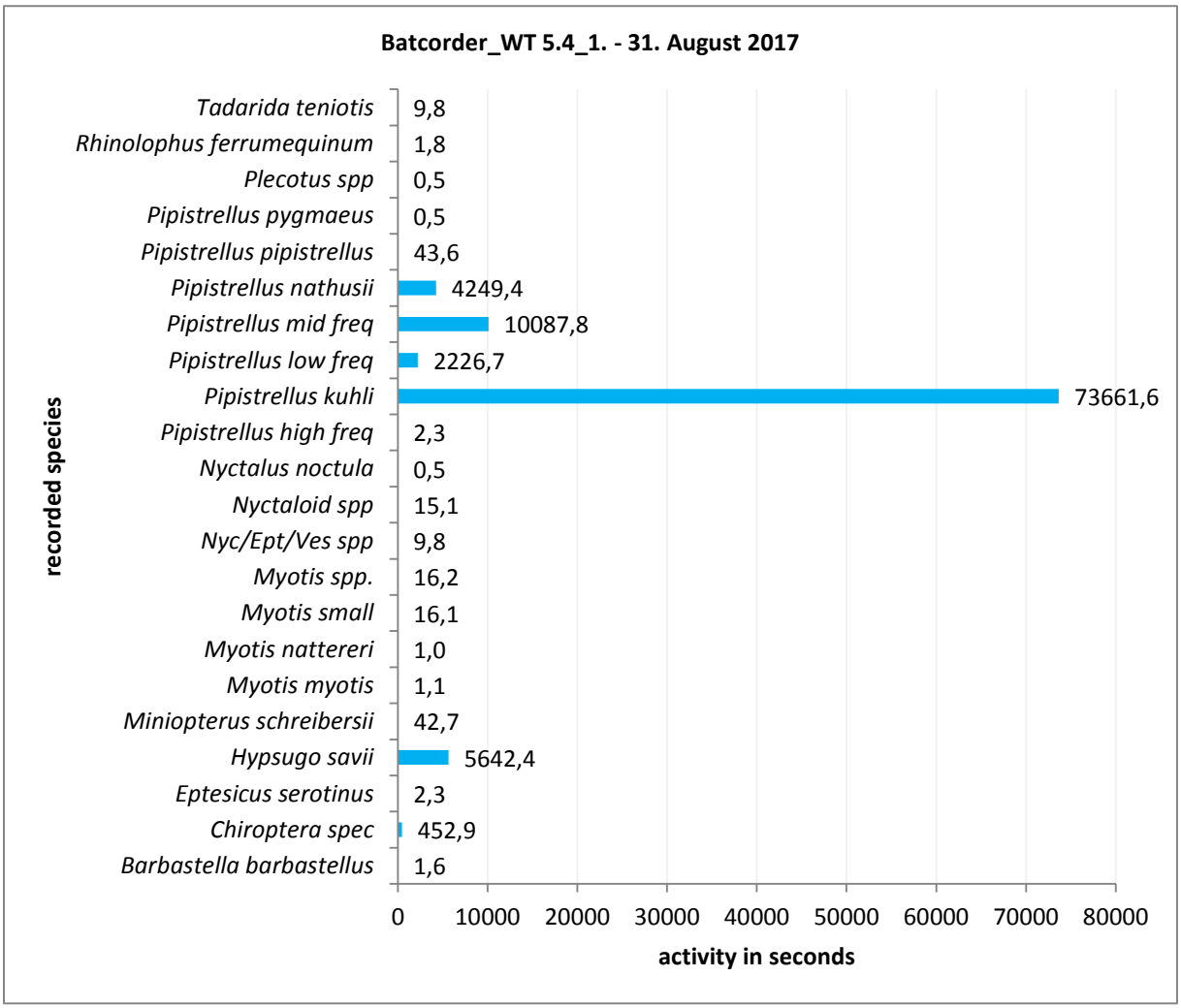


Figure 9. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 31st August 2017 at location of WF Jelinak.

Figure 9 shows all recorded bat species in the period 1st – 31st August 2017 at wind turbine O.U.01 and their total recorded activity in seconds. According to the species/group share, the largest share belongs to species *P. kuhlii* (76%). Analysis was also done for species *H. savii* (6%), *P. nathusii* (4%) and *P. pygmaeus* (< 0.1%) because of their share in recorded mortality.

Activity of all recorded bats in August (Appendix 2; 7) was distributed from 8 pm to 5.30 am, with activity peaks from 9.20 pm to 10.10 pm, from 10.40 pm to 1.20 am and from 2.50 am to 3.30 am. Species *P. kuhlii* in August (Appendix 2; 8) was continuously present during complete night with activity peaks from 9.40 pm to 10 pm and from 10.50 pm to 1.20 am. Species *H. savii* in August (Appendix 2; 9) was active from 8.50 pm to 4.40 am, with higher activity drop from 0.50 am to 2.50 am and with activity peak from 2.50 am to 3.40 am.

Activity of species *P. nathusii* in August (Appendix 2; 10) was distributed from 8.20 pm to 5 am, with clear activity drops from 2 am to 2.30 am and after 3.30 am. Activity of species *P. pygmaeus* in August was recorded only as individual flight at 0.05 am.

September 2017

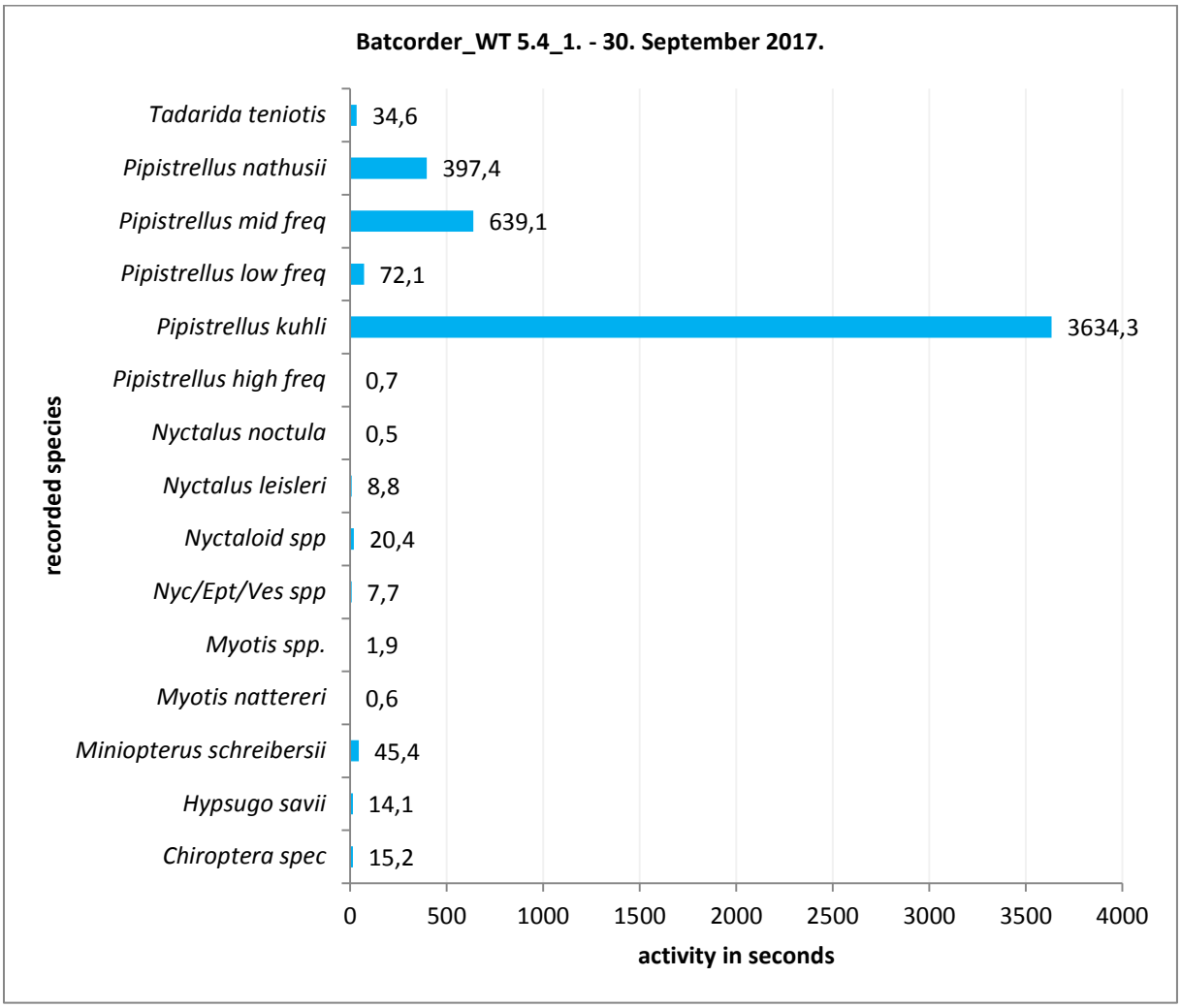
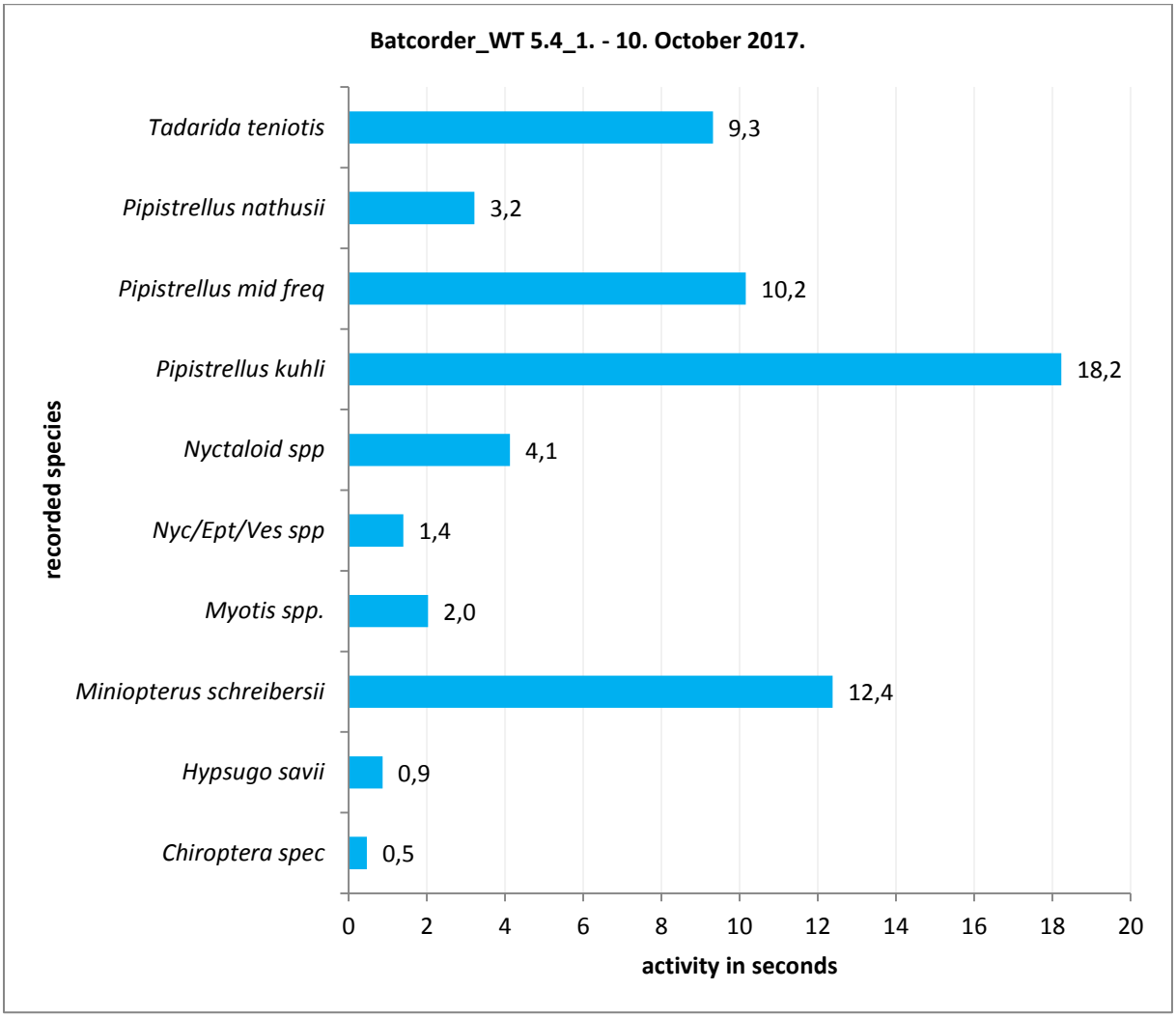


Figure 10. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 30th September 2017 at location of WF Jelinak.

Figure 10 shows all recorded bat species in the period 1st – 30th September 2017 at wind turbine O.U.01 and their total recorded activity in seconds. According to species/groups share, the largest share belongs to species *P. kuhlii* (74%).

Activity of all recorded bats in September (Appendix 2; 11) was distributed from 7 pm to 6 am, main activity was in the first part of the night with activity peak from 8.30 pm to 9.40 pm, while after 11 pm activity was significantly decreased. Activity of species *P. kuhlii* in September (Appendix 2; 12) was distributed in the same way.

October 2017



Slika 11. Total activity of all recorded bat species at wind turbine O.U.01 in the period 1st – 10th October 2017 at location of WF Jelinak.

Figure 11 shows all recorded bat species in the period 1st – 10th October 2017 at wind turbine O.U.01 and their total recorded activity in seconds. According to species/groups share, the largest share belongs to species *P. kuhlii* (29%).

Activity of all recorded bats in October (Appendix 2; 13) was inttermitent distributed from 7 pm to 5.40 am, with large activity stops periods during the night, and all recorded activity are individual flights. Species *P. kuhlii* in October (Appendix 2; 14) was present only as individual flights on three occasions till midnight.

4. Analysis of bat activity in relation to the wind speed

For analysis of bat activity in relation to the wind speed we took the activity data from batcorder device placed at wind turbine O.U.01 (5.4) and related wind speed data from the same wind turbine. We analyzed these data for the same bat species as for activity, which is for total activity of all bat species in each month and for species/groups which made the highest activity and mortality share.

Batcorder wind turbine O.U.01 (5.4)

June 2017

In June to the wind speed of 5.0 m/s 50% of total bat activity was recorded (Appendix 3; 1), and 80% activity was recorded to 7.5 m/s wind speed. Bat activity was recorded to the 12.0 m/s wind speed. To the wind speed of 5.0 m/s 50% activity of species *P. kuhlii* was recorded (Appendix 3; 2), and 80% activity was recorded at wind speed slightly above 7.5 m/s. To the wind speed of 5.0 m/s 60% activity of species *H. savii* was recorded (Appendix 3; 3), and 80% activity of this species was recorded to the wind speed of 6.5 m/s.

July 2017

In July to the wind speed of 5.0 m/s 45% of total bat activity was recorded (Appendix 3; 4), and 80% activity was recorded to the wind speed slightly below 8.0 m/s. Bat activity was recorded to 12.0 m/s wind speed. To the wind speed of 5.0 m/s 45% activity of species *P. kuhlii* was recorded (Appendix 3; 5), and 80% activity of this species was recorded to the wind speed to 7.5 m/s. To the wind speed of 5.0 m/s 60% activity of species *H. savii* was recorded (Appendix 3; 6), and 80% activity of this species was recorded to the wind speed to 7.0 m/s.

August 2017

In August to the wind speed of 5.0 m/s around 40% of total bat activity was recorded (Appendix 3; 7), and 80% activity was recorded to 9.0 m/s wind speed. Bat activity was recorded to 12.0 m/s wind speed. To the wind speed of 5.0 m/s 40% activity of species *P. kuhlii* was recorded (Appendix 3; 8), and 80% activity of this species was recorded to the wind speed slightly below 9.0 m/s. To the wind speed of 5.0 m/s 45% activity of species *H. savii* was recorded (Appendix 3; 9), and 80% of this species activity was recorded to the wind speed slightly below 8.0 m/s. To the wind speed of 5.0 m/s 50% activity of species *P. nathusii* was recorded (Appendix 3; 10), and 80% of this species activity was recorded to the wind

speed to 7.5 m/s. Individual flight of species *P. pygmaeus* (Appendix 3;11) was recorded at 3.5 m/s wind speed.

September 2017

In September to the wind speed of 5.0 m/s 50% of total bat activity was recorded (Appendix 3; 12), and 80% activity was recorded to slightly below 8.5 m/s wind speed. Bat activity was recorded to 13.5 m/s wind speed. To the wind speed of 5.0 m/s more than 50% activity of species *P. kuhlii* was recorded (Appendix 3; 13), and 80% activity of this species was recorded to the wind speed slightly above 8.0 m/s.

October 2017

In October to the wind speed of 5.0 m/s 65% of total bat activity was recorded (Appendix 3; 14), and 80% activity was recorded to slightly above 6.5 m/s wind speed. Bat activity was recorded to 9.0 m/s wind speed. To the wind speed of 5.0 m/s more than 30% activity of species *P. kuhlii* was recorded (Appendix 3; 15), and 80% activity of this species was recorded to the wind speed slightly above 6.0 m/s.

5. Analysis of the recorded bat mortality during monitoring in 2013, 2014, 2015, 2016 and 2017

When comparing the overall mortality observed at the wind farm Jelinak during five years (2013, 2014, 2015, 2016, 2017) it is necessary to take into account the different field management for each year which refers to the different number of turbines with mitigation measure, different periods (date) with implemented measure and different duration of the implemented measure throughout the night (hours). Thus, in 2013 there weren't any mitigation measure. In 2014 mitigation measure was implemented in the period from 1st July to 30th September 2014, in a way that at six turbines cut-in speed was increased from 3.0 m/s to 5.0 m/s during four hours (one hour before sunset and three hours after sunset). In 2015 mitigation measure covered two more turbines so that in total eight turbines had mitigation measure in the period from 1st July to 31st August in a way that these eight turbines started at wind speed of 5.0 m/s in the period from 9 pm to 3 am next morning. In 2016 mitigation measure covered six more turbines so in total fourteen turbines had mitigation measure with cut-in speed 5.0 m/s. Total period with mitigation measure in 2016 was from 1st July to 31st August but in that period there were two different protocols which differed in whether measure was implemented in part of the night (from 9 pm till 3 am) or it was implemented

during complete night. First protocol was conducted in two parts, from 1st July 2016 till 15th July 2016 and from 16th August 2016 till 31st August 2016 when mitigation measure was conducted from 9 pm to 3 am next day. Second protocol was conducted from 16th July 2016 till 15th August 2016 when mitigation measure was conducted during complete night (from half an hour before sunset till half an hour after sunrise). During 2017, compared to 2016, additional measure increasement was implemented in a way that in period with highest bat mortality, from 16th July to 15th August, measure was implemented at nineteen turbines (all exept O.U.19). So, in 2017 mitigation measure during July and August was conducted according to two protocols. First protocol was conducted in two parts. From 1st July 2017 till 15th July 2017 and from 16th August 2017 till 31st August 2017 mitigation measure was conducted at fourteen turbines from 9 pm to 3 am next day with cut-in speed 5.0 m/s and feathering below that wind speed. Second protocol was conducted from 16th July 2017 till 15th August 2017 when mitigation measure was conducted at nineteen turbines during complete night (from half an hour before sunset till half an hour after sunrise) with cut-in speed 5.0 m/s and feathering below that wind speed.

Also, when comparing data about recorded mortality between years it is necessary to keep in mind significantly different field effort between years but also in the same year during 2014. During 2013 searches for dead bats were done at all twenty wind turbines twice a month from March to October, in total sixteen times (OIKON). During 2014 in period from March to August searches for dead bats were done twice a month, in total twelve times (OIKON). Additionally, from July to September every day monitoring was done (EURUS) but only at nine chosen turbines, thus losing the information what was going on at the same time on other turbines. In September 2014 the searches was done only by EURUS every day at nine chosen turbines, and in October 2014 nobody was doing searches. During 2015 the searches for dead bats were done from June to October at all twenty turbines (FOKUS). During June, September and October searches included two days searches every seven days, while in July and August every day searches were done. During 2016 we (FOKUS) followed protocol from 2015 (with exception in October because, according to results of three years of monitoring on the site, we concluded that monitoring in October wasn't necessary, but in order to follow Croatian legislative, the last search was done in the period from 1st - 5th October.) During 2017 (FOKUS) monitoring protocol from 2016 was modified in a way that instead of every day searches, in July and August every three days searches were done, based on removal time. So, in 2017 searches for dead bats included every seven days searches

during June and September, every three days searches during July and August, and last search in period between 1st and 5th October.

Although wind farm had different management protocol every year, and although field effort differs significantly between years, below are given absolute numbers of dead bats found during all five years of monitoring.

Figure 12 shows total bat mortality recorded during each of five years of monitoring. During 2013 in total 148 dead bats were recorded, i.e. 7.4 bats per wind turbine. During 2014 in total 70 dead bats were recorded, i.e. 3.5 bats per wind turbine. During 2015 in total 54 dead bats were recorded, i.e. 2.7 bats per wind turbine. During 2016 in total 30 dead bats were recorded, i.e. 1.5 bats per wind turbine. During 2017 in total 20 dead bats were recorded, i.e. 1 bats per wind turbine.

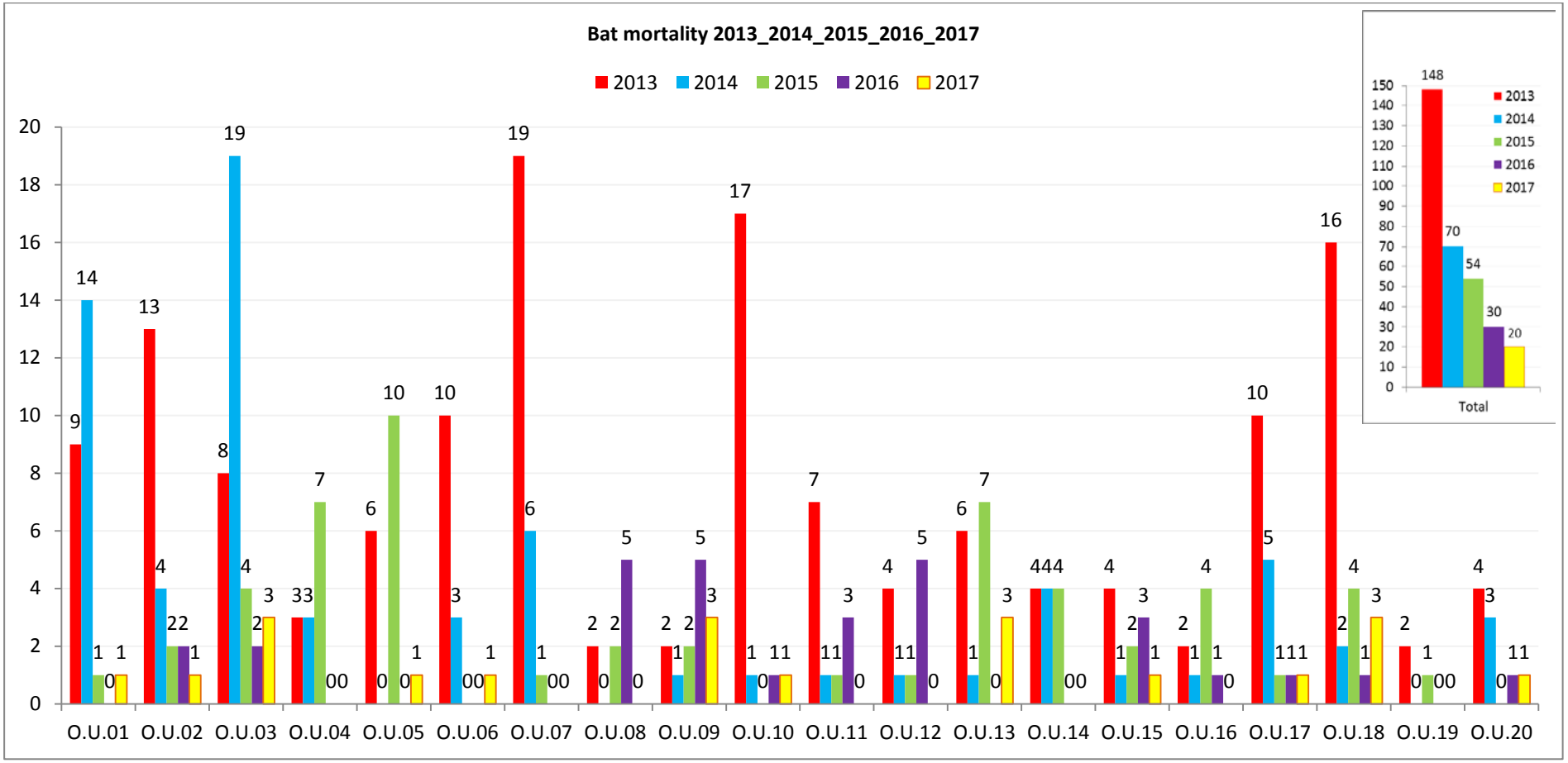


Figure 12. Total recorded bat mortality during 2013, 2014, 2015, 2016 and 2017 at location of WF Jelinak.

6. The proposal of mitigation measures, ways of their implementation and monitoring of their effectiveness

Implementation of mitigation measures in 2017 led to the further reduction in mortality. However, it should keep in mind that in July and August 2017, unlike every day searches in 2016 and 2015, searches were done every 3 days, and that for this period both statistical estimators have suggested that real mortality is significantly higher than recorded mortality. So, it is possible that total number of dead bats in 2017 is higher than recorded 20 dead bats, which would still be significant mortality at wind farm Jelinak. It is necessary to continue implementing mitigation measures.

Data from 2016 and 2015 (obtained with every day searches in July and August) pointed out the period with mortality peak at wind farm Jelinak in period from 16th July to 15th August and that's why in that period in 2017 mitigation measure was implemented during complete night at all turbines (except O.U.19). With measure implemented during complete night at all turbines in most critical period, mortality in that period in 2017 was reduced to 6 bats, i.e. was reduced for 30% comparing with the same period in 2016. In other two periods, 1. – 15.07.2017 and 16. – 31.08.2017, measure was implemented at fourteen turbines in period from 9 pm to 3 am. In these two periods at turbines without measure four dead bats were recorded, while at turbines with measure eight bats were recorded. In period 1. – 15.07.2017 number of dead bats increased compared with previous two years. Five out of eight dead bats in this period in 2017 was recorded at turbines with measure (but without knowledge were these bats get killed during hours with or without measure), and three at turbines without measure. In period 16. – 31.08.2017 number of dead bats stayed the same as in previous two years.

It is possible to influence four main parameters of mitigation measure implementation. All recorded mortality data analysis compared with implemented mitigation measure during 2017 shows that cut-in speed was correctly defined (5.0 m/s) with feathering below that wind speed and time period with measure (date) was also correctly defined. Also, it was correct to increase the number of wind turbines with implemented measure in most critical period (complete field (except O.U.19) from 16.07.2017 to 15.08.2017). In order to further decrease mortality it is possible to extend the period of the night with implemented measure (hours) in period 1. – 15.07.2017.

Taking into account all the results and all the analysis, we give a proposal to continue with the same implementation of mitigation measures at location of wind farm Jelinak as it was in 2017. By continuing with implementation of the same mitigation measure to reduce negative impact on bats during 2018 it will be possible to gain the right insight about effectiveness of this kind of measure considering that the number of found dead bats in 2017 is at the border of acceptable limit.

Therefore, in 2018 we propose, like in 2017, to divide period with mitigation measure in two protocols considering period with highest recorded mortality and the rest of high season (Table 3). In the period from 16th July to 15th August it is necessary to implement mitigation measure on nineteen turbines (complete field except O.U.19) in a way that all wind turbines should have cut-in speed at 5.0 m/s and feathering below that speed during complete night, from half an hour before sunset till half an hour after sunrise. In the period from 1st July to 15th July and from 16th August to 31st August fourteen turbines (all except: O.U.08; O.U.09, O.U.11, O.U.12, O.U.15, O.U.19) should have mitigation measure including cut-in speed at 5.0 m/s and feathering below that speed from 9 pm till 3 am next morning.

To monitor effectiveness of proposed mitigation measures it is necessary to conduct monitoring program at location of WF Jelinak. In 2018 it is necessary to follow monitoring protocol from 2017. That is the only way to compare results and to have the real insight what is going on at the location. Therefore, in 2018 we propose (Table 4) to install batcorder device on the site from June to October at the same location. We propose visual search for dead bats on the site every seven days in June and September, and in July and August every three days searches. The last field survey (visual search for dead bats) should be done in the period from 1st to 5th October. Based on the analysis and results of monitoring in 2018, it is necessary to made possibly corrections of mitigation measure and also of proposal for further monitoring program.

Table 3. Proposal of mitigation measures in 2018 at location of WF Jelinak.

MITIGATION MEASURES IN 2018 AT WF JELINAK			
Period: 1.7.2018. - 15.7.2018.			
Wind turbine	**Cut-in speed**	**Feathering**	**Timing**
Mitigation measure at fourteen turbines (without measure: O.U.08; O.U.09, O.U.11, O.U.12, O.U.15, O.U.19)	5.0 m/s	yes	9 pm – 3 am
Period: 16.7.2018. - 15.8.2018.			
Wind turbine	**Cut-in speed**	**Feathering**	**Timing**
Mitigation measure on the complete field (except O.U.19)	5.0 m/s	yes	*complete night
* from half an hour before sunset till half an hour after sunrise			
Period: 16.8.2018. - 31.8.2018.			
Wind turbine	**Cut-in speed**	**Feathering**	**Timing**
Mitigation measure at fourteen turbines (without measure: O.U.08; O.U.09, O.U.11, O.U.12, O.U.15, O.U.19)	5.0 m/s	yes	9 pm – 3 am

Table 4. Proposal for a monitoring program in 2018 at location of WF Jelinak.

MONITORING IN 2018 AT WF JELINAK		
Period: June – October 2018		
Month	**Field work**	**Date**
JUNE	• visual search for dead bats on the site • installation of batcorder on the site	every 7 days
JULY	• visual search for dead bats on the site	every 3 days
AUGUST	• visual search for dead bats on the site	every 3 days
SEPTEMBER	• visual search for dead bats on the site	every 7 days
OCTOBER	• visual search for dead bats on the site • removal of batcorder from the site	1st – 5th October

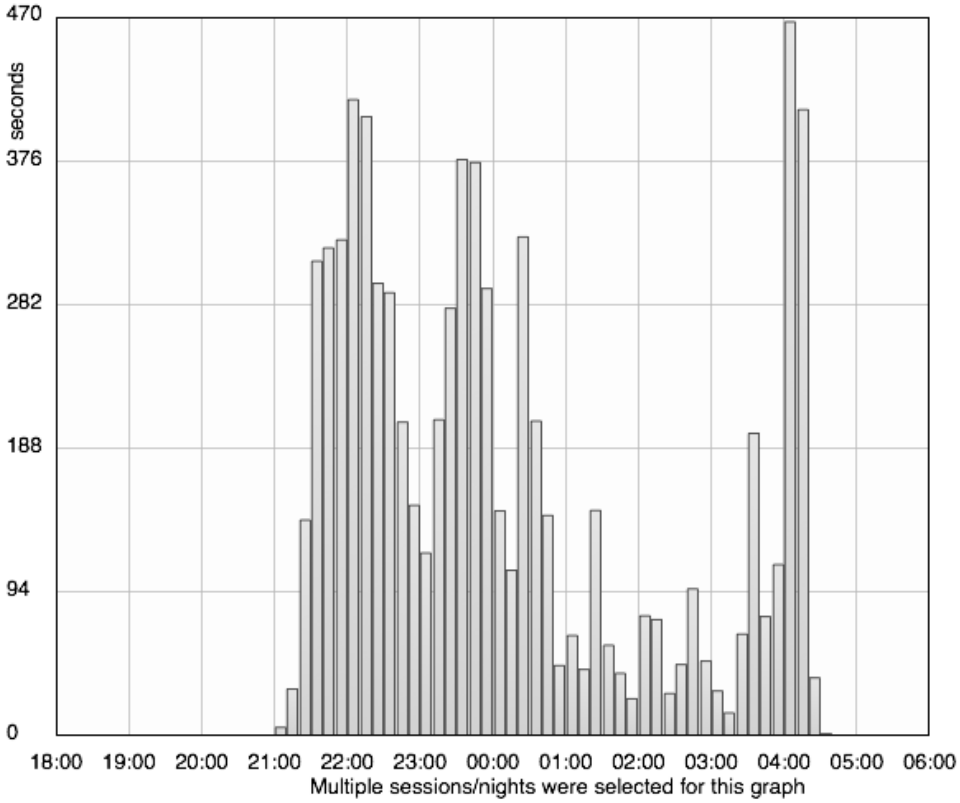
7. Appendix

Appendix 1. Table of total recorded mortality during monitoring from June to October 2017.

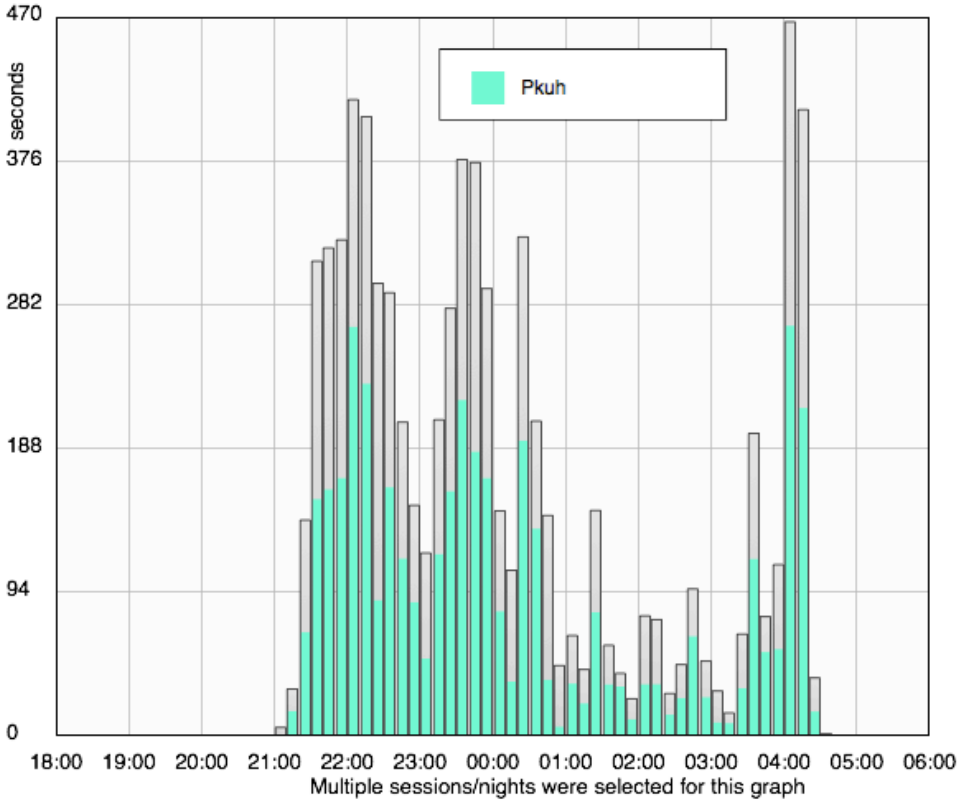
Bat mortality_monitoring_WF_Jelinak_June – October 2017.					
No.	**Date**	**Species**	**Sex**	**Turbine**	**note**
1	2017.06.24.	*Hypsugo savii*	I	O.U.10	
2	2017.07.08.	*Pipistrellus sp.*	I	O.U.03	
3	2017.07.08.	*Pipistrellus kuhlii*	H	O.U.17	
4	2017.07.08.	*Pipistrellus kuhlii*	H	O.U.18	female with breasts
5	2017.07.14.	*sp.*	I	O.U.01	
6	2017.07.14.	*sp.*	I	O.U.09	
7	2017.07.14.	*Hypsugo savii*	I	O.U.09	
8	2017.07.14.	*sp.*	I	O.U.15	
9	2017.07.14.	*sp.*	I	O.U.18	
10	2017.07.25.	*Pipistrellus kuhlii*	H	O.U.03	
11	2017.07.25.	*Pipistrellus kuhlii*	H	O.U.05	
12	2017.07.28.	*Pipistrellus kuhlii*	H	O.U.13	
13	2017.08.03.	*Hypsugo savii*	H	O.U.13	
14	2017.08.06.	*Pipistrellus kuhlii*	I	O.U.03	
15	2017.08.12.	*Pipistrellus nathusii*	H	O.U.02	
16	2017.08.21.	*Hypsugo savii*	M	O.U.13	
17	2017.08.24.	*Pipistrellus pygmaeus*	M	O.U.06	
18	2017.08.27.	*Pipistrellus kuhlii*	I	O.U.18	
19	2017.08.30.	*Pipistrellus nathusii*	H	O.U.09	
20	2017.09.14.	*sp.*	I	O.U.20	

(Sex: M=male, H=female, I=indefinite.)

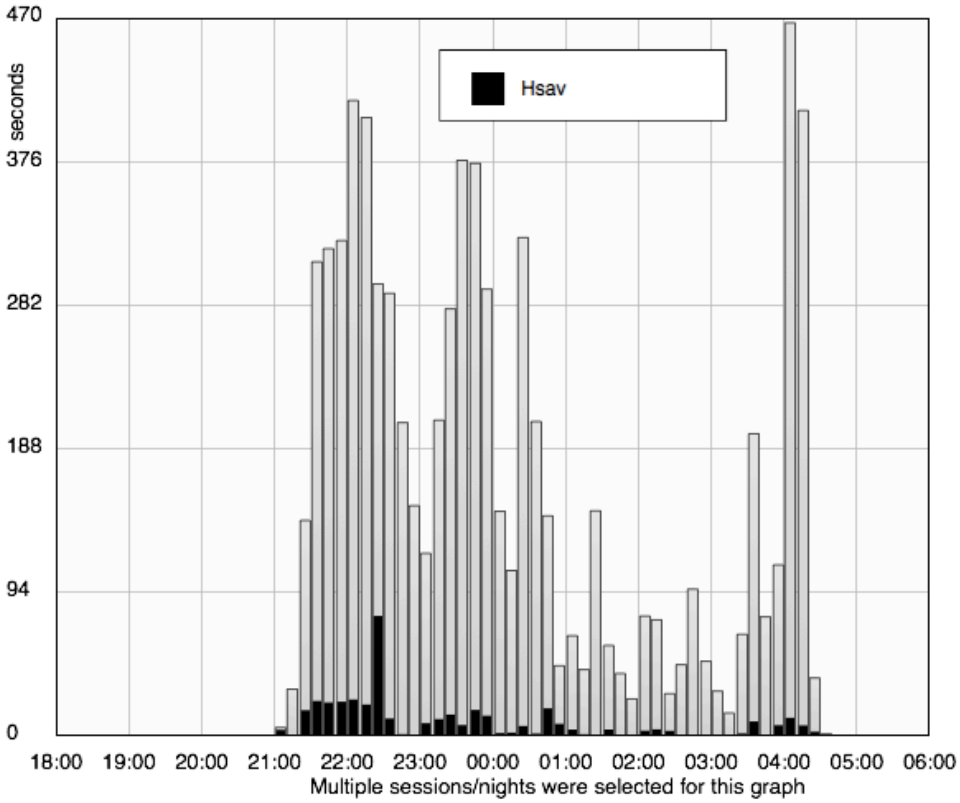
Appendix 2. Batcorder wind turbine O.U.01 (5.4).



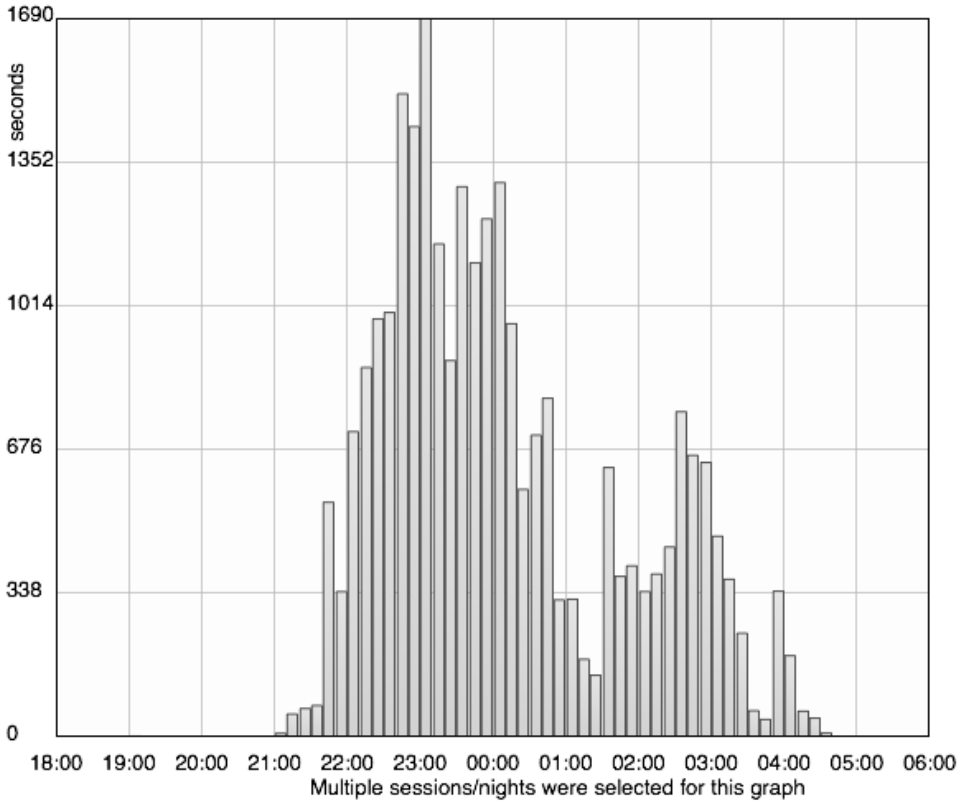
1. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 2nd – 30th June 2017 at location of WF Jelinak.



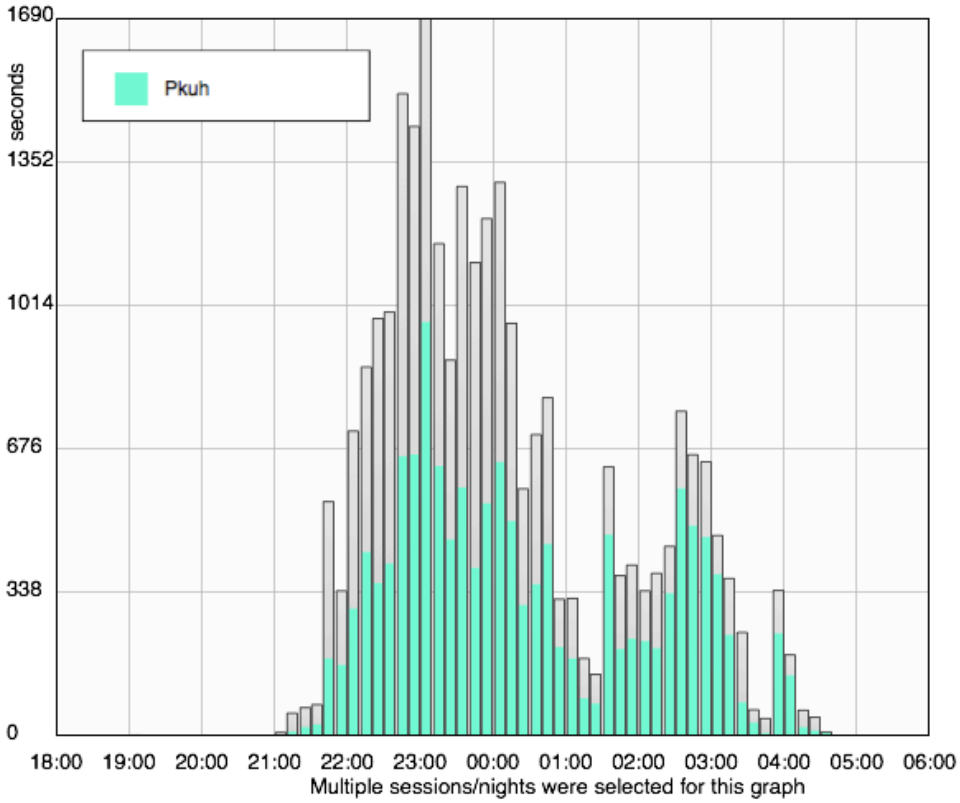
2. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 2nd – 30th June 2017 at location of WF Jelinak.



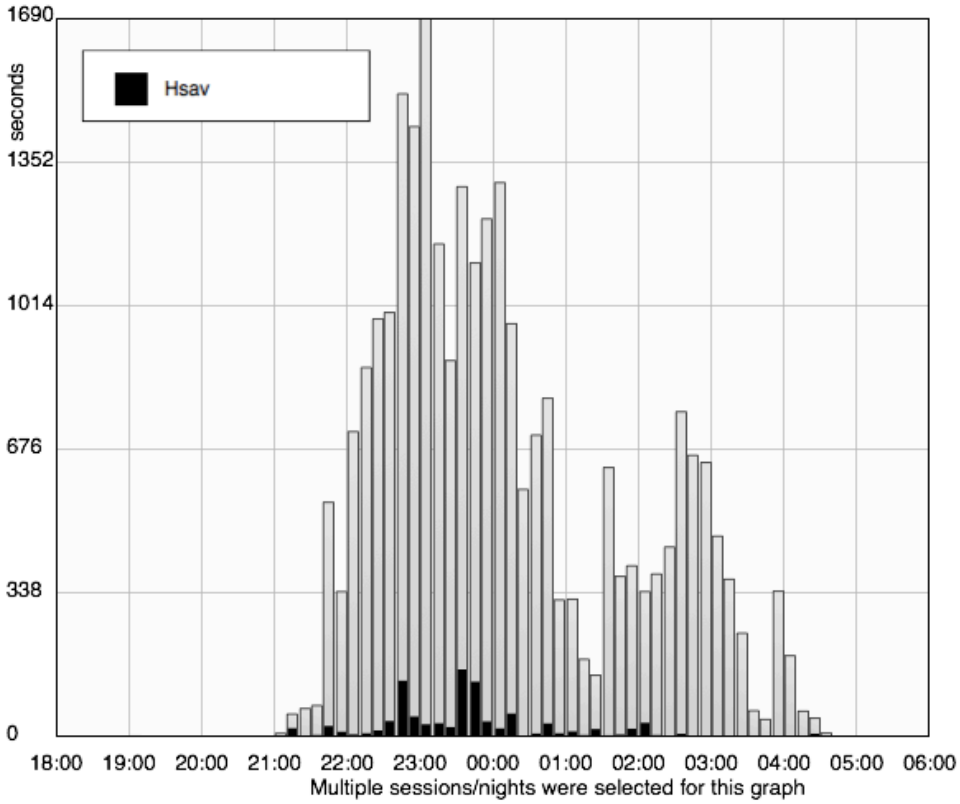
3. Activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 2nd – 30th June 2017 at location of WF Jelinak.



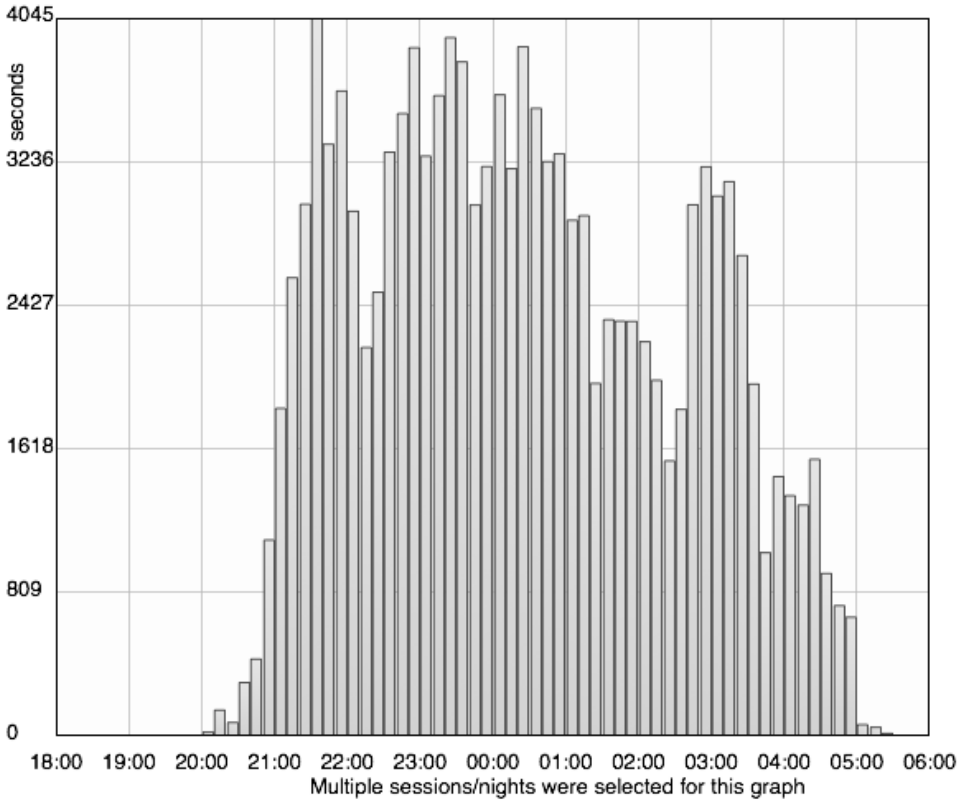
4. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 22nd July 2017 at location of WF Jelinak.



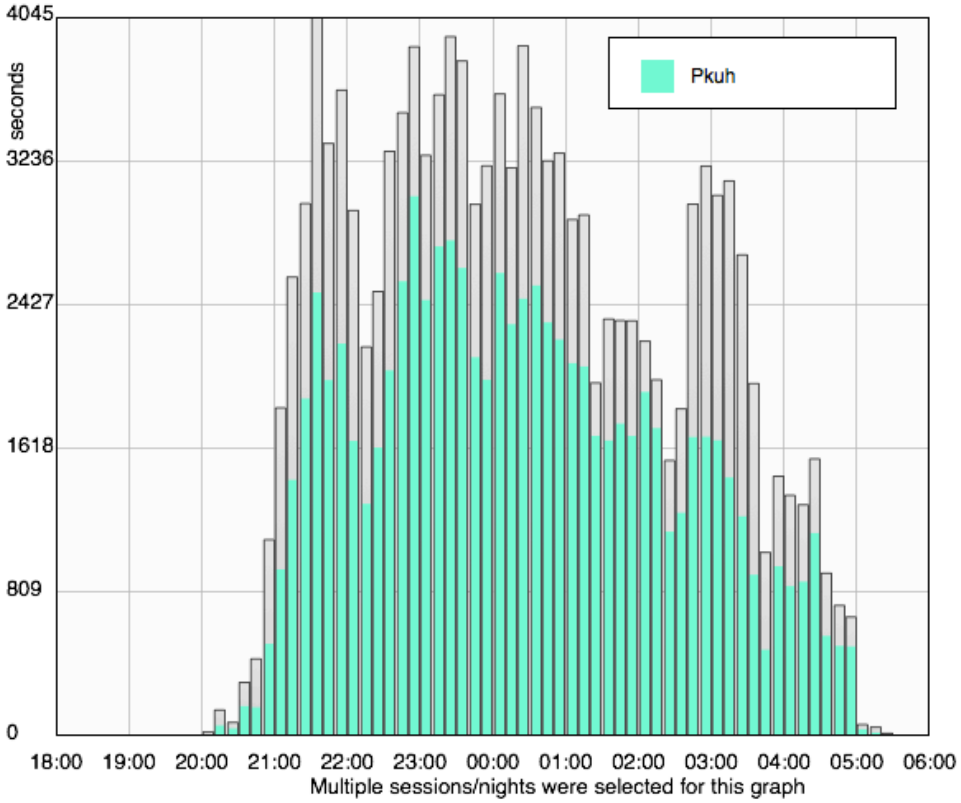
5. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 22nd July 2017 at location of WF Jelinak.



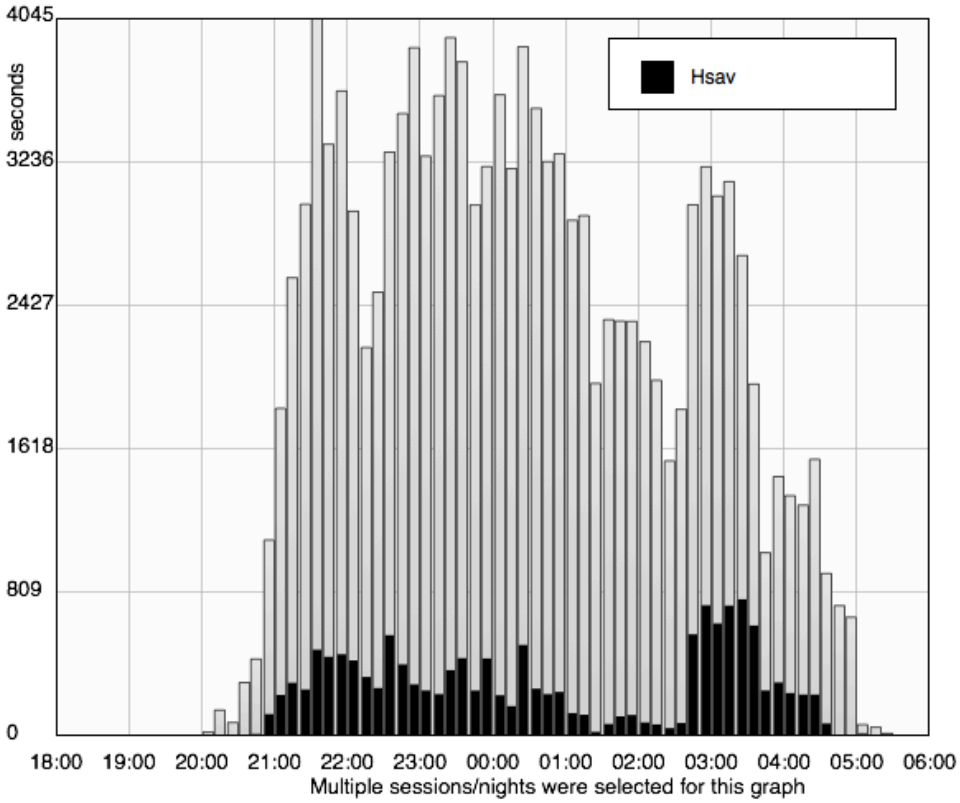
6. Activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 1st – 22nd July 2017 at location of WF Jelinak.



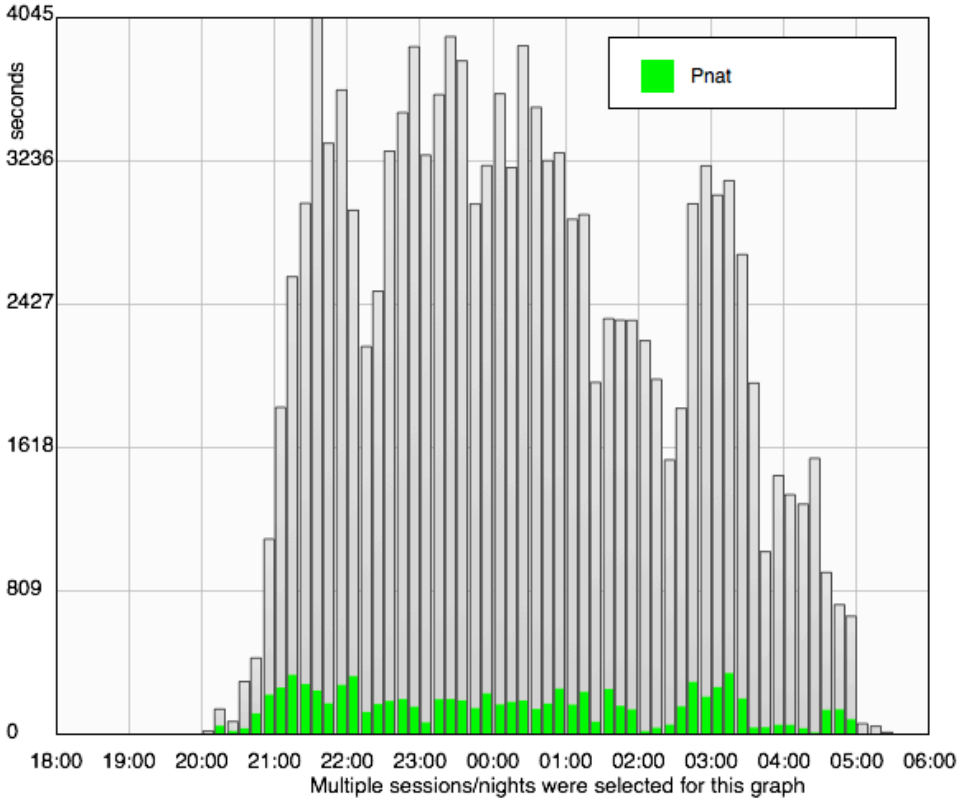
7. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 31st August 2017 at location of WF Jelinak.



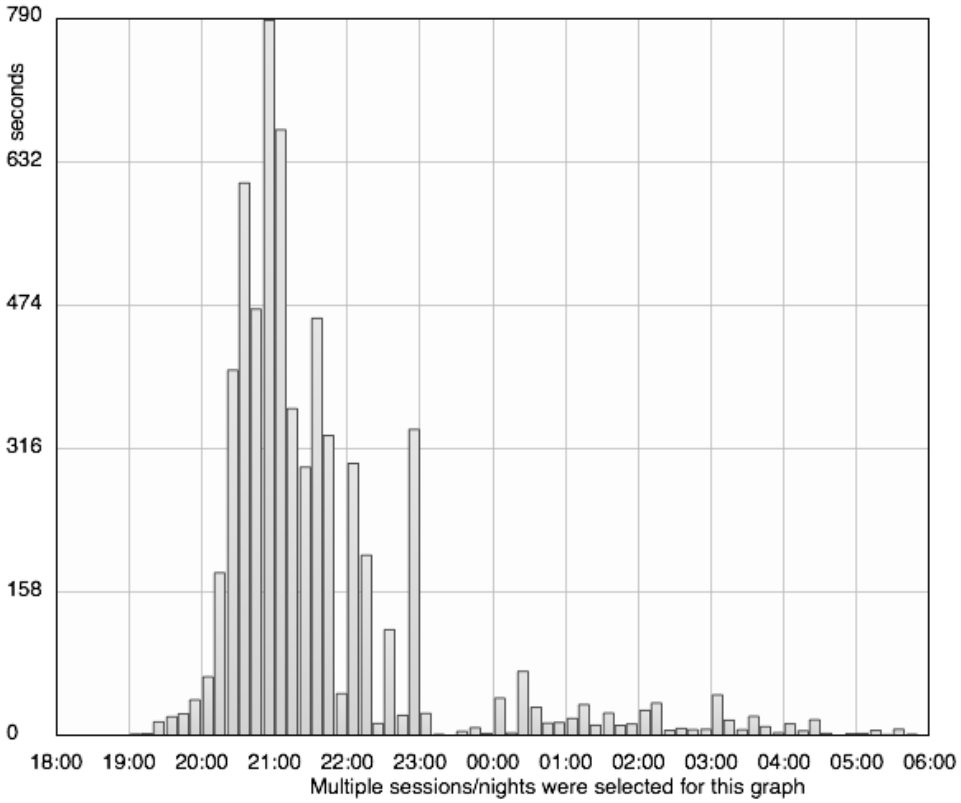
8. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 31st August 2017 at location of WF Jelinak.



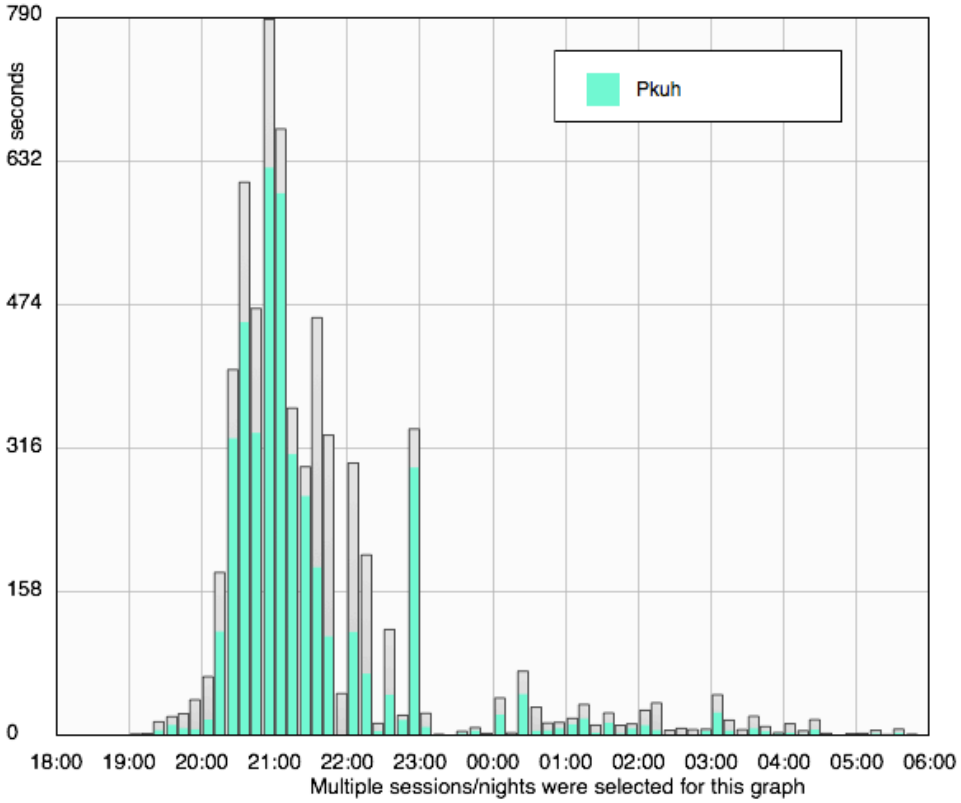
9. Activity of species *Hypsugo savii* during entire nights at wind turbine O.U.01 in period 1st – 31st August 2017 at location of WF Jelinak.



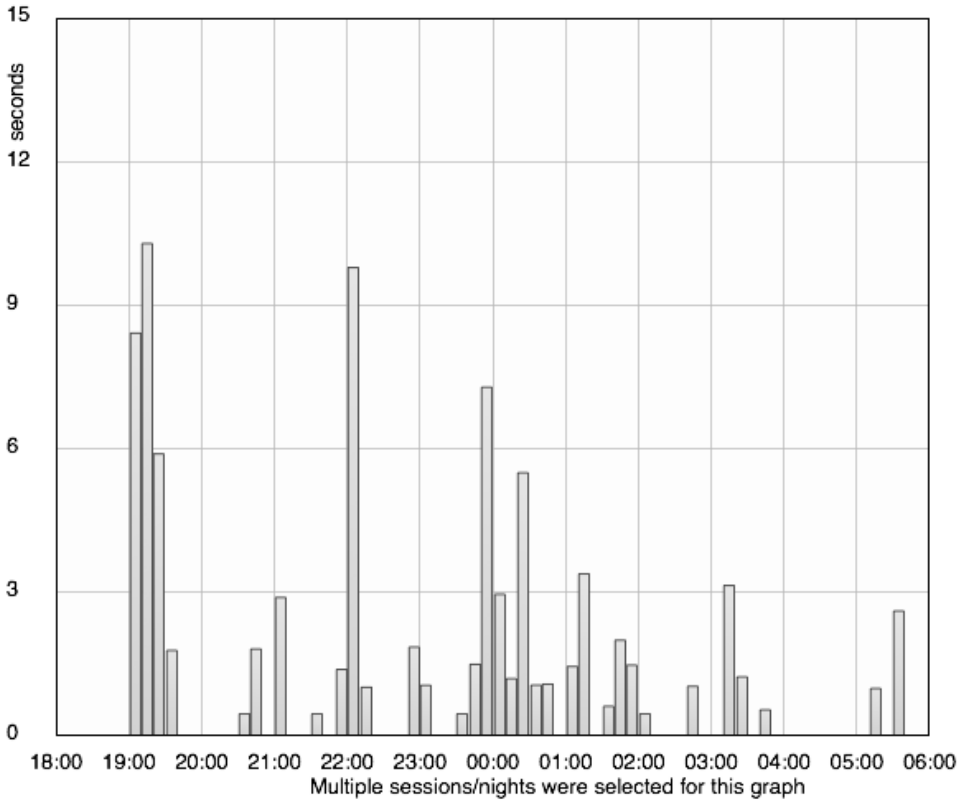
10. Activity of species *Pipistrellus nathusii* during entire nights at wind turbine O.U.01 in period 1st – 31st August 2017 at location of WF Jelinak.



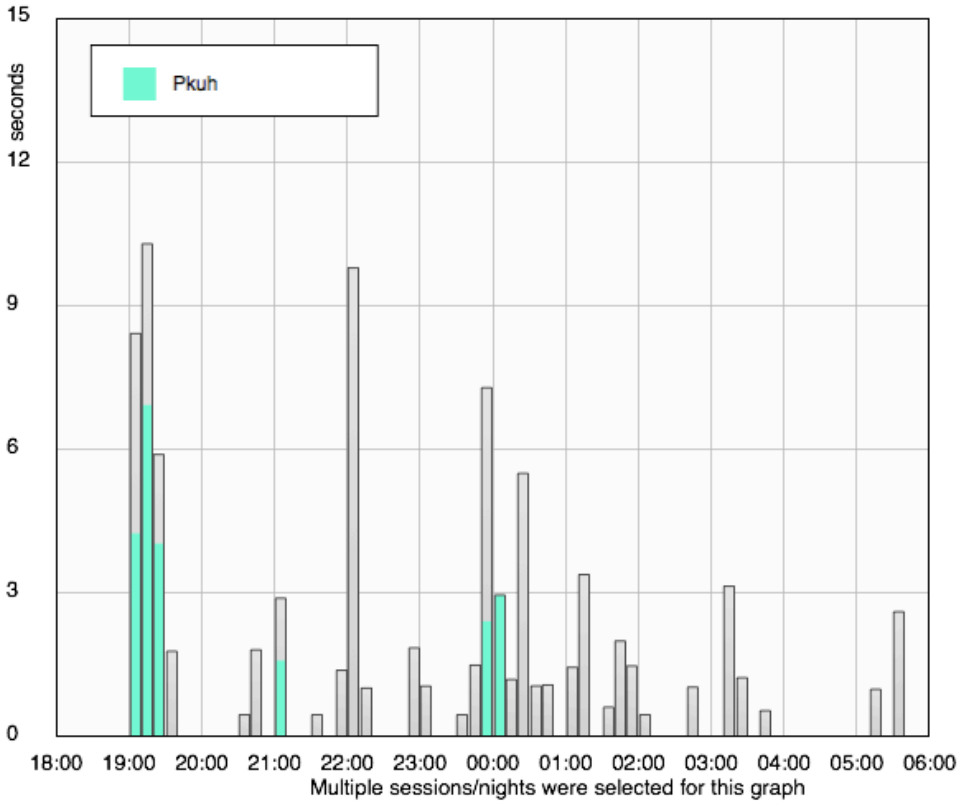
11. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 30th September 2017 at location of WF Jelinak.



12. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 30th September 2017 at location of WF Jelinak.

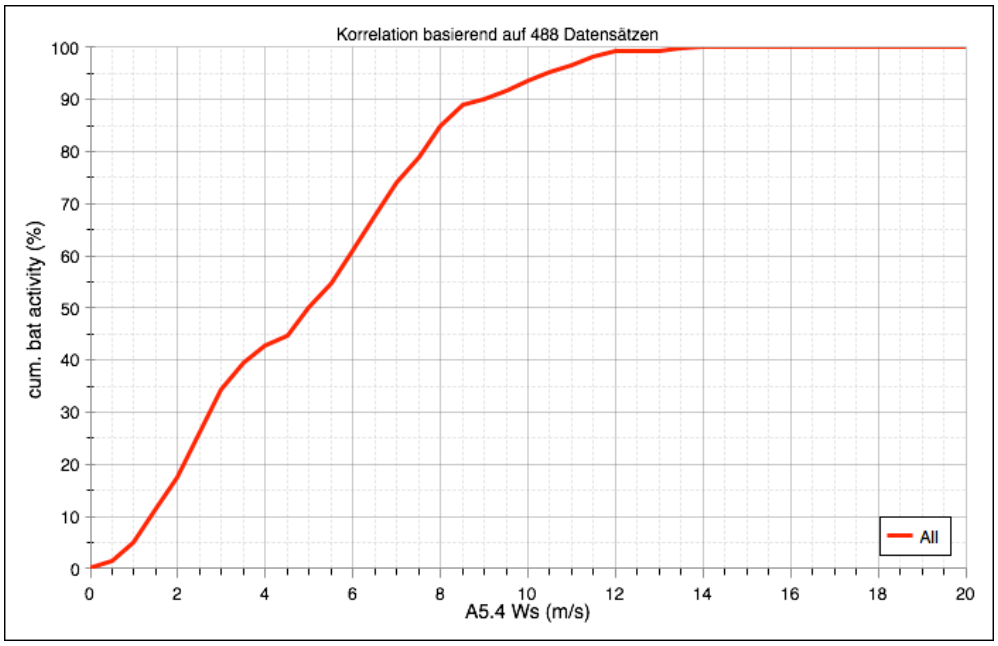


13. Total activity of all recorded bat species during entire nights at wind turbine O.U.01 in period 1st – 10th October 2017 at location of WF Jelinak.

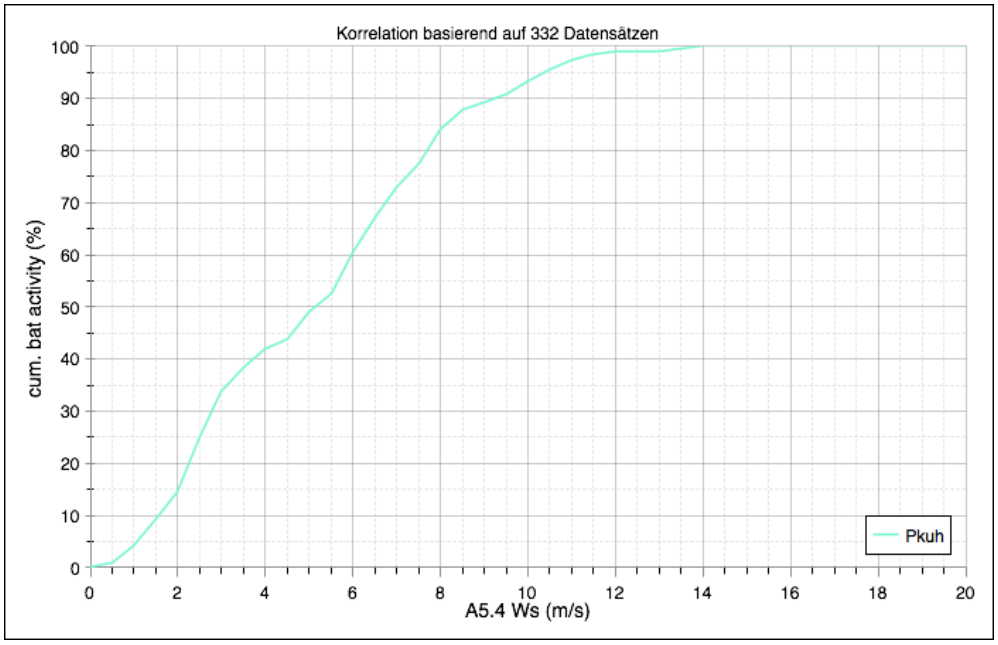


14. Activity of species *Pipistrellus kuhlii* during entire nights at wind turbine O.U.01 in period 1st – 10th October 2017 at location of WF Jelinak.

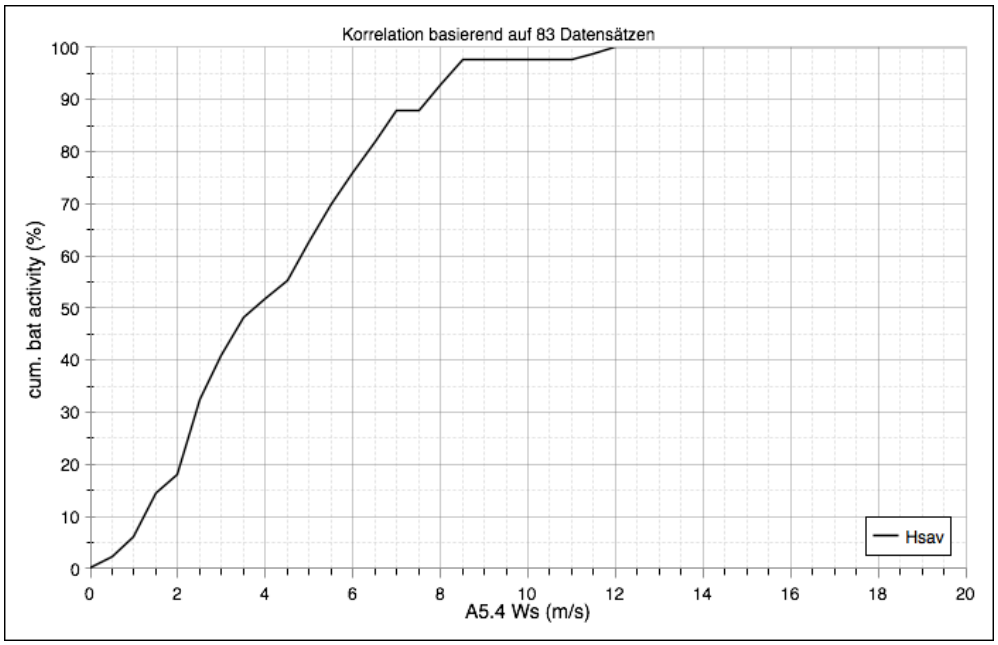
Appendix 3. Bat activity in relation to the wind speed - Batcorder wind turbine O.U.01 (5.4).



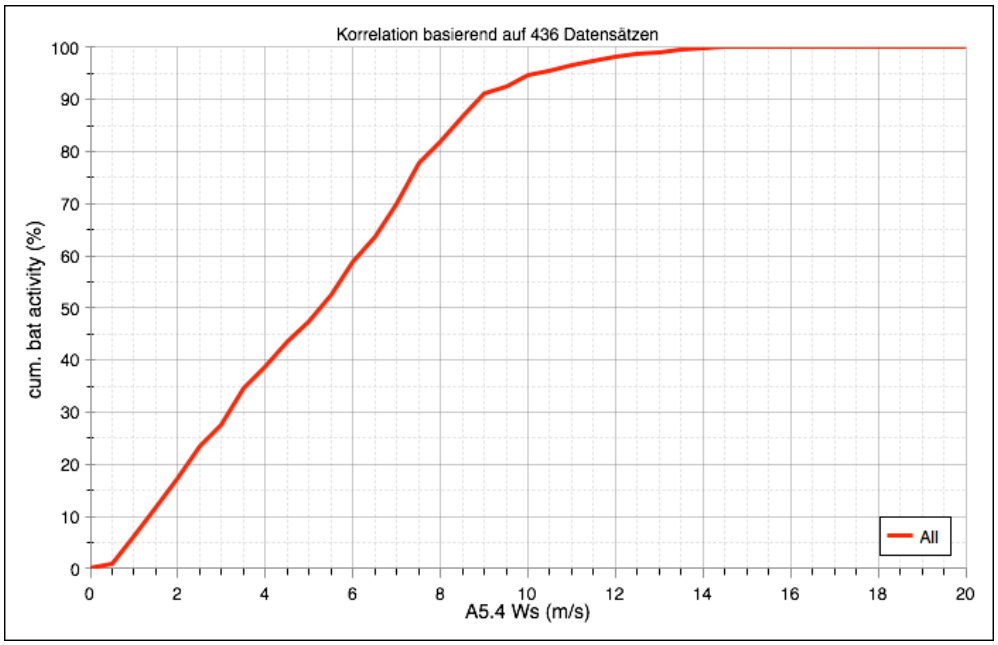
1. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in June 2017 at location of WF Jelinak.



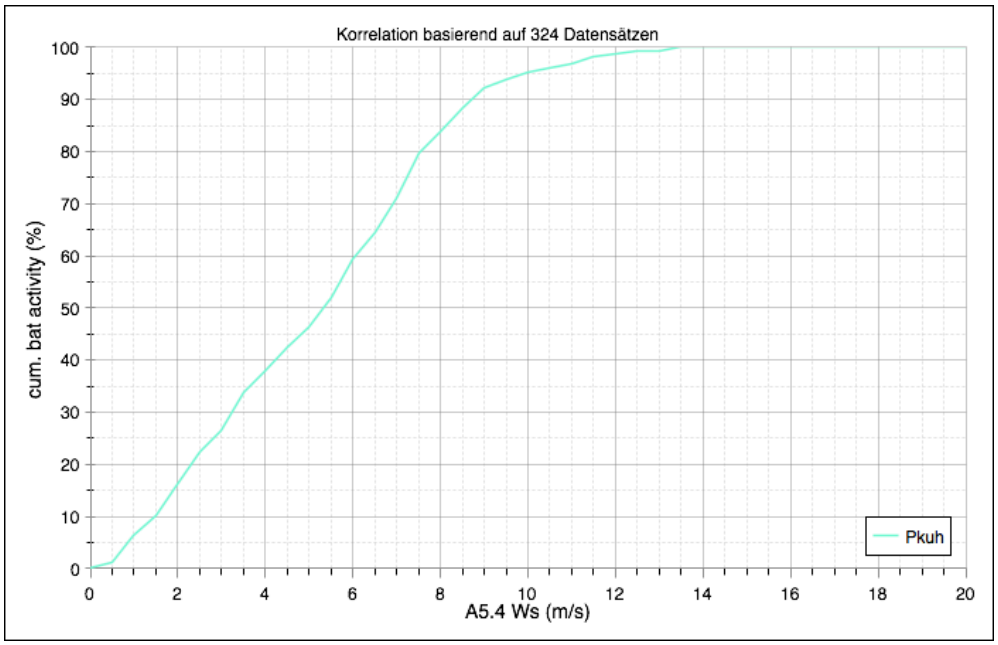
2. Activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in June 2017 at location of WF Jelinak.



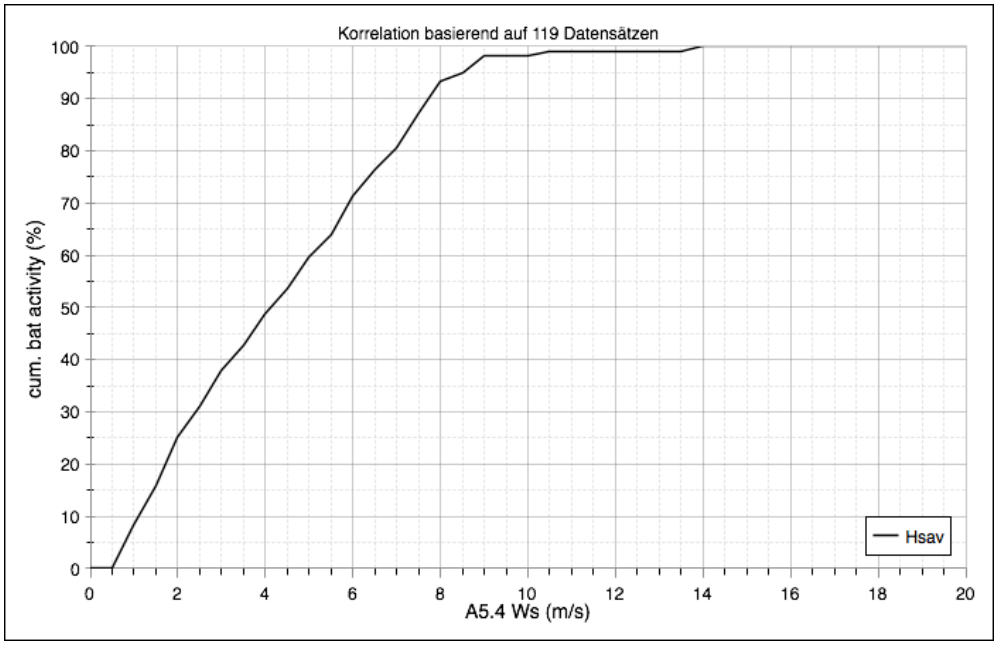
3. Activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in June 2017 at location of WF Jelinak.



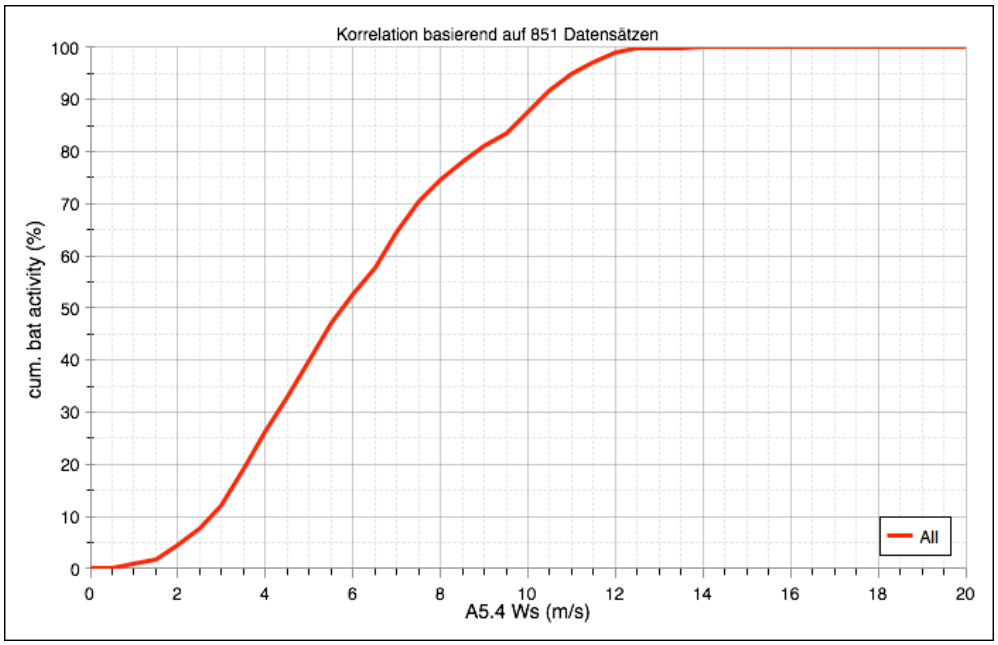
4. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in July 2017 at location of WF Jelinak.



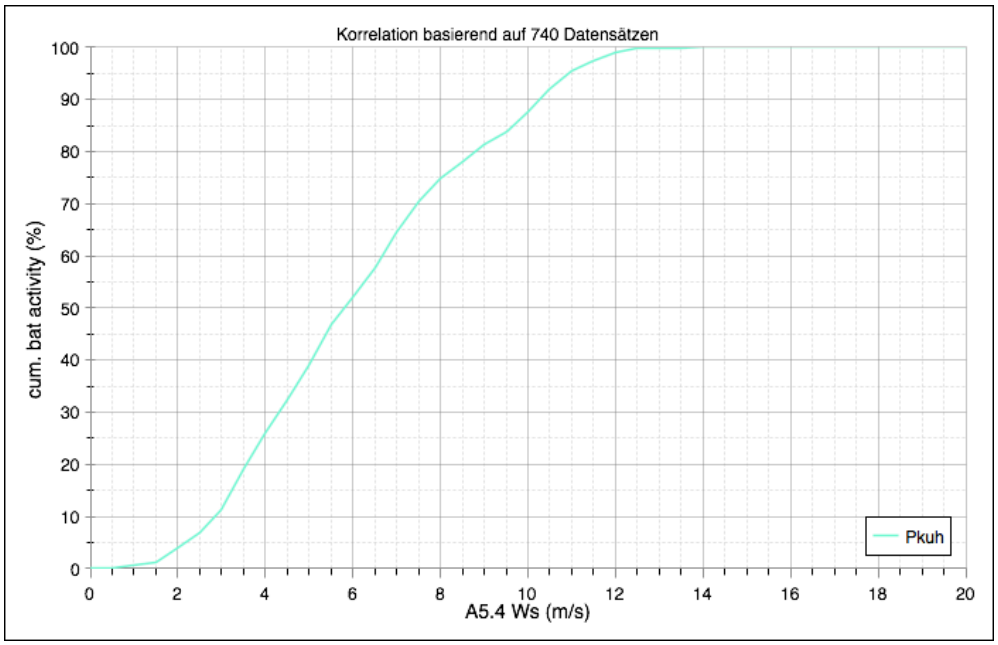
5. Activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in July 2017 at location of WF Jelinak.



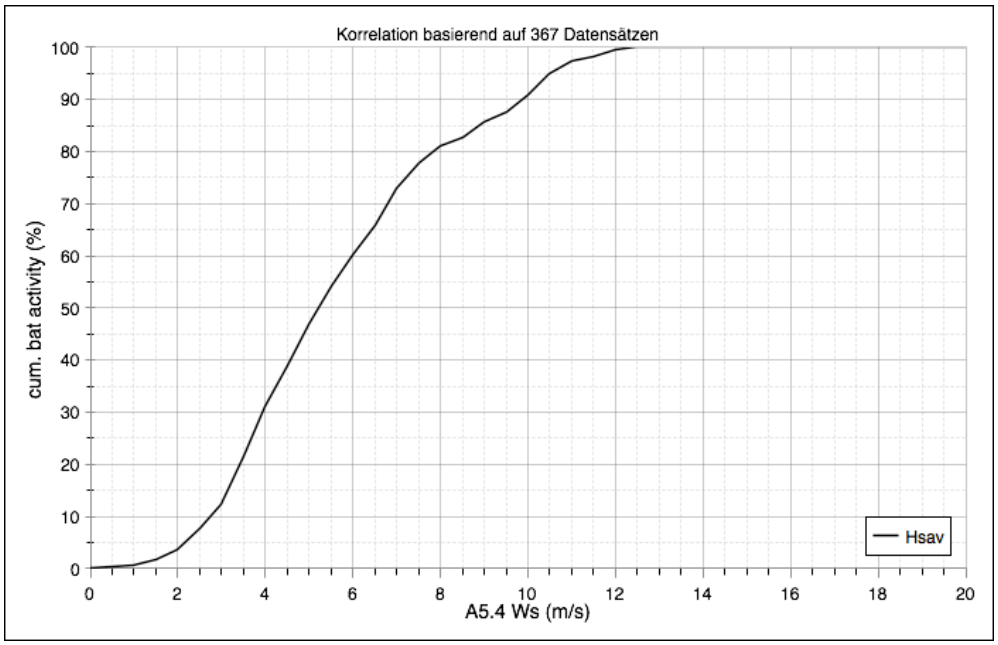
6. Activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in July 2017 at location of WF Jelinak.



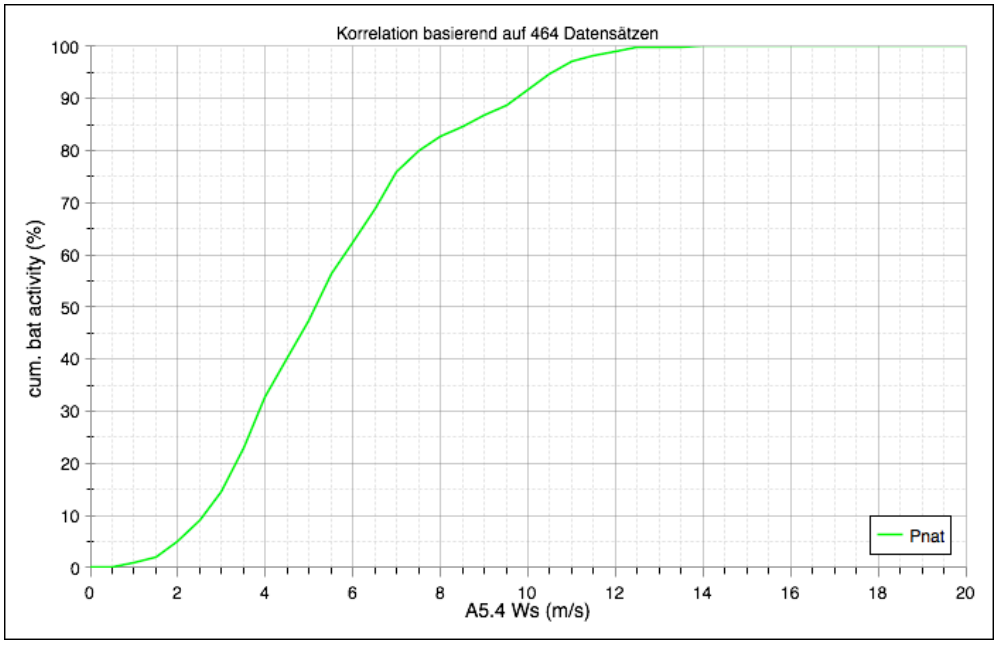
7. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in August 2017 at location of WF Jelinak.



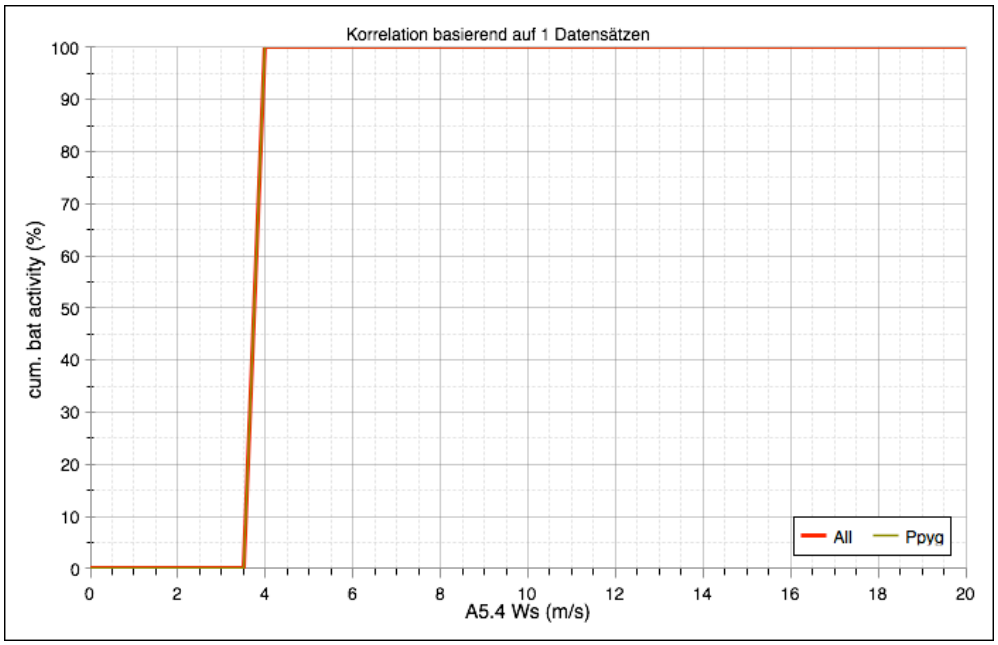
8. Activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in August 2017 at location of WF Jelinak.



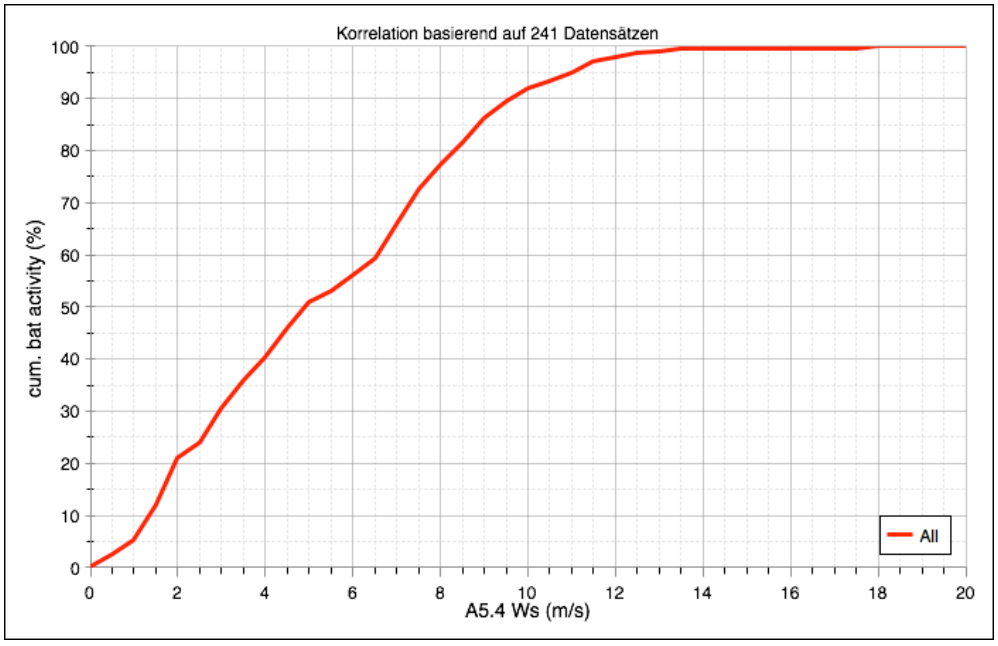
9. Activity of species *Hypsugo savii* in relation to the wind speed at wind turbine O.U.01 in August 2017 at location of WF Jelinak.



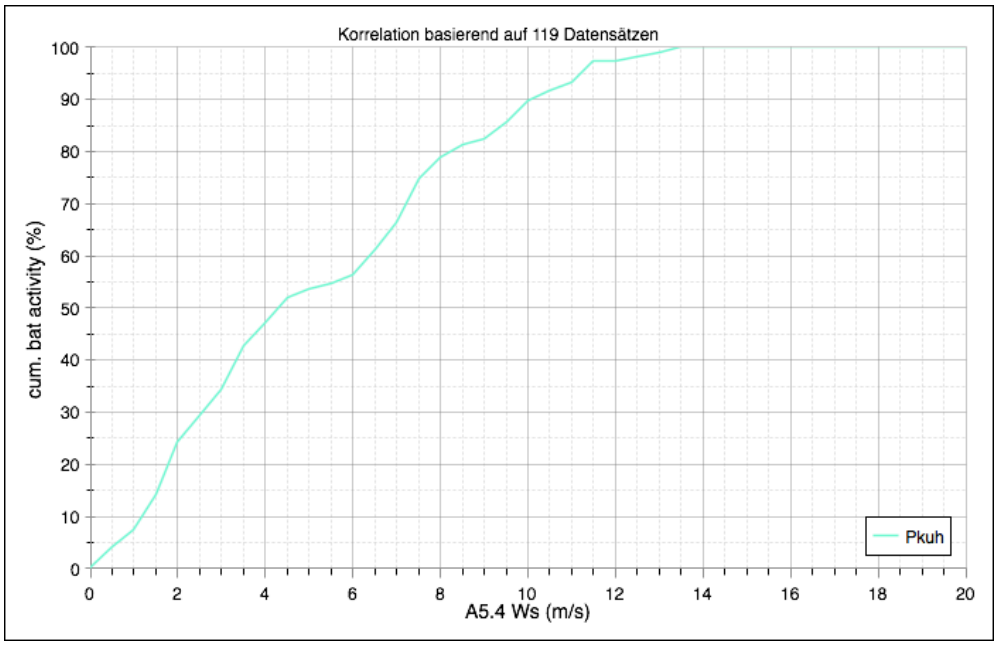
10. Activity of species *Pipistrellus nathusii* in relation to the wind speed at wind turbine O.U.01 in August 2017 at location of WF Jelinak.



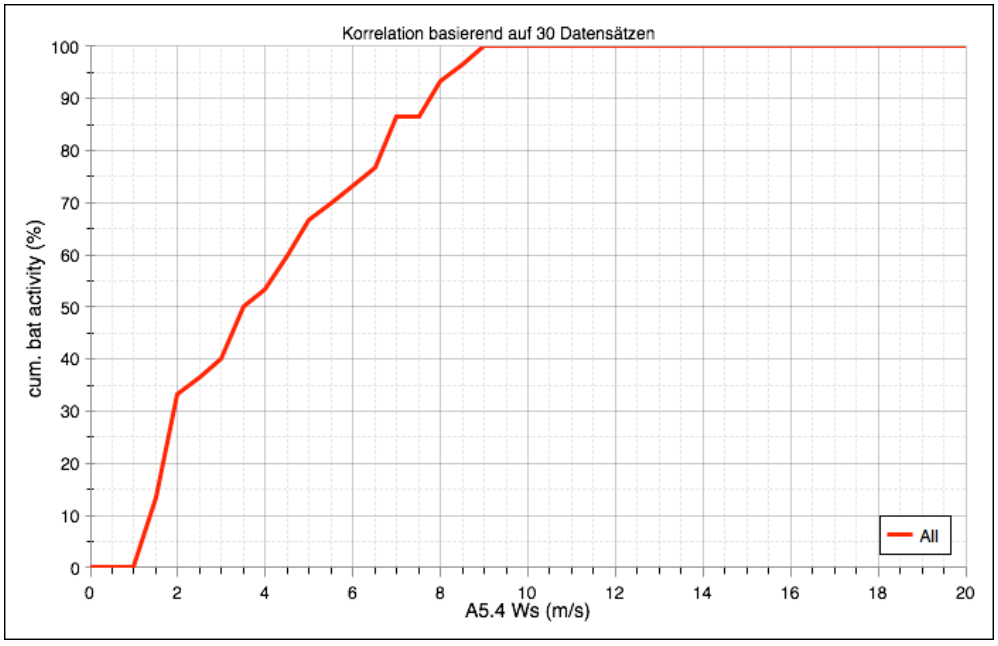
11. Activity of species *Pipistrellus pygmaeus* in relation to the wind speed at wind turbine O.U.01 in August 2017 at location of WF Jelinak.



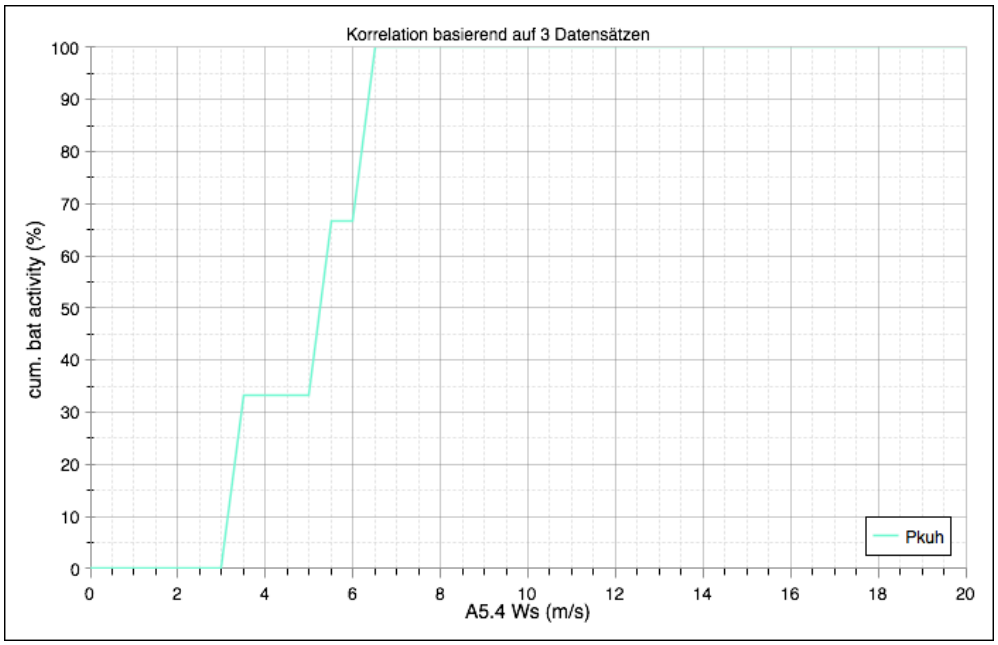
12. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in September 2017 at location of WF Jelinak.



13. Activity of species *Pipistrellus kuhlii* in relation to the wind speed at wind turbine O.U.01 in September 2017 at location of WF Jelinak.



14. Total activity of all recorded bat species in relation to the wind speed at wind turbine O.U.01 in October 2017 at location of WF Jelinak.



15. Ukupna aktivnost šišmiša vrste *Pipistrellus kuhlii* u odnosu na brzinu vjetra kod vjetroagregata O.U.01 u listopadu 2017. godine na lokaciji VE Jelinak.