



Short Note

Salix flowers, *Orthosia* moths and moth specialist bats – a possible connection

Grzegorz APOZNAŃSKI^{1,*}, Alek RACHWAŁD²

¹Department of Vertebrate Ecology and Paleontology, Institute of Environmental Biology, Wrocław University of Environmental and Life Sciences, ul. Koźuchowska 5b 51–631 Wrocław, Poland

²Forest Ecology Department, Forest Research Institute, Ul. Braci leśnej 3 05–090 Sękocin stary, Raszyn, Poland

Keywords:

hibernation
brown long-eared bat
western barbastelle
willow moth
trophic relationship

Abstract

We present the results of 63 nights of recordings carried out in early spring in the years 2017 to 2020. In the beginning of vegetative season in northern Europe insects are scarce and one of the first blossoming trees – *Salix* spp. are providing local hotspots of *Orthosia* moths – a possible food source for moth specialized bats, such as the brown long-eared and barbastelle. Our experiment confirms a relationship between willows and long-eared bats, manifested with overall higher activity around willow than in vicinity of other trees and remains inconclusive for barbastelles.

Article history:

Received: 6 August 2022

Accepted: 18 April 2023

Acknowledgements

The project was funded by the Swedish Energy Agency through the Vindval program (no. 2016-00010). The authors declare there is no conflict of interest. GA participated in all parts of the project; conceptualization, field work, analysis, drafting and writing. AR contributed to writing and drafting. We would like to thank Andrew Carr for English proofreading. Last but not least we would like to highlight a great contribution to this work by late professor Jens Rydell, who inspired us to carry out this project and helped both in the field collecting date and in the office working on the early stage of this note, his incredible energy will be missed.

The common willow *Salix caprea* (Linnaeus, 1767) is a dominant pollen and nectar producer in early spring and is therefore of high ecological importance (Sommerville, 1992; Enescu et al., 2016). Particularly male trees, more abundant and flowering slightly earlier than females, are visited by many insects, including bees (Hymenoptera, Apidae), hover flies (Diptera, Syrphidae) and, at night, moths (Lepidoptera, Noctuidae) (Füssel 2008).

The genus of noctuid moths *Orthosia*, also called willow moths, includes several large species which imagos feed on the pollen and nectar of *Salix* flowers. The flight activity of willow moths coincides almost perfectly with flowering *Salix caprea*, which, in northern Europe mostly occurs in April (Evans, 1846; Skou, 1991). The noctuids, including willow moths, belong to a major group of moths which evolved a highly efficient protection against echolocating bats, based on ultrasonic hearing (Roeder and Treat, 1961; Miller and Surlykke, 2001).

Bat echolocation calls of high intensity trigger various evasive maneuvers making the moth difficult to catch in most situations (Roeder, 1967; Hofstede and Ratcliffe, 2016).

In northern Europe, April is also the time when most bats leave their winter roosts and start feeding. Insect availability is generally low at this time of year due to low night temperatures and highly unpredictable weather (Rydell, 1989). Given the predictable occurrence of catkins and willow moths at a time when only a few other nocturnal insects are active, we can expect this potential food resource might be targeted by certain species of bats. There are two species of bat in the study area that are able to bypass the acoustic defense system of noctuid moths by

using low amplitude echolocation calls or passive listening to approach prey (Görlitz et al., 2010). Brown long-eared bat *Plecotus auritus* (Linnaeus, 1758) and the barbastelle *Barbastella barbastellus* (Schreber, 1774) they are also known to catch insects on a substrate, a technique called “gleaning”, and both are considered moth specialists (Rydell, 1989; Rydell et al., 1996; Vesterinen et al., 2018; Carr et al., 2021).

There is no evidence that the above scenario actually occurs in nature. Therefore, we designed a pilot study to investigate this potential phenomenon. We aimed to test the hypothesis that the moth specialist bats (*Plecotus* and *Barbastella*) could feed on willow moths captured near flowering *Salix* trees. The null hypothesis is that there is no such relationship. We predict that *Plecotus* and/or *Barbastella* are more abundant at willows than at other trees in April, when the trees are in flower and adult willow moths are expected to be active. Using acoustic monitoring, we compared the relative activity of these bats at flowering willows and other trees, following a pairwise experimental design.

Field work was undertaken during April and early May of 2017, 2018, 2019 and 2020. Data was collected in two provinces of southern Sweden (Table 1), both of which have been described in detail in previous papers (Rydell 1989, Apoznański et al. 2018). Generally, the areas are characterized by small-scale mix of semi-boreal forest, deciduous woodland and agriculture. One area (used in 2017) is in the coastal province of Halland at 0–100 m elevation (57°0' N, 12°40' E), and the other, (used between 2018–2020), was located at ca 250 m elevation inland in the province of Västergötland (57°45' N, 13°25' E). Additionally, detector pairs deployed during controls on 21st and 22nd April 2020 were located in vicinity of churches known to be used by long-eared bats in order to increase the chance of recording their activity.

*Corresponding author

Email address: grzegorz.apoznanski@upwr.edu.pl (Grzegorz APOZNAŃSKI)

Table 1 – Date, location (center point), number of detectors pairs and test/control species in the experiment. Paur = *P. auritus*, Bbar = *B. barbastellus*, Myotis sp. = genus *Myotis*. In the column “summary results” trees (genus) and the corresponding number of recorded bat flights are given in parentheses).

date	province	location [GPS]	no. of pairs	summary results test (Paur/Bbar/Myotis sp.)	control [no.] genus (Paur/Bbar/Myotis sp.)
05.04.2017	Halland	Askome [57.016 12.668]	4	<i>Salix</i> (4/0/4)	[3] <i>Betula</i> (0/2/0), <i>Corylus</i> (0/0/0)
08.04.2017		Askome [57.016 12.668]	16	<i>Salix</i> (3/31/6)	[2] <i>Alnus</i> (0/0/1), [9] <i>Betula</i> (1/16/3), [3] <i>Picea</i> (3/16/20) <i>Pinus</i> (1/0/0), <i>Quercus</i> (0/0/0)
20.04.2018	Västergötland	Ulricehamn R40 [57.804, 13.466]	6	<i>Salix</i> (0/0/0)	<i>Populus</i> (0/0/0), [4] <i>Quercus</i> (0/0/1), <i>Alnus</i> (0/0/0)
21.04.2018		Böne [57.882, 13.517]	1	<i>Salix</i> (0/0/0)	<i>Alnus</i> (0/0/0)
		Dalum [57.900, 13.476]	1	<i>Salix</i> (0/0/0)	<i>Betula</i> (0/0/0)
		Blidsbergs [57.927, 13.489]	1	<i>Salix</i> (1/0/0)	<i>Alnus</i> (0/0/0)
		Kölaby [57.981, 13.557]	1	<i>Salix</i> (0/0/2)	<i>Betula</i> (0/0/0)
		Möne [57.926, 13.380]	1	<i>Salix</i> (0/0/0)	<i>Betula</i> (0/0/0)
		Kärråkra [57.961, 13.360]	1	<i>Salix</i> (0/0/0)	<i>Betula</i> (0/0/0)
		Brunn [57.797, 13.368]	1	<i>Salix</i> (3/0/4)	<i>Fraxinus</i> (0/0/0)
22.04.2018		Grönahög [57.664, 13.597]	1	<i>Salix</i> (0/0/2)	<i>Sorbus</i> (0/0/0)
		Gällstad [57.664, 13.431]	1	<i>Salix</i> (0/0/0)	<i>Sorbus</i> (0/0/0)
		Finnekumla [57.656, 13.349]	1	<i>Salix</i> (0/0/2)	<i>Betula</i> (0/0/0)
		Tvärred [57.726, 13.316]	1	<i>Salix</i> (0/0/0)	<i>Betula</i> (0/0/0)
05.05.2018		Källebacka [57.731, 13.427]	2	<i>Salix</i> (0/0/0)	<i>Acer</i> (0/0/0), <i>Fraxinus</i> (0/0/0)
		Alenäset [57.739, 13.399]	1	<i>Salix</i> (0/1/2)	<i>Betula</i> (0/0/0)
		Sjögunnarsbo [57.748, 13.397]	1	<i>Salix</i> (0/0/2)	<i>Alnus</i> (0/0/0)
		Ubbarp [57.702, 14.213]	2	<i>Salix</i> (0/0/0)	<i>Quercus</i> (0/0/0), <i>Populus</i> (0/0/0)
08.04.2019		Sanatorieskogen [57.399, 14.652]	3	<i>Salix</i> (3/0/0)	[2] <i>Betula</i> (1/0/0), <i>Sorbus</i> (0/0/0)
16.04.2019		Fänneslunda [57.876, 13.166]	4	<i>Salix</i> (5/0/0)	<i>Alnus</i> (0/0/0), <i>Populus</i> (1/0/0), <i>Betula</i> (2/0/0), <i>Fraxinus</i> (0/0/0)
17.04.2019		Årås [57.884, 13.642]	4	<i>Salix</i> (4/0/0)	[2] <i>Betula</i> (3/0/3), <i>Alnus</i> (0/0/0), <i>Ulmus</i> (1/0/0)
06.04.2020		Skottek [57.768, 13.398]	2	<i>Salix</i> (2/0/0)	<i>Quercus</i> (0/0/0), <i>Betula</i> (0/0/0)
07.04.2020		Lassalyckan [57.783, 13.438]	1	<i>Salix</i> (0/0/0)	<i>Fraxinus</i> (0/0/0)
		Skottek järnvägen [57.765, 13.399]	1	<i>Salix</i> (1/0/0)	<i>Betula</i> (0/0/0)
		Vegby [57.678, 13.376]	1	<i>Salix</i> (0/0/0)	<i>Betula</i> (1/0/1)
08.04.2020		Sanatorieskogen [57.399, 14.652]	4	<i>Salix</i> (1/0/0)	[2] <i>Populus</i> (1/0/0), <i>Quercus</i> (0/0/0), <i>Fraxinus</i> (0/0/0)
		summary:	63	test (27/32/22)	control (15/33/29)

Salix caprea is a characteristic tree in both areas providing abundant resources at a time of year when few plants are in flower.

In addition to *P. auritus* and *B. barbastellus* we included the mouse-eared bats, *Myotis* spp., some of which may perhaps glean insects and other arthropods, i.e. spiders, from surfaces although none of them appear to specialised on moths (Vesterinen et al., 2018). The brown long-eared bat and several *Myotis* species (*M. brandtii*, *M. mystacinus*, *M. nattereri*, and *M. daubentonii*) occur in both areas, but the barbastelle only occurs in the study area in Halland, where it is relatively common (Apoznański et al., 2018).

Strictly aerial-hawking bats such as noctules *Nyctalus* spp., serotines *Eptesicus* spp., pipistrelles *Pipistrellus* spp., and the parti-colored bat *Vespertilio murinus* also occur in the study areas and were frequently recorded. However, they were omitted from this study, as we consider it highly unlikely than they would glean insects from flowers (Schaub and Schnitzler, 2007; Denzinger et al., 2013).

The study was based on recording bats with ultrasonic detectors (Table 1). Bat calls were recorded automatically from sunset to sunrise, using real time full spectrum bat detectors D500X (Pettersson Elektronik AB, Uppsala, Sweden; www.batsound.com). The detectors were placed pairwise at 1-2 m height in a flowering *Salix caprea* and in a non-*Salix* tree of similar size within 50–100 m. The detectors were activated for one full night at each site with the microphone directed sideways. They were programmed as follows: sensitivity = medium, sampling frequency = 384 kHz, recording time = 3 s, input gain = 45, trigger level = 80 and trigger interval = 10 s. The recordings were saved

as wave files on 32 or 64 GB memory cards and later transferred to a hard-drive for permanent storage.

The sound files were manually identified from spectrograms using BatSound version 4.4. (Pettersson Elektronik AB, Uppsala, Sweden). The files were identified to species (or species group) using the illustrations in Russ (2012) and complemented with various other sources as well as the authors’ own experience. *Plecotus auritus* is often quiet or nearly so when actively foraging, but they commonly use echolocation during aerial foraging (Anderson and Racey, 1991), emitting sound through the nostrils as well as the mouth (Jakobsen et al., 2017). They also can be recognized by the “social calls” which are commonly emitted in spring (Furmankiewicz et al., 2013; Middleton, 2014). The occurrence of another species of this genus, *Plecotus austriacus*, has not been confirmed in the part of Sweden where the research was conducted (this species is known from Sweden from one dead specimen, Razgour et al., 2013).


Due to the inflation of zeros our data was not normally distributed. Nevertheless, since the sample size was over 50 (N=63) we employed paired t-test to compare experiment with control. For the same reason tests based on median comparison were ineffective, we therefore compared the results for pairs with at least one bat with the Mann–Whitney U test (Table 2).

The result of this pilot shows significant relation between willows and brown long-eared bats (Table 2). This indicates that the phenomenon is worth more thorough study. There could be a connection between gleaning bats, moths and *Salix*, according to our hypothesis,

but only with respect to *Plecotus*. There was no sign that other species behave in this way (Table 2). However, the preliminary results provide the first step in the testing of our hypothesis. The results should be confirmed through a more directed study, perhaps using video at known *Salix* trees to record the behavior of *Plecotus* at the catkins. Further research should include the study on moths. We have no doubt that *Salix* trees could indirectly benefit bats, by concentrating the prey to easily recognized sites in the critical period of the season (end of hibernation). In fact, there were probably so many *Salix* flowering at the same time that most of them were not visited by bats on any given night. This relative scarcity of bats (compared to the plants) resulted in zero inflation in our data set. Indeed, bats were recorded on 22 out of 63 nights only. Additionally, results were further distorted by an interesting single case phenomenon – an unexpectedly high activity of bats of all taxa in vicinity of one of the control trees – a young norther spruce. After a close examination of the tree in question it was established that it was covered with fresh raisin, likely attracting insects and therefore their predators. This observation on its own is worth further examination. However, due to its singular occurrence it was impossible to verify statistically. Overall, the reason for the relatively low activity of bats during the research period (early spring) may be the lack of larger hibernation sites in this area of Sweden, and further studies should be carried out in the vicinity of large hibernation sites. Nevertheless, obtained result is significant.

Table 2 – The outcome of paired recording nights on three bat taxa at flowering *Salix* trees (test) and other trees (control), respectively (n=63 nights), in Sweden in April 2017-2020 .

	number of observations		
	<i>Plecotus</i>	<i>Barbastella</i>	<i>Myotis</i>
<i>Salix</i>	27	32	22
control	15	33	29
paired t-test, one-tailed	p < 0.05	ns	ns
	number of pairs with activity n>0		
<i>Salix</i>	18	6	11
control	10	6	8
Mann–Whitney U test	p < 0.05	ns	ns

Our results suggest a possible important role of early flowering trees for the population of bats hibernating in a given area. Further research should answer the question whether the protection of the mentioned tree and shrub species may constitute a new element of the strategy for the protection of endangered bat species. 

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Associate Editor: L. Ancillotto