

Sękocin Stary 31.03.2019

AUTOREFERAT

Dr Aleksander Rachwald
Forest Research Institute
(English language version)

Academic degrees:

PhD in forest sciences (17.11.1998)

Forestry Department of the Warsaw University of Life Sciences (SGGW)

Thesis supervisor: professor Simona Kossak

The title of the dissertation: "Environmental preferences and activity of bats in natural stands of the Białowieża National Park"

MSc in biology (10.05.1987)

University of Gdańsk, Faculty of Biology, Geography and Oceanology

Thesis supervisor: professor Stefan Strawński

The title of the master's thesis: "Research on bats of the Vistula Spit, with particular emphasis on the Nathusius' pipistrelle *Pipistrellus nathusii* (Keys. Et Blas.) in the years 1985-1986"

Further education

University of Aberdeen, School of Biological Sciences, Royal Society/NATO Postdoctoral Fellowship, head of the lab: *Regius professor* Paul A. Racey (2002 – 2003)

Professional career in the field of science

01.01.1999 – today

Forest Ecology Department, Forest Research Institute, 3 Braci Leśnej St., Sękocin Stary, Raszyn – senior scientist (adiunkt)

01.04.2004-31.12.1998.

Forest Ecology Department, Forest Research Institute, 3 Braci Leśnej St., Sękocin Stary, Raszyn – scientist (asystent)

01.01.1990-30.01.1994

Mammal Research Institute (Polish Academy of Sciences), 1 Stoczek St., Białowieża – scientist (asystent)

The most important experiences gained abroad

- Russia, Moscow, Moscow State University (MGU), research in the zoological collection, 1994

- Russia, Sankt Petersburg, Zoological Institute (Academy of Sciences), research in the zoological collection, 1995

- United Kingdom, University of Aberdeen, postdoc Royal Society/NATO Research Fellowship, 2002-2003

- United Kingdom, University of Aberdeen, Honorary Research Fellowship, 2003-2004

- Albania, four zoological expeditions in 2004-2007

- France, Paris, 12th SBSTTA Convention of Biological Diversity (expert from the Ministry of Environment), VII 2007

- Italy, Rome, 13th SBSTTA Convention of Biological Diversity (expert from the Ministry of Environment), V 2008

- Czech Republic, Prague, Meeting of Parties EUROBATs agreement (expert from Ministry of Environment), 2010

- Georgia, Tbilisi, Meeting of Advisory Committee EUROBATS agreement (expert from Ministry of Environment(, 2011
- Greece, Heraklion, Meeting of the Advisory Committee EUROBATS agreement (expert from the Ministry of Environment), 2012
- Montenegro, two zoological expeditions in 2014-2015

ACHIEVEMENT THAT IS THE BASIS FOR THE APPLICATION OF THE DEGREE

As an achievement resulting from art. 16 sec. 2 of the Act of 14 March 2003 on academic degrees and academic title, and on degrees and title in the field of art (*Dz. U. nr 65, poz. 595 ze zm.*), I indicate a series of five original scientific publications under the joint title "Bats in the forest ecosystem under the influence of anthropogenic factors" in which I am the main author:

Rachwald A., Wodecka K., Malzahn E. & Kluziński L. 2004. Bat activity in coniferous forest areas and the impact of air pollution. *Mammalia* 68 (4), 445-453

H index 31, JIF2004: 0,269/Pkt MNiSW2012: 15

Rachwald A., Bradford T., Borowski Z. & Racey P. A. 2016. Habitat Preferences of Soprano Pipistrelle *Pipistrellus pygmaeus* (Leach, 1825) and Common Pipistrelle *Pipistrellus pipistrellus* (Schreber, 1774) in Two Different Woodlands in North East Scotland. *Zoological Studies*, 55 (22): 1-8.

H index 37, JIF2016: 1,054/Pkt MNiSW2016: 25

Rachwald A., Gottfried I., Gottfried T. & Szurlej M. 2018. Occupation of crevice-type nest-boxes by the forest-dwelling western barbastelle bat *Barbastella barbastellus* (Chiroptera: Vespertilionidae). *Folia Zoologica* 67 (3-4), 231-239.

H index 30, JIF2018: 0,467/Pkt MNiSW2016: 20

Rachwald A. 2019. Nietoperze jako wskaźniki stanu środowiska leśnego. Sylwan 163 (03): 228-237.

H index 6, JIF2019: 0,623/Pkt MNiSW2016: 15

Rachwald A. & Fuszara M. 2014. Podręcznik najlepszych praktyk ochrony nietoperzy w lasach. CKPŚ, Warszawa, pp. 87. DOI 10.5281/zenodo.2602675

Pkt MNiSW: 25

Total JIF: 2,413/Pkt MNiSW: 100

EXPLANATION OF THE SCIENTIFIC PURPOSE OF PAPERS SUBMITTED FOR SCIENTIFIC DEGREE AND ACHIEVED RESULTS

In the period after the obtaining the PhD degree, one of the main directions of my scientific activity was research on bat communities in commercial forests in Europe, with particular emphasis on coniferous stands as a dominant element in the contemporary forest landscape. The research was aimed, on the one hand, at the analysis of bats' assemblage in forest stands, with particular emphasis on coniferous forests, on the other hand, on bats as an element of the forest ecosystem and possible indicator of its transformation. With such a research direction, the natural development of interest was also the protection of forest bats, which (in particular in recent years) is an issue important due to the large number of forest areas of Natura 2000, in which one of the objects of protection are bats. In my research, I focused on the following issues:

- the question whether, apart from geographical factors (resulting from the natural ranges of geographical distribution), there are also other factors affecting species composition and density of bats in the forest environment, with particular emphasis on coniferous stands,
- how bats differentiate their occurrence between the deciduous forest of natural regeneration and the commercially used coniferous forest

- what method can be used to increase the species diversity of bat community in managed forests (especially mixed forests and in coniferous), especially when it comes to vulnerable and Natura 2000 species. The chosen species was the barbastelle bat *Barbastella barbastellus* (Schreber, 1774), a species typical of old forests, often appearing in the conservation tasks of the Natura 2000 forest areas
- summary of existing knowledge about the impact of anthropogenic factors on forest bats and on the indicator role that bats can play in the forest environment, especially in managed stands
- the purpose of the work was also to provide general knowledge and suggestions for specific solutions applicable to the protection of bats that are ecologically connected with forests. This knowledge is intended for foresters, employees of National Parks and Regional Directorates of Environment Protection (RDOS), as well as for all others dealing with this issue in practice.

A detailed description of the research results described in the individual publications constituting the scientific achievement that is the basis for applying for the degree:

1. Rachwald A., Wodecka K., Malzahn E. & Kluziński L. 2004. Bat activity in coniferous forest areas and the impact of air pollution. *Mammalia* 68 (4), 445-453

The research concerned the comparison of occurrence (relative density measured by acoustic activity) of bats on five study areas in mixed coniferous forests, exposed to varying degrees to the effects of air pollution. These were: Puszcza Białowieska, Biebrza Valley, Puszcza Kozienicka, Bory Tucholskie and forests in Upper Silesia. Areas with stands between 70 and 100 years of age were selected, the dominant species was pine. The roosting potential for bats between areas (number of hollows and dead trees - habitat trees) was also compared. The main method was the recording of bats activity using the ultrasound detector on linear transects, two transects located on each area. In order to compare the food potential between the surfaces, the catches of flying insects (potential bats food) were also carried out, the samples were dried to dry weight and weighed. In order to determine the degree of environmental pollution, the content of five contaminants (SO₂ in air and elemental sulphur, copper, lead and cadmium in moss *Pleurozium schreberi*) was tested on all surfaces. The

analyses were carried out in the laboratory of the Forest Research Institute using Perkin Elmer AAS-1100 atomic absorption spectrophotometer (heavy metals) and LECO SC-32 (sulphur).

There were significant differences in bats' activity between the studied areas. The average flight activity (median number of recorded flights) was from 21 flights/1 control (Dolina Biebrzy) to 1 flight/1 control (stands in Upper Silesia). The highest species diversity of bats (Shannon's coefficient) was found in the Białowieża Forest and the Biebrza Valley, the lowest was found in Upper Silesia, in the area of Świerklaniec, in an area that has been under the influence of industrial emissions for many years. Cluster analysis (in terms of the following factors: median number of flights, median number of feeding buzzes, species diversity coefficient and the proportion of bat species preferring a close forest to those preferring open spaces) showed the greatest similarity between the areas in the Białowieża Forest and the Biebrza Valley, and the farthest from all the remaining ones were results from Upper Silesia. There were significant differences between study areas in terms of the concentration of most toxic substances. The lowest concentration of sulphur and cadmium was found in the Białowieża Forest, concentration of lead in the Biebrza Valley, copper and SO₂ in the Tuchola Forests. In all cases, the highest concentrations were found in Upper Silesia. On most areas, no correlation was found between insect biomass and bat activity, with the exception of the Biebrza Valley, where such relationship was significant.

Large differences were found in bat community between the studied forest areas, which were consistent with the direction of diversity of environmental contamination, both with sulphur dioxide and heavy metals. In addition to other possible factors (such as the impact of forest management in the past), the level of heavy metal pollution and sulphur dioxide may be one of the reasons for the pattern of bats in these areas. It should be emphasized that the impact of air pollution on various animal species is not only direct (poisoning the organism, reproductive impairment) but also indirect, through the impact on tree stands (eg limiting the growth of trees). The conclusions stated that further work should be developed in the direction of comparisons of selected features of tree stands between particular areas, as well as the analysis of heavy metal content in bats' bodies and their food.

2. Rachwald A., Bradford T., Borowski Z. & Racey P. A. 2016. Habitat Preferences of Soprano Pipistrelle *Pipistrellus pygmaeus* (Leach, 1825) and Common Pipistrelle

Pipistrellus pipistrellus (Schreber, 1774) in Two Different Woodlands in North East Scotland. Zoological Studies, 55 (22): 1-8.

The research included the analysis of the activity of two co-occurring bat species: the common pipistrelle *Pipistrellus pipistrellus* and the soprano pipistrelle *Pipistrellus pygmaeus*. *P. pipistrellus* is considered to be an eurytopic species, occupying hiding places both in buildings and tree hollows. *P. pygmaeus* is a species that prefers the forest environment and areas close to the waters to a greater extent.

Until the 1990s, *P. pygmaeus* species was not distinguished, existing individual differences were attributed to the internal diversity of *P. pipistrellus* species. After the final confirmation of the existence of two (so-called) twin species, in the course of further research, the presence of the newly discovered species was found throughout the prevalence of *P. pipistrellus*, in many areas these species coexist, but with a certain distribution of resources (both roosting places and feeding areas). Currently, these species are easily recognisable due to a number of morphological features and due to the significant difference in frequency of echolocation signals of both species (f_{\max} : 45 vs. 55 kHz).

The research was carried out in the Deeside area (eastern Scotland). In the Deeside area, which lies in the northern part of the British Isles, the bats' community is poor compared to the southern part of the country. Relatively high densities here show only *P. pipistrellus* and *P. pygmaeus*, which makes this area particularly conducive to analyzes of the coexistence and interaction of these two species, with no possible disturbance caused by the presence of a larger bats complex. Two types of forested area were selected for analysis. One of them was represented by the widespread (mature) forest in this area, coniferous woodland originating from artificial planting, in which Douglas fir (*Pseudotsuga menziesii* Mirb. Franco) dominates, with the participation of Sitka spruce (*Picea sitchensis* (Bong.) Carrière) and Norway spruce (*Picea abies* (L.) Karst. In these stands, commercial use was carried out (in the form similar to that of nest felling), as well as management treatments. The second type of stand was a mature stand entirely of natural regeneration, dominated by silver birch (*Betula pendula* Roth), in a nature reserve established in the area of overgrown moors (unused since the 1940s, previously a place of grazing sheep). This tree stand is a natural forest succession step in these areas.

Two methods of monitoring the activity of bats were used. The first of these was the ultrasound recording of bats along linear transects (three transects for each study area, respectively in the forest-shrub-water ecotone, in a dense forest and in the forest-meadow ecotone). At the same time, recording was used at stationary points, using automatic recorders

developed by prof. Paula Racey and Dr. Nick Downs (School of Biological Sciences, University of Aberdeen). The first method allowed to distinguish the species of recorded bats, as well as to distinguish the type of activity: flight, foraging or social. The second method gave the result in the total number of bat flights in a given period of time (no distinction between species). The advantage of the second method is the possibility of continuous overnight recording. In addition to the recording of flight activity, a search for colonies of bats was carried out in buildings in the Dee river valley, within a radius of around ten kilometres from the study area.

The disadvantage of the adopted methodology was a relatively small number of research areas (only one area in each type of stand, three transects and 10 points in each). This was due to the unique character and limited area of the forest of natural origin in Deeside: it was not possible to designate more transects for recording. Natural forests are scarce in Scotland and it has not been possible to cover a larger area with research. Therefore, the statistical analyzes carried out were not as advanced as it would be possible to study in larger areas, but nevertheless allowed to find the existence of significant relationships.

In terms of the general activity of all bats, preference was given to the deciduous forest, as well as a more even distribution of bats' activity in this stand. In coniferous stands, the significant majority of bats activity was concentrated in ecotones, especially in the forest-shrub-watery area. Analyzing particular species it was found that in the birch stand of natural regeneration *P. pygmaeus* preferred significantly aquatic ecotone, while *P. pipistrellus* were less selective, using the area near the water, meadows and dense forest more evenly. The dense coniferous stand was generally the least preferred environment. *P. pygmaeus* was more numerous than its twin species, but its density was significantly higher than *P. pipistrellus* only on transects near waterbodies (both in the conifers and in the deciduous forest). The social activity of this species was also particularly high in the vicinity of waters, which suggests the occurrence of competitive behaviour (stripping other individuals from the feeding grounds). The results of this work confirm that dense coniferous stands create an environment that is particularly unfavorable to the occurrence of bats. The low bat hunting activity observed in this environment suggests that there is insufficient supply of food. Because conifers (especially spruces, but also morphologically similar Douglas firs) are less susceptible to the formation of hollows (natural bats' roosting places), the lack of suitable places for nursery colonies may also be an important factor. Among the final conclusions was the suggestion that it would be advisable to conduct research on the preferences of both

species studied in areas where occur in allopatry, to determine whether in the absence of pressure from the second species significant changes in environmental preferences will occur.

The research was conducted as part of a one-year post-doctoral stay, funded by the Royal Society / NATO Fellowship Fund.

3. Rachwald A., Gottfried I., Gottfried T. & Szurlej M. 2018. Occupation of crevice-type nest-boxes by the forest-dwelling western barbastelle bat *Barbastella barbastellus* (Chiroptera: Vespertilionidae). *Folia Zoologica* 67 (3-4), 231-239

Loss of hollow trees (with hollows forged by woodpeckers, as well as other types of holes and cracks of the trunk and bark) is a key factor deteriorating the habitat for many species of animals inhabiting the forests, including bats. The holes forged by woodpeckers (*Picidae*), as well as other natural openings in trees, provide typical roosting place for bats in the temperate forest. Thus, the loss of such shelters, apart from the loss of food resources, is a key factor threatening the durability of bat populations, especially considering that natural hollows in trees give bats protection against predators for the day, but above all they are a place for nursery roosts, so they are crucial for survival and development of the population.

Not every type of forest provides the same conditions for the occurrence of bats. In terms of the occurrence of potential roosting places, the forest (especially spruce) is a particularly unfavourable environment, because relatively little natural hollows are created there. In most cases only the gradual decay of standing dead spruces results in the formation of more convenient holes in them, which can be occupied by various species of animals. In the case of the dominance of fast-growing coniferous stands in economic forests in Europe (including Poland), bats from species typical of forests have limited settling possibilities. The standard method of increasing the ecological capacity of a poor forest environment in a hollows is the distribution of special nesting boxes for birds and bats in stands. The boxes for bats, made according to several standard projects, have been used as a means of active protection of bats in forests for several decades. There are cases of mass occurrence of some species of bats in boxes located in forest complexes, largely devoid of natural hollows (e.g. Bory Tucholskie). This is a very beneficial phenomenon due to the useful role that bats play in limiting the population of insects, which may especially threaten single-species conifers.

Of the species of bats found in forests in Poland, the only species that so far in principle did not use artificial shelters (bat boxes) is the western barbastelle *B. barbastellus*. This is due to the specific preferences of the species to the roost: it does not use the typical woodpeckers'

hollows (and boxes that are their equivalent), but forms colonies in the crevices created by the cracks in the trunk, under a thick protruding bark etc. Probably this is the main reason for this species is found almost exclusively in old deciduous tree stands. Pine and spruce stands are usually poorer in natural hollows and cracks. Barbastelle is a protected species listed in Annex II of the EU Habitat Directive, and one of only two Polish "Natura 2000" bat species closely related to the forest environment. As such, it is a frequent subject of protection in the forest areas of Natura 2000. Until now, a significant difficulty in the implementation of the conservation task plans for these areas caused the lack of an applicable method of active protection of this species. The aim of the work was to test on a sufficiently large research material a new type of bat box specifically designed for this species, and to assess whether this type of boxes will be able to be used for the active protection of the barbastelle also in coniferous stands.

The research was carried out on 6 research sites located in various stands throughout the country. Among them were deciduous, mixed and coniferous forests, all with mature stands. A total of 290 boxes were placed in the area. Observations were made during the two summer seasons, content of the boxes was controlled in June, August and October (once a month). Bats were counted using binoculars and a strong flashlight, from the foot of the tree, which was possible due to the open construction of the box. Thanks to this method, the bats were not disturbed and the nursery colonies that were formed did not leave the boxes.

In total, during the two-year observation period, 478 bats were recorded in new boxes, including 345 barbastelle. On all study stands except one, colony formation was also found, most of which had to be nursery colonies (in order to confirm this hypothesis, a control netting was made). It was also found that bats were the most abundant on areas in deciduous stands with oak dominance, least in dense coniferous stand (pine dominance), while in mixed stands the results varied. Nevertheless, even in the least favourable forest, the area was found to be populated with new types of boxes by barbastelle.

Such a large number of occurrence of bats in a new type of artificial shelter is a breakthrough in the methods of barbastelle protection. Until now, despite the use of bat boxes for decades and despite the fact that bats also occupy bird boxes, only one time in Poland the presence of a single specimen of this species in a bat box has been recorded. It is also confirmed now, that the barbastelles were colonizing a new type of boxes in a less favourable habitat, which is a coniferous stand. Thanks to this, it is now possible to use these boxes wherever protection plans require active methods of protecting barbastelles. This method has

already gained some interest, eg in 2018, the number of 100 boxes of this type was placed in coniferous stands in Mazowsze.

The research was carried out as part of the project "Development of artificial summer shelters for barbastelle *Barbastella barbastellus* and testing their effectiveness in practice", from IBL's own funds (No. 260103).

4. Rachwald A. 2019. Nietoperze jako wskaźniki stanu środowiska leśnego. Sylwan 163 (3): 228-237. [*Bats as indicators of the condition of forest environment*]

The work is an overview of published information on the impact of anthropogenic factors on the bats population, and on the role of bats as indicators of the condition of the environment, with particular emphasis on the forest environment. The article discusses the role of bats in the forest ecosystem (especially in European forests), the impact of environmental pollution on the forest and on bats and the related issue of the possible indicator role of these mammals. The existing data on the transfer of pollutants to the environment and between the aquatic and terrestrial environment were reviewed. The water environment is an important recipient of pollutions, which are then transferred to the terrestrial environment, including via larvae of terrestrial insects, which have their larval stage in an aqueous environment (eg Diptera: *Chironomidae*). Bats, being predators of insects, play an important role in this cycle. Another potential source of toxins for bats are terrestrial insects feeding on plants that carry toxins upstream of the food chain (insecticides, fungicides, substances from industry) that settle on the leaf surface. Bats as predators of the first or even second order store in this case in their bodies toxic substances (including heavy metals).

Air pollution also has a direct impact on forest stands, causing (in zones of heavy industrial pollution) inhibiting the growth of trees. The result is, among others, a smaller number of natural hollows, which in turn results in weaker settlement of stands by bats (the same phenomenon includes birds).

Populations of various species of bats living in the forest depend on such factors as the availability of natural roosting places, the age structure and spatial structure of tree stands. All these factors (as well as others which indirectly result from them) are subject to modifications in the forest management, which also translates into changes in bat populations. Ecological studies of forest bats show the variability of settling of forest stands, especially the reduced occurrence of typically forest bats connected ecologically with forests (eg *Barbastella barbastellus* or *Nyctalus leisleri*), favoring bats preferring open spaces and built-up areas

(*Eptesicus serotinus*). It was found that this is the result of the transformation of the stand structure. The collected information indicates that some species of bats (those that occur regularly in the forests) can be considered indicators of the condition of the forest environment.

5. Rachwald A. & Fuszara M. 2014. Podręcznik najlepszych praktyk ochrony nietoperzy w lasach. CKPŚ, Warszawa, pp. 87. DOI 10.5281/zenodo.2602675

In 2014, together with a co-author (Dr Maciej Fuszara, UKSW), we undertook to write a monographic study, summarizing our knowledge on the methods of protection of bat populations, with particular reference to the conditions of our country and the protection of bats in the forests. For my part, I have included examples and conclusions drawn from twenty years of my own research on bats in a forest environment, with particular emphasis on the managed coniferous stands, but also on the basis of research in stands of natural origin. In the assumption of the authors and publisher (Center for Coordination of Environmental Projects), this publication constitutes an overview and compendium of knowledge applicable in the protection of bats connected ecologically with forests. The book is divided into the following parts: Introduction - general information about bats, Threats and methods of bat protection, Best practices in bats protection, Other methods of bat protection and Bats protection in forests: summary. The first part describes species of these animals, occurring in temperate European forests (including Poland), as well as their role in the forest ecosystem. The second part describes the threats to the bat population associated with changes introduced into the natural environment through urbanization, industrialization and also the transformation of forest habitat, especially coniferous stands. The legal status of the protection of these animals has been described and legal acts have been listed. One chapter is devoted to the latest form of protection used in Poland, which are Natura 2000 sites.

The third part of the study is devoted to the recommended practical activities in the protection of these animals, on the example of specific actions implemented in Poland in the protection of summer roosts, wintering grounds and in the creation of new shelters for those animals that could replace the resource lost as a result of various factors. Among these factors is a long-term tendency to create economic conifer monocultures, which is currently limited, but its effects in the form of the current species structure of many forest stands and far-reaching transformations of the forest environment are still valid. Bats belong to those animals for which age-unified monoculture stands are an unfavourable habitat. The fourth part

describes the question of foraging areas (especially important in the context of forests and forest management), the issue of protection against collisions with vehicles and architectural objects (buildings, wind turbines, etc.) and the problem of light pollution. This last issue is important for bats even to a greater extent than for many other groups of organisms, because light on the one hand brings together bats attracting flying insects (their food), and on the other hand makes bats vulnerable to attacks by predators (mainly owls). The book also devotes a place to protection and creation of special shelters in forest areas (not only natural shelters, but also, for example, artificial objects that constitute hibernacula, or wintering places), and describes educational activities undertaken to disseminate knowledge about the situation of these animals and their role in forests. The book closes the list of addresses of specialists and institutions dealing in bats research and protection in Poland. This list includes, among others, the Forest Research Institute. This monograph was published in book form (as part of the cycle "Best for biodiversity"), as well as published as an Internet publication (DOI 10.5281 / zenodo.2602675), and then (also in the net) an extended version of this study was published in English.

The most important achievements of the mentioned works, broadening the state of knowledge in a given subject include:

- analysis of the possible relationship between the long-term impact of industrial emissions and the occurrence of bats in coniferous forest, especially in the case of indirect impact of emissions, which has not been taken into account so far,
- assessment of differences in preferences between two closely related species of bats, in relation to single-species deciduous forest from natural regeneration to economic coniferous forests growing in the same habitat,
- development of a new type of roosting boxes for bats and demonstration that it is suitable for use in the active protection of the species of bats typical for forests, also in the coniferous stands, considered to be unfavourable for the occurrence of this species,
- gathering and critically developing knowledge about the possible role of bats as indicators of the state of the environment, both their place in the chain of transfer of toxic substances to the forest environment, and the relationship between changes in the structure of tree stands and the occurrence of these animals in economic forests,

- development of recommendations for the practice of bats protection in forests based on existing best solutions in this field and based on own knowledge and research experience.

PRESENTING THE OTHER ACHIEVEMENTS IN THE FIELD OF RESEARCH-DEVELOPMENT, TEACHING AND ORGANIZATION OF SCIENCE

Presenting of scientific and research achievements other than those that form the basis for applying for the degree (the list of items cited below is in the appendix “Wykaz opublikowanych prac naukowych lub twórczych prac zawodowych oraz informacja o osiągnięciach dydaktycznych, współpracy naukowej i popularyzacji nauki”, 24 pp.)

After publishing the first scientific note from the work done during the university studies (Bielecka-Rządowska & Rachwald 1988), from the first research on biology and ecology of bats, conducted by me in northern Poland as part of my master's thesis, I focused my research interests on bat biology in forest environment. The results of works on colonization of bats *Nathusius' pipistrelle* *Pipistrellus nathusii* of pine forests on the Vistula Spit, obtained during the work on the MSc thesis, I published in two papers (Rachwald 1992b, c). After starting work as a research assistant at the Polish Academy of Sciences, I conducted the first in Poland research on bat ecology using an ultrasonic detector (in the Białowieża Forest), the results of which are quoted regularly until today (Rachwald 1992a, the latest quoted March 10, 2019). During the same period, I published two methodical publications devoted to methods of field research on bats (Rachwald 1995a, 1996).

After taking up a job at the Natural Forests Department of the Forest Research Institute (1994) in 1994-1995, I conducted research into the ecology of bats in the strict protection area in the Białowieża Forest, financed from the individual KBN grant No. 6P205 081 06 and from the GEF project funds 05-21685 POL. The result was a PhD dissertation titled "Activity and environmental preferences of bats in natural stands of the Białowieża National Park", finished in 1998. The work was done under the supervision of professor Simona Kossak, with whom I had the opportunity and pleasure to cooperate in the implementation of the GEF grant. During this period, I also published further publications devoted to ecology of forest bats (Rachwald & Nowakowski 1994, Rachwald 1995b, Rachwald & Labocha 1996).

After finishing my PhD degree (in 1998), I continued publishing materials obtained in the course of work in the Białowieża Forest and writing methodical and review papers, one-person and co-authored (Rachwald 2000a, b, Struzik & Rachwald 2000, Kowalski et al. 2000, Nowakowski et al. 2000, Rachwald 2001, Rachwald & Szkudlarek 2001, Rachwald et al. 2001, Sachanowicz et al. 2001). At that time I joined the work on the project "Biodiversity as an indicator of processes and changes of forest ecosystems in sustainable forest management" carried out at the Forest Ecology Department IBL, which then developed into a research cycle whose first work (Rachwald et al. 2004) is one of the publications included in the "habilitation" degree cycle. (The works that I have included in the series have been described in detail in the part of the "Autoreferat" directly related to the degree publications).

In 2011-2015, as part of the research project "Dynamics of selected species of zoocenosis based on long-term observations conducted in the Białowieża Forest. Part: Bats (Chiroptera)" funded by DGLP, carried out by a consortium under the leadership of IBL, I conducted research on the activity of bats in economical stands throughout the entire Białowieża Forest. The species composition was analyzed as well as the relationship between bat activity and distance to the nearest buildings and open waters. The relationship between bats activity and tree stand age, type of stand (coniferous versus deciduous) and canopy closure was also examined. Bats activity was recorded on eight linear transects, with a typical length of 2.5-3 km, using Pettersson D1000X ultrasonic detectors, and then analyzed using BatSound 4.2 and SonoBat 4 software. During the research, I found the following species of bats: barbastelle (*Barbastella barbastellus*), late moth (*Eptesicus serotinus*), Great echinococcus (*Eptesicus nilssoni*), common noctule (*Nyctalus noctula*), lesser noctule (*Nyctalus leisleri*), small dwarf (*Pipistrellus pygmaeus*), greater dwarf (*Pipistrellus nathusii*), tiny dwarf (*Pipistrellus pipistrellus*), silver-faced moth (*Vespertilio murinus*) and bats from the genus *Myotis* (nocturnal). Significantly higher activity of bats was observed in deciduous stands than in coniferous stands, the level of activity (recorded number of passes) of some bat species was also correlated with the proximity of buildings (positively for late morpho and negatively for the larger dwarf). During the five years of the study, among others, an increase in barbastelle densities was recorded (measured by recorded activity). One of the possible reasons for this phenomenon could be the growing number of dead spruces in the studied stands, resulting from the spread of bark beetle. Barbastelle is a bat species that uses as roosts, among others, cracks under the protruding bark of dead trees. The results suggest that commercial forests with limited economic activity impact (e.g., those part of the Natura 2000 network) may be appropriate habitats for forest species of bats, including vulnerable and

endangered species. However, the possibility of occurrence of synanthropic species (e.g., *E. serotinus*) in such areas is increased. Such factors like changes in the species, age and spatial structure of tree stands and the presence of open departmental roads, favors the penetration of synanthropic bats into the depths of tree stands. The work based on these studies is currently at the stage of adopting reviewers' corrections ("Forests" journal).

In the early 2000s, I started a parallel cycle of research devoted to the fauna of bats in the Balkan region. During the four zoological expeditions to Albania (2004-2007), conducted by a research team from the University of Gdańsk, the Institute of Zoology (PAN) and the Forestry Research Institute (represented by me), we found, inter alia, the occurrence of eight species of bats new to this country, including *Myotis alcathoe* von Helversen and Heller, 2001, a species whose existence was discovered only a few years earlier. The research covered the whole area of the country and a hundred research plots. In the course of this work, we also found one new bat species for Bosnia and Herzegovina. The results of the research were published in five co-authored publications in international scientific journals (Niermann et al., 2007, Ciechanowski et al. 2005, Sachanowicz et al. 2006, Sachanowicz et al. 2008, 2016) and were presented at scientific conferences (including international: 13th IBRC 2004, International Workshop "Nietoperek Winter Bat Census 2005, XIII EBRs 2014.) In 2014 and 2015 I participated in two zoological expeditions to Montenegro, the results of which were published this year (Rachwald et al. 2019 in print) .

The third research cycle is less related to the forest environment, because it includes research on wintering bats, both species found in forests, as well as cave and eurytopic bats. The research has been carried out over the past 15 years in the area of the largest wintering ground of bats in Poland: the underground of Międzyrzecki Rejon Umocniony. During 15 years of uninterrupted research, conducted by a large international team led by Dr. T. Kokurewicz from the University of Life Sciences in Wrocław (with the participation of scientists from Great Britain, the Netherlands, Belgium, Germany, Finland, Slovakia, Poland and several other countries), a huge the number of unique data on wintering bats, as well as data on the variability of the microclimate of the underground. These materials were presented at international conferences (most recently at the 13th EBRD in 2014), and now the publication analyzing all collected data from 2002-2017 in the context of climate change is being finalized. Work will be continued in subsequent years to capture the future direction of the trend.

The fourth research topic (research on rodent biology and behavior), was initiated by research on the acoustic behavior of Dormice family in the team with Dr. W. Nowakowski

from UP-H in Siedlce (including Nowakowski et al. 2000 and grant KBN "Ultrasound signaling of the forest dormouse *D. nitedula* - the circumstances of the issue, function and structure of signals"), and then continued during the implementation of the individual research grant DGLP "The use of natural stress signals and artificially generated ultrasound to limit damage from rodents in forests". The project investigated the vocalization of two rodent species: red vole *Myodes glareolus* (Schreber, 1780) and northern vole *Microtus oeconomus* (Pallas, 1776). It was found, inter alia, that the previously published information on the vocalization of the red vole was erroneous as a result of using a flawed methodology by their authors. The work included the recording of stress signals emitted by both rodent species (under conditions of contact with another individual) and then the rodent response to these signals was examined. The reaction to artificial signals synthesized using bioacoustic software was also tested. The influence of signals on motor activity and on rodent foraging was tested. The animals' reaction to the smell signals was also examined. There was a significant influence of the emitted signals on the activity of animals, manifested by the limitation of mobility and feeding activity in the presence of signals. The tests were carried out in the laboratory, as well as in the open space in semi-natural and natural conditions. After a certain period of signaling, habituation followed and the effect limiting the activity decreased. The results of this work are currently being prepared for publishing.

As part of the research on bat biology, in addition to the "core" cycle, in 2015-2017, the study on biology of barbastelle bat *B. barbastellus* in the Białowieża Forest was also carried out. This was part of the project "Assessment of biodiversity in the Białowieża Forest based on selected natural and cultural elements" (financed by DGLP, led by a consortium headed by IBL). As a result of the application of a combination of methods (netting, ultrasound recording and building check in the vicinity of stands) and the establishment of a large number of research points, extensive material was collected, which allowed the use of statistical modeling in the analyzes. The relationship between such factors as the species composition and age structure of tree stands, and the occurrence of barbastelles in the Białowieża Forest was examined. The starting point for the project were data on the occurrence of this species obtained earlier in my studies on bat community in the BF. The results of the research have been presented several times at international and national conferences (XXV OKCh, XXVII OKCh, XIII EBRs, International Workshop "Nietoperek Winter Bat Census 2018", "Forests at risk: Białowieża and beyond" 2019) and are currently being prepared for publishing. Further research is planned for this species in the Białowieża Forest, where it is in my opinion a model species closely related to the temperate lowland

natural forest. It is planned to study roosting of this species and its foraging areas using the radiotelemetry method. Another project, being in the preparation stage, is devoted to the influence of the bark beetle spread on the forest bats communities. It is to include studying the activity of bats and their feeding base (flying insects) on research plots located in spruce stands of healthy, dead standing, dead lying and on the areas from which dead trees have been removed. The results of these studies should make a significant contribution to knowledge about the functioning of the forest ecosystem and the impact of ecosystem disorders on animal communities.

A detailed list of scientific achievements along with a numbered list of publications is provided in the attachment “Wykaz opublikowanych prac naukowych lub twórczych prac zawodowych oraz informacja o osiągnięciach dydaktycznych, współpracy naukowej i popularyzacji nauki” (24 pp.).

Most important scientific achievements in short:

1. Number of peer-reviewed publications: 37
2. Number of peer-reviewed publications after the PhD: 26
3. Number of publications indexed by Clarivate Analysis (former Thomson Reuters, list A of MNiSW): 11
4. Number of peer-reviewed publications from the B list of the MNiSW: 4
5. Number of peer-reviewed publications in magazines outside the list of MNiSW: 10
6. Number of monographs: 2
7. Number of chapters in monographs: 3
8. Number of presentations at international conferences: 16
9. Number of presentations at national conferences: 25
10. Total JIF (Clarivate Analysis) according to the year of publication: 9.5
11. Number of citations according to the Web of Science (29 March 2019): 71 without self-citations
12. Number of citations by Google Scholar (31 March 2019): 281
13. H-index according to the Web of Science (29 March 2019): 4 without self-citations
14. H-index by Google Scholar (31 March 2019): 7
15. Total score of publications according to the MNiSW in accordance with the year of publication: 388

16. Including: publication score after the PhD according to the MNiSW in accordance with the year of publication: 341

17. Total score of publications in the cycle according to MNiSW: 100

Sękocin Stary, 31 marca 2019

Aleksander Rachwald

A handwritten signature in black ink, appearing to read 'ARachwald', written in a cursive style.