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CONFIRMATION OF THE OCCURRENCE OF *THYRIS FENESTRELLA* (SCOPOLI, 1763) (LEPIDOPTERA: THYRIDIDAE) IN POLAND AND REMARKS ABOUT ITS BIOLOGY

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Abstract: This paper presents the first data about the presence of *Thyris fenestrella* (Scopoli, 1763) in Poland after a few decades of the absence of any records and suggests the opportunity of a second generation occurrence under the Polish conditions. The species was found in the Lublin Region, SE Poland. The locality is situated within the Vistula Valley on a sunny slope overgrown by *Clematis vitalba* L. and *C. recta* L.

Key words: rare species, *Clematis*, conservation, red list, the Vistula Valley, new record

INTRODUCTION

Thyris fenestrella (Scopoli, 1763) is a thermophilous species frequently occurring on sunny slopes (very often with calcareous subsoil) overgrown by *Clematis* spp. assemblages. Thus, the species is most abundant in the southern part of Europe. In Central Europe, *T. fenestrella* is quite rarely encountered and practically restricted to the warmest regions (Buszko 1979; Thiele 1986; Tőrők 2012). Despite its rarity, the biology and developmental stages of the species in question are well described. Imagines are predominantly encountered from mid-May till mid-August (with a flight peak in June). Moths have black and dusky brown wings with a few yellowish or orange dots and two transparent areas separated by a dark narrow stripe on each wing. Wingspan ranges from 12 to 15 mm (Fig.1a, b). Pupa are stubby and reddish brown with a typical lepidopteran shape. Caterpillars are also quite stubby with a brown head and a dark yellow body colour. The whole larva is covered by numerous black verrucae. Ovum can vary from red-

dish-brown to dark brown and measure about 1 mm high (Fig.1c) (Buszko 1979, Forster and Wohlfart 1960; Hasenfuss 1980; Thiele 1983).

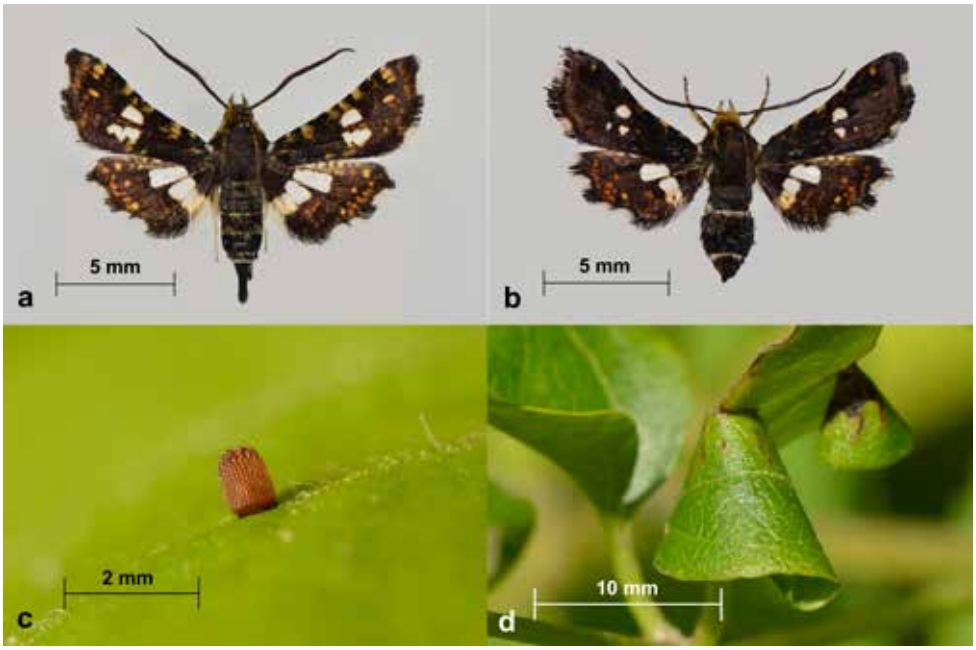

Fig. 1. *Thyris fenestrella (Scopoli, 1763): a – male (caught in the wild 08.05.2015); b – female (obtained by rearing 28.06.2015); c – ovum on Clematis vitalba (photographed in the laboratory 12.05.2015); d – feeding trace on C. vitalba (photographed in the wild 27.07.2015).*

MATERIALS AND METHODS

All the materials examined were the male and female of *Thyris fenestrella* caught feeding on a blooming hawthorn *Crataegus* sp. during the day, the ovum found on *Clematis recta* L. and the feeding traces of caterpillars observed on *Clematis vitalba* L. leaves (Fig.1 d). The pair of moths were reared in conditions similar to the natural ones for this species, providing them with nectar plants and a source of mineral salts as feed to create suitable conditions for mating and ovipositing. During the rearing period, the host plant for the larvae constituted only of sprigs of *C. vitalba* due to the fact that *C. recta* is a legally protected plant species in Poland. The depicted photographs of the imagines, ovum and feeding trace were taken with a Nikon D5100 camera + Nikon Nikkor Micro 105 mm lens.

RESULTS

All the collected material came from one locality situated on a steep sunny slope with calcareous subsoil having a southern exposure (within the Vistula Valley). The site is lushly overgrown by *Clematis recta* L. and C. *vitalba* L. (especially by the latter) which are the host plants of the species in question.

The presented data confirm the occurrence of *T. fenestrella* in Poland after a few decades of the absence of any data and constitute the first record from the eastern part of Poland.

The information are as follows:

UTM: EB68, ad. Janowiec (xerothermophilous slope with calcareous subsoil):
- 08.05.2015 – male and female on a blooming hawthorn *Crataegus* sp. (first generation), leg. Ł. Dawidowicz
- 13.05.2015 – one ovum on *C. recta*, leg. Ł. Dawidowicz
- 28.06.2015 (ex. cult.) – one female reared from the pair caught in the wild (second generation), cult. & leg. Ł. Dawidowicz
- 27.07.2015 – two fresh feeding traces on *C. vitalba* (probable second generation), leg. Ł. Dawidowicz

The reference material is deposited in the author's collection.

DISCUSSION

Thyris fenestrella is a commonly known species to European lepidopterologists but it is rarely encountered, mainly owing to its small size and rarity, especially within Central Europe (Buszko and Nowacki 2002; Fazekas 1992; Pawłowski 2003; Tőrők 2012). Information about the presence of this species in Poland is quite limited and dated. The most recent records of its occurence are from several decades ago, and these were only from the Mazovia and Świętokrzyskie Province (Buszko and Nowacki 2000). This species limited occurrence in Poland may result from its climatic requirements (this is a thermophilous species) and required host plants. The primary and most preferred host plant species of *T. fenestrella* is *Clematis vitalba*, however, the species has also been occasionally recorded from an array of other congeneric representatives (Thiele 1986). The finding of an ovum on *Clematis recta* in the wild may constitute an indirect confirmation of this information. Unfortunately, no caterpillars were directly observed. In Poland, only *C. vitalba* and *C. recta* occur in the wild. The former is a neophyte which is rarely encountered in nature, mainly on sunny slopes within large river valleys in the western part of the country, but the later may form large, dense fields in the occurrence areas. The Vistula Valley has suitable conditions for

C. vitalba which is common in places. On the other hand, *C. recta* is a native species, however, it is rarely encountered and mainly limited to the Lublin Region (SE Poland) (Zając and Zając 2001). The caterpillars feed in a characteristic way of wrapping leaf tips what may facilitate searches of the species (Fig.1d). The larvae are not very active and their main defence strategy is the secretion of a stinkbug-like-scented substance (Hasenfuss 1980; Thiele 1983).

In past studies, *T. fenestrella* has been reported to be univoltine (Buszko 1979). However, through rearing (female of a second generation emerged 28.06.2015) and quite late field observations of fresh feeding traces – 27.07.2015 (especially taking into account a relatively early flight period in the considered locality in 2015) may suggest that in proper habitats and under suitable weather conditions, the species may have two generations per year. In all probability, this second generation is merely partial. Only one specimen of the second generation emerged out of seven pupae obtained through rearing. The remaining pupae overwintered in the normal way. The year 2015 was very hospitable for many thermophilous moths owing to the very long and hot summer in Poland. Undoubtedly, this fact may have had a crucial impact on the phenology of this species (i.e. quite early appearance of the first generation individuals). Many recent studies have mentioned the possible effects of climate change on the biology and phenology of Lepidoptera which this study may corroborate (Kocsis and Hufnagel 2011; Roy and Sparks 2000).

The fact remains that *T. fenestrella* is a rare and endangered species in Central Europe which figures, inter alia, in the red lists of Poland, the Carpathians and Romania (Buszko and Nowacki 2002; Pawłowski 2003; Tőrők 2012). Every locality of this species is remarkable and worth protecting within Central Europe.

POTWIERDZENIE WYSTĘPOWANIA W POLSCE *THYRIS FENESTRELLA* (SCOPOLI, 1763) (LEPIDOPTERA: THYRIDIDAE) I UWAGI NA TEMAT JEGO BIOLOGII

STRESZCZENIE

Niniejsza praca prezentuje pierwsze dane na temat występowania *Thyris fenestrella* (Scopoli, 1763) w Polsce po kilku dekadach braku jakichkolwiek doniesień z kraju oraz sugeruje możliwość występowania drugiego pokolenia w warunkach polskich. Gatunek został odnaleziony na terenie województwa lubelskiego, płd.-wsch. Polska. Stanowisko znajduje się w obrębie doliny Wisły na nasłonecznionym zboczu obficie porośniętym przez powojnika pnącego (*Clematis vitalba* L.) i powojnika prostego (*C. recta* L.).

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BRACHYCHTHONIUS HIRTUS (MORITZ, 1976) AND *SUBIASELLA (LALMOPPIA) EUROPAEA* (MAHUNKA, 1982) – TWO NEW SPECIES OF ORIBATID MITES (ACARI: ORIBATIDA) TO POLISH FAUNA AND TWO OTHER SPECIES NEW TO THE MAZOVIAN REGION WITHIN POLAND

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Abstract: Two oribatid mite species *Brachychthonius hirtus* and *Subiasella (Lalmoppia) europaea* (Mahunka, 1982) new to Poland and two species of which were previously unreported in the Mazovian region within Poland (*Acrogalumna longipluma* and *Metabelba (M.) pulverulenta*) are recorded from a soil mesocosm study conducted in 2004-2006, in Łomianki near Warsaw, Mazovia, Poland.

Key words: *Oribatida*, mesocosm study, new records, Poland

INTRODUCTION

About 11,000 species of oribatid mites have already been described and it is believed that there are 2 to even 9 times more extant species worldwide (WALTER and PROCTOR 2004). Almost half of all European oribatid species (i.e. ca. 500) occur in Poland (OLSZANOWSKI et al. 1996). Recognition of oribatid mites' distribution and ecology is still incompletely recorded (NIEDBAŁA 2015). Long-term studies on oribatid mites' ecology brings an opportunity for new discoveries of these mites, because in such studies, samples are taken periodically from the same habitats (e.g. SKUBAŁA 2004), noticeably increasing the chance of finding rare species.

The aim of this paper was to communicate the finding of new species to Poland and Mazovia reported during a mesocosm study conducted between June 2004 and September 2006.

MATERIAL AND METHODS

Mites were extracted from soil samples taken from a mesocosm experiment conducted in Dziekanów Leśny near Warsaw, Poland (52°20'45.4"N 20°51'21.3"E). In June 2004, 600 plastic containers (mesocosms, capacity: 10 L) were placed into the ground, and filled with soil (sandy loam) taken from a nearby, cultivated field and sown with grass. One half of the mesocosms were sown with one grass species (*Festuca rubra*, Linnaeus) – monoculture, and the second half were sown with a mixture of eight grass species (among them *F. rubra*). After one growing season, six individual earthworms (*Aporrectodea caliginosa*) (Savigny) were introduced into half of the mesocosms in each treatment – monoculture and mixture. To analyse oribatid mite communities, soil samples were taken four times a year until September 2006. A MacFadyen extractor was used to collect the mites (Krantz 1978). Individuals (adults only) were cleared in lactic acid before determination and examined under a compound microscope using the half-covered cavity-slide method of Grandjean (Niedbała 1980). Keys to oribatid mites by Gilyarov and Krivolutskiĭ(1975) and Weigmann (2006) were used for species identification.

RESULTS

A total of 12,090 individuals of oribatid mites were extracted. Among these, two new species to Poland and two new species to the Mazovian region within Poland were found:

Brachychthonius hirtus Moritz, 1976, *Brachychthonioidea: Brachychthoniidae*

Material: 715 specimens from all treatments, i.e. monoculture, mixture, as well as with and without earthworms, September 2005 – September 2006.

Distribution: the species has been noted in Spain and Ukraine (Niedbała 2015). It typically inhabits beech forest litter (Moritz 1976). Subias (2004, updated in 2015) notes this species as occurring in South-Central Europe and Mongolia. It has also been found in Iran, in soil from alfa alfa fields (Mirzaie *et al.* 2011).

Subiasella (Lalmoppia) europaea (Mahunka, 1982), *Oppioidea: Oppiidae*

Material: 29 specimens from all treatments, i.e. monoculture, mixture, as well as with and without earthworms, June 2004 – September 2006.

Distribution: *S. europaea* was first recorded in Hungary (Subias and Balogh 1989, Niedbała 2015). Weigmann (2006) claims that this species also occurs in Czech Republic. Subias (2004, updated in 2015) generally notes that this species inhabits South-Central Europe. The ecology of *S. europaea* is still largely unknown (Weigmann 2006).

Acrogalumna longipluma (Berlese, 1904), *Galumnoidea: Galumnidae*

Material: one specimen from monoculture without earthworms, September 2006.

Distribution: this species is semi-cosmopolitan, it occurs in Holartica, South Africa, India, Southeast China and New Zealand (Subias 2004, updated in 2015). It is widely distributed in Europe (Niedbała 2015), including Poland (Olszanowski *et al*. 1996) but it is has never been recorded in Mazovia. It dwells mainly in forest soil (Weigmann 2006), decaying wood, humus, organic remains and bird guano from tree hollows (Żbikowska-Zdun *et al.* 2006).

Metabelba (*M.*) *pulverulenta* (Koch,1839), *Damaeoidea: Belbidae*

Material: two specimens from monoculture and mixture, both without earthworms, September 2006

Distribution: *M. pulverulenta* occurs in Holarctica, frequently in Palearctica (Subias 2004, updated in 2015). In Europe, it appears in Austria, Denmark, Finland, Germany, Hungary, Romania, Slovakia and Ukraine (Niedbała 2015). It is widely distributed in Poland (Olszanowski *et al.* 1996) but it is new for Mazovia. It occupies different habitats: damp decaying wood, rotting leaves (Żbikowska-Zdun *et al.* 2006), forest litter, mosses, lichens, peat-bogs (Weigmann 2006), stumps and tree hollows (Skubała and marzec 2013).

BRACHYCHTHONIUS HIRTUS Moritz, 1976 I *SUBIASELLA (LALMOPPIA) EUROPAEA* (Mahunka, 1982) – DWA NOWE DLA POLSKI GATUNKI MECHOWCÓW (*ACARI: ORIBATIDA*) ORAZ NOWE STANOWISKO DLA MAZOWSZA DWÓCH INNYCH GATUNKÓW

STRESZCZENIE

Praca zawiera doniesienie o występowaniu *Brachychthonius hirtus* oraz *Subiasella (Lalmoppia) europaea*, gatunków nowych w faunie Polski oraz stwierdzenie występowania dwóch innych, nowych dla Mazowsza gatunków mechowców: *Acrogalumna longipluma* i *Metabelba(M.) pulverulenta*.

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SPECIMENS OF SPIDER FAUNA FROM UKRAINE IN THE COLLECTION OF THE MUSEUM OF NATURAL HISTORY, WROCLAW UNIVERSITY (ACCORDING TO THE COLLECTION OF STANISŁAW PILAWSKI AND KAZIMIERZ PETRUSEWICZ)

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Abstract: The Collection of Spiders of Podillya (Museum of Natural History, Wroclaw University) has been processed. It originated from the accession of collections by Stanisław Pilawski and Kazimierz Petrusewicz (1937-1938) as well as the personal collections of Stanisław Pilawski (1933-1935, 1939-1940, 1954-1956). It represents the fauna of the territory of modern Ukraine, including Lviv, Ternopil, Rivne, Ivano-Frankivsk and Zakarpattia regions. During the collection review, attention was paid to processing the toponyms used on the labels of specimens. A list of these names was created; their compliance with the current names of settlements and the administrative and physical geographic regions was established.

Key words: Collection of Spiders of Podillya, Ukraine, Museum of Natural History, Wroclaw University, S. Pilawski, K. Petrusewicz

INTRODUCTION

The spider fauna of Ukraine has been studied unevenly. Some territories, including those of Western Ukraine, still remain unexplored. Therefore, the *Collection of Spiders of Podillya* is essential for creating lists of regional fauna and is the foundation for the development of environmental measures.

Most specimens of the collection were collected from deciduous forests in what is now West Podolian, Mid-Podolian, and Roztochchya-Opillya uplands, particularly in Holohory-Kremenets Ridge, as well as adjacent parts of Small Polissya (see Marynych *et al*., 2007), which is also considered to be Northern Podillya. These collections were created by Polish arachnologists Stanisław Pilawski and Kazimierz Petrusewicz (1937-1938s) and S. Pilawski (1939-1940, 1954-1956).Until 1937, the date of publication of *The Catalogue of spiders of Poland* by Petrusewicz (1937),

Podillya was the least explored region of the Polish Republic. Partial information about the spiders this region was concentrated in a few works by the Physiographic Commission (Koch 1870, 1871; Łomnicki 1870; Nowicki 1870; 1874; Wajgiel 1867, 1868, 1874, 1895) and in some separate publications (Eichwald 1830; Kuntze and Noskiewicz, 1938). In 1937-1938 S. Pilawski and K. Petrusewicz, taking part in a commission created by the Copernicus Society of Naturalists exploring Northern Podillya, conducted joint research in this area. Using the 1937 collection as their basis, they published a work entitled *Badania pająków na północnej Krawędzi Podola* which examined the ecological and faunistic features of the distribution of *Pisauridae*, *Lycosidae*, and *Argiopidae* families (Petrusewicz 1938) and *Theridiidae*, *Linyphiidae*, and *Agelenidae* families (Pilawski 1938). From 1938 to 2006, no araneologic studies in Holohory-Kremenets Ridge were conducted (Hirna 2011).

A small number of specimens in the *Collection of Spiders of Podillya* was collected in the Carpathians (S. Pilawski's materials, 1933-1935), in the massifs of Chornohora, Gorgany, Chyvchyny, and Rebrovach-Dil, as well as two localities in the Ivano-Frankivsk region.

MATERIALS AND METHODS

This article was written on the basis of a partial review of the *Collection of Spiders of Podillya* (Natural History Museum, University of Wroclaw), in particular a study of the exhibits labels. The collection was processed in accordance with the rules of the Museum collections usage and the conventional methods of arachnology. The nomenclature of taxa is given according to Platnick (2014).

RESULTS AND DISCUSSION

When assessing the scientific value of Stanisław Pilawski's and Kazimierz Petrusewicz's collection (1937-1938), and Stanisław Pilawski's collections (1933-1935, 1939-1940, 1954-1956), it should be first taken into account that the knowledge of spiders in Ukraine's Podillya and the Carpathians is insufficient.

The *Collection of Spiders of Podillya* covers two historical periods of Ukraine, the first before September of 1939, when the territory of Northern Podillya and the Carpathians was part of Galicia, a territorial entity of Poland, and the second after October of 1939, when Western Ukraine was officially annexed by the Soviet Union.

The main merit in forming the collection as a complete araneological one is undoubtedly due to Stanisław Pilawski who, despite the Second World War and the difficult political situation in the country, managed not only to preserve the collection but to supplement it with new specimens.

Stanisław Pilawski (01/01/1909 – 24/12/1978). Born in Sanok (Poland). In 1927-1932 he studied at the Faculty of Mathematics and Natural Sciences of the Jan Kazimierz University in Lviv. From 1930 he worked in the Department of Zoology at Lviv University. In 1933 he was promoted to senior assistant of the Department of Zoology and Anatomy of Domestic Animals of the Lviv Polytechnic. In May of 1939 he submitted a Ph.D. thesis to the Board of the Faculty of Mathematics and Natural Sciences; however, he could not defend his thesis due to the beginning of the Second World War. From 1940 he served as an assistant professor and was promoted to associate professor in 1941. During the war and German occupation (1941-1944) he worked in the R. Weigl Institute of typhus (spotted fever) research. In July of 1944 S. Pilawski resumed work at the Lviv Polytechnic in the position of the Zoology Department head. From December of 1946 he worked at the Agricultural Institute in Dubliany as assistant professor of zoology and entomology. In May of 1958 he moved to Wroclaw (Poland) where he joined the Zoological Museum of Wroclaw University; in 1959 he became an assistant professor of the General Zoology Department. From 1963 he was the head of the Department of Animal Systematics and Zoogeography of the Zoological Institute of Wroclaw University (Instytut Zoologiczny, Katedra Systematyki Zwierząt i Zoogeografii) which he headed till his death. The main focus of his research after returning to Polish territory were ecological and faunistic studies of spiders. From 1970 to 1972 he served as acting head of the Department of General Parasitology of the Microbiological Institute of the Wroclaw University. He was a member of many scientific societies in Poland, headed the Wroclaw branch of the Polish Entomological Society, edited the Zoological works of the „Acta Universitatis Wratislaviensis"; above all, he was a teacher. In 1973 he was awarded with a Golden Cross of Merit (Złoty Krzyż Zasługi). He published over 30 scientific papers, ten of which were dedicated to the fauna and ecology of spiders. Stanisław Pilawski died in Wroclaw in 1978 (Bednarz, 1979).

In 1993, after the death of the researcher, the collection was processed (refilled, structured and preserved, and certain types redefined) and transferred for preservation to the Museum of Natural History of Wroclaw University by Dr. Marek Woźny, a Polish arachnologist (then a worker for the Department of Animal Systematics and Zoogeography of the Zoological Institute of Wroclaw University). The scientist also made an inventory description of the collection which eventually became the basis for the materials presented in this article.

The collection is properly structured (in terms of methodology) and kept in good condition (although there are a small number of refilled, previously dried specimens). It contains 164 species of spiders belonging to 18 families. The most numerous are *Linyphiidae* (53 species), *Theridiidae* (24), *Lycosidae* (24), *Araneidae* (19), *Tetragnathidae* (11).

The territory, where the materials were collected, covers five administrative regions of Ukraine. Lviv region is represented in the fullest measure (four districts, vicinities

of 23 settlements). Its fauna is represented by 110 species of spiders. Ternopil region (four regions; vicinities of seven localities) is represented by specimens of 56 species; Rivne (one district, vicinities of four settlements) is represented by 30 species. Some of the exhibits, according to localities and dates of collection, are the material which served as the basis for the works on the fauna of Northern Podillya S. Pilawski and K. Petrusewicz published in 1938 (Petrusewicz 1938; Pilawski 1938; table).

The materials from the Ivano-Frankivsk region represent the spider fauna of the Carpathians. In particular, the collection regards the town of Yaremche (Vorohta and Voronenko; three species) and the village of Verkhovyna (one species). Five species were collected in the massif of Gorgany; two species in the Chyvchyny; one species in the Rebrovach Dil. The Chornohora is represented in the collection by 12 species. Some of the mountains, namely Breskul, Dantsir, and Hoverla, are located on the border of the Ivano-Frankivsk and Zakarpattia regions. Therefore, it is impossible to undoubtedly speak of collecting the materials in one of these areas.

The spider collection in the Museum of Natural History of Wroclaw University contains species which are typical of the fauna of western Ukraine. It supplements the information about spiders that can be found in certain administrative and physiographic units of the state and is invaluable as one of the few arachnological collections from Ukraine which has been preserved from the middle of the last century. The collection is a good resource and a basis for the further work of arachnologists and faunists of Europe.

TABLE

Description of the the *Collection of Spiders of Podillya* of the Museum of Natural History, Wroclaw University (based on the inventory description by M. Woźny (1993), with some clarifications in accordance with Stanisław Pilawski's labels)

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Atypidae			
Atypus muralis (Bertkau, 1890)		Gołogóry	1938
		Lysa Góra	1938
		Święta Góra	1938
		Góra Kamusik	1938
		Góra Strachowa	1938
Atypus piceus (Sulzer, 1776)		Trędowacz	1937
Pholcidae			
Pholcus opilionoides (Schrank, 1781)		Lackie Małe	1938
		Krzemieniec	1939
Eresidae			
Eresus kollari (Rossi, 1846)	*E. cinnaberinus* (Olivier)	Lysa Góra	1940

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Uloboridae			
Hyptiotes paradoxus (C. L. Koch, 1834)	*Hyptiotes paradoxuys*	Lasy Lackie	1938
Theridiidae			
Asagena phalerata (Panzer, 1801)	*Steatoda phalerata*	Góra Maślatyn	1938
		Trędowacz	1938; 1940
		Lackie Małe	1938
		Majdan Gołogórski	1938
		Lysa Góra	1938
Cryptachaea riparia (Blackwall, 1834)	*Achaearanea riparia*	Młynowce	1937
		Święta Góra	1938
Dipoena braccata (C. L. Koch, 1841)		Góra Żulicka	1938
Dipoena inornata (O.P.-Cambridge, 1861)		Góra Strachowa	1938
Dipoena melanogaster (C. L. Koch, 1837)		Góra Kamusik	1938
Dipoena torva (Thorell, 1875)		Lackie	1938
Enoplognatha ovata (Clerck, 1757)	-	Góra Maślatyn	1938
		Buszcza	1938
		Góra Kamusik	1938
		Lysa Góra	1938
Enoplognatha thoracica (Hahn, 1833)		Góra Maślatyn	1938
		Lysa Góra	1938
		Trędowacz	1938
Euryopis flavomaculata (C. L. Koch, 1836)		Lysa Góra	1938
Lasaeola tristis (Hahn, 1833)		Góra Strachowa	1938
		Krzemieniec	1938
Neottiura bimaculata (Linnaeus, 1767)	*Theridion bimaculata*	Lysa Góra	1938
		Święta Góra	1938
		Ścianki	1937
		Góra Wysoka	1938
Parasteatoda lunata (Clerck, 1757)	*Achaearanea lunata*	Lackie Małe	1938
		Lackie	1938
		Buszcza	1938
		Góra Żulicka	1938
		Góra Strachowa	1938
		Lasy Lackie	1938
		Krzemieniec	1937
		Góra Boratyńska	1938
Parasteatoda simulans (Thorell, 1875)	*Achaearanea simulans*	Ścianki	1937
		Buszcza	1938

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Phylloneta impressa (L. Koch, 1881)	*Theridion impressum*	Lysa Góra	1938; 1955
		Góra Strachowa	1938
		Kamienica Wołyńska	1938
		Buszcza	1938
		Góra Maślatyn	1938
		Święta Góra	1938
Phylloneta sisyphia (Clerck, 1757)		Buszcza	1938
Platnickina tincta (Walckenaer, 1802)	*Theridion tinctum*	Buszcza	1938
		Lackie	1938
		Poczopy	1938
		Gliniany	1937
Robertus arundineti (O. P.-Cambr., 1871)		Lackie Małe	1938
		Ożydów	1956
Steatoda albomaculata (De Geer, 1778)		Góra Maślatyn	1938
		Lackie Małe	1938
Steatoda bipunctata (Linnaeus, 1758)		Poczopy	1938
		Nikiticze	1939
Steatoda castanea (Clerck, 1757)		Poczopy	1938
		Krasne	1938
Theridion mystaceum (L. Koch, 1870)		Kniaże	1938
		Góra Wysoka	1938
Theridion pictum (Walckenaer, 1802)		Buszcza	1938
		Przejazdy	1937
Theridion pinastri (L. Koch, 1872)		Gliniany	1937
		Buszcza	1938
Theridion varians (Hahn, 1833)		Kniaże	1938
		Buszcza	1938
		Góra Maślatyn	1938
		Święta Góra	1938
		Ścianki	1937
		Trędowacz	1938
		Lysa Góra	1938
		Góra Kamusik	1938
		rz. Ikwa	1938
		Góra Strachowa	1938
Theridiosomatidae			
Theridiosoma gemmosum (L. Koch, 1877)		Buszcza	1938
Linyphiidae			
Anguliphantes angulipalpis (Westring, 1851)	*Lepthyphantes angulipalpis* (Wider)	Góra Maślatyn	1937

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Araeoncus humilis (Blackwall, 1841)		Lackie	1937
Bathyphantes gracilis (Blackwall, 1841)		Lasy Lackie	1938
Bathyphantes nigrinus (Westring, 1851)		Lasy Lackie	1938
		Góra Maślatyn	1937
Centromerita bicolor (Blackwall, 1833)		Góra Maślatyn	1937
Ceratinella brevis (Wider, 1834)		Majdan Gołogórski	1937
Ceratinella scabrosa (O. P.-Cambr., 1871)		Lysa Góra	1938
Diplocephalus cristatus (Blackwall, 1833)		Góra Strachowa	1938
Drapetisca socialis (Sundevall, 1833)		Zaroślak	1934
		Krzemieniec	1937
Entelecara acuminata (Wider, 1834)		Góra Strachowa	1938
		Góra Kamusik	1938
		Lasy Lackie	1938
		Lysa Góra	1937
		Buszcza	1938
Erigone atra (Blackwall, 1833)		Majdan Gołogórski	1937
Erigone dentipalpis (Wider, 1834)		Góra Łoskotowa	1938
		Lackie Małe	1938
		Kamienica Wołyńska	1938
		Kniaże	1937
		Góra Kamusik	1938
Floronia bucculenta (Clerck, 1757)		Żeniów	1940
		Boniszyn	1940
Gnathonarium dentatum (Wider, 1834)		Lysa Góra	1937
Gonatium paradoxum (L. Koch, 1869)		Lysa Góra	1955
Gongylidiellum murcidum (Simon, 1884)		Buszcza	1938
Gongylidium rufipes (Linnaeus, 1758)		Kniaże	1937; 1938
		Góra Kamusik	1938
		rz. Ikwa	1938
		Buszcza	1938
Helophora insignis (Blackwall, 1841)	*Lepthyphantes insignis* O.P.-Cambridge	Lasy Lackie	1939
Hypomma cornutum (Blackwall, 1833)		Buszcza	1938
Lepthyphantes leprosus (Ohlert, 1865)		Podlesa	1940
Lepthyphantes minutus (Blackwall, 1833)		Czugale	1937
Linyphia hortensis (Sundevall, 1830)		Krzemieniec	1938
		Lysa Góra	1937
		Lasy Lackie	1938

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Linyphia tenuipalpis (Simon, 1884)		Zaleszczyki	1939
Linyphia triangularis (Clerck, 1757)		Zaleszczyki	1939
		Worochta	1935; 1938
		Lysa Góra	1955
Macrargus rufus (Wider, 1834)		Buszcza	1938
Maso gallicus (Simon, 1894)	*Maso gallica*	Buszcza	1938
Maso sundevalli (Westring, 1851)		Góra Żulicka	1937
Megalepthyphantes nebulosus (Sund., 1830)	*Lepthyphantes nebulosus*	Gołogóry	1940
Megalepthyphantes collinus (L. Koch)	*Lepthyphantes collinus* (L. Koch)	Krzemieniec	1937
Meioneta rurestris (C. L. Koch, 1836)		Żołoby	1938
		Lackie Małe	1938
		Lysa Góra	1937
		Majdan	1938
		Lasy Lackie	1938
		Krzemieniec	1937
Meioneta saxatilis (Blackwall, 1844)		Lysa Góra	1938
Microlinyphia pusilla (Sundevall, 1830)		Worochta	1938
		Góra Żulicka	1938
		Lysa Góra	1938
		Lackie Małe	1938
		Święta Góra	1938
		Góra Wysoka	1937
Microneta viaria (Blackwall, 1841)		Ścianki	1937
Neriene clathrata (Sundevall, 1830)		Kniaże	1938
		Krzemieniec	1938
Neriene emphana (Walckenaer, 1841)		Trędowacz	1937
Neriene montana (Clerck, 1757)		Worochta	1934
		Lackie Małe	1938
		Kniaże	1938
		Boniszyn	1940
Neriene peltata (Wider, 1834)		Gorgany	1933
		Krzemieniec	1935
		Woronienka	1935
		Kukul	1935
		Lasy Lackie	1938
		Trędowacz	1937
Neriene radiata (Walckenaer, 1841)		Buszcza	1938
		Smyha	1939
		Trędowacz	1938
		Święta Góra	1938

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Oedothorax retusus (Westring, 1851)		Gołogóry	1937
Pelecopsis parallela (Wider, 1834)		Lysa Góra	1938
Poeciloneta variegata (Blackwall, 1841)		Howerła	1934
Porrhomma convexum (Westring, 1851)		Trędowacz	1937
Porrhomma pygmaeum (Blackwall, 1834)		Buszcza	1938
Stemonyphantes lineatus (Linnaeus, 1758)		Trędowacz	1937
Tapinocyboides pygmaeus (Menge, 1869)		Święta Góra	1938
Tapinopa longidens (Wider, 1834)		Czugale	1937
Tenuiphantes flavipes (Blackwall, 1854)	*Lepthyphantes flavipes*	Trędowacz	1937
Tenuiphantes mengei (Kulczyński, 1887)	*Lepthyphantes mengei*	Krzemieniec	1937
		Czugale	1937
Tenuiphantes tenebricola (Wider, 1834)	*Lepthyphantes tenebricola*	Trędowacz	1937
		Lasy Lackie	1937
		Dolina Szypuchy	1937
		Lysa Góra	1937
		Lackie Małe	1938
		Góra Strachowa	1937
Tenuiphantes zimmermanni (Bertkau, 1890)	*Lepthyphantes zimmermanni*	Lasy Lackie	1938
Trematocephalus cristatus (Wider, 1834)		Buszcza	1938
*Trichoncus hackmani (*Millidge, 1955)		Lysa Góra	1938
*Walckenaeria cuspidata (*Blackwall, 1833)		Buszcza	1938
Tetragnathidae			
Metellina mengei (Blackwall, 1870)		Żeniów	1940
		Ożydów	1956
Metellina merianae (Scopoli, 1763)		Wołkowce	1939
Metellina segmentata (Clerck, 1757)		Lysa Góra	1955
Pachygnatha clercki (Sundevall, 1823)		Przejazdy	1940
		Buszcza	1939
Pachygnatha degeeri (Sundevall, 1830)		Kniaże	1937
*Pachygnatha listeri (*Sundevall, 1830)		Trędowacz	1940
		Gliniany	1937
Tetragnatha extensa (Linnaeus, 1758)		Przejazdy	1940
		Chmiele	1940
Tetragnatha montana (Simon, 1874)		Kułakowce	1939
?*Tetragnatha nigrita* (Lendl, 1886)		Kułakowce	1939
Tetragnatha obtusa (C. L. Koch, 1837)		Fedkowce	1939
Tetragnatha pinicola (L. Koch, 1870)		Zarwanica	1940
Araneidae			
Aculepeira ceropegia (Walckenaer, 1802)		Breskuł	1938
Agalenatea redii (Scopoli, 1763)	*A. redii* (Schenkel)	Krawska Góra	1940

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Araneus alsine (Walckenaer, 1802)		Foreszczenka	1935
		Przejazdy	1940
Araneus angulatus (Clerck, 1757)		Lackie Małe	1940
Araneus diadematus (Clerck, 1757)		Lysa Góra	1955
Araneus marmoreus (Clerck, 1757)		Lysa Góra	1955
Araneus nordmanni (Thorell, 1870)		Zaroślak	1934
Araneus quadratus (Clerck, 1757)		Lysa Góra	1955
Araneus sturmi (Hahn, 1831)		Czarnohora	1934
Araniella cucurbitina (Clerck, 1757)		Boryszkowce	1939
		Trędowacz	1940
Cyclosa conica (Pallas, 1772)		Nowosiółki	1940
Hypsosinga albovittata (Westring, 1851)		Lysa Góra	1938
		Lackie Małe	1940
Mangora acalypha (Walckenaer, 1802)		Zaroślak	1935
		Góra Strachowa	1939
		Lysa Góra	1955
Neoscona adianta (Walckenaer, 1802)		Zaleszczyki	1938
Nuctenea umbratica (Clerck, 1757)		Żabie-Stupejka	1934
		Gołogóry	1940
Parazygiella montana (C. L. Koch, 1834)	***Tetragnathidae:*** *Zilla montana*	Zaroślak	1934
Singa hamata (Clerck, 1757)		Lysa Góra	1940
		Ożydów	1956
Singa nitidula (C. L. Koch, 1844)	-	Przejazdy	1940
Stroemiellus stroemi (Thorell, 1870)	***Tetragnathidae:*** *Zygiella stroemi*	Nowosiółki	1940
Lycosidae			
Alopecosa aculeata (Clerck, 1757)		Gajek	1934
		Rebrowacz	1938
Alopecosa cuneata (Clerck, 1757)		Gajek	1934
		Ożydów	1956
Alopecosa fabrilis (Clerck, 1757)		Czolakin	1935
Alopecosa pulverulenta (Clerck, 1757)		Dancerz	1934
Alopecosa solitaria (Herman, 1879)		Ożydów	1956
Arctosa leopardus (Sundevall, 1833)		Nikiticze	1939
		Gliniany	1937
		rz. Ikwa	1937
Arctosa maculata (Hahn, 1822)		Dolina Prutu	1934
Aulonia albimana (Walckenaer, 1805)		Szpyń	1934
		Smyha	1939
Pardosa amentata (Clerck, 1757)		Ożydów	1956
Pardosa bifasciata (C. L. Koch, 1834)		Lysa Góra	1937; 1940

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Pardosa lugubris (Walckenaer, 1802)		Lysa Góra	1940
		Ożydów	1956
Pardosa nebulosa (Thorell, 1872)		Bielowce	1939
Pardosa prativaga (L. Koch, 1870)		Nikiticze	1939
Pardosa pullata (Clerck, 1757)		Ścianki	1937
		Ożydów	1956
Pardosa saltuaria (L. Koch, 1870)		Szpyń	1934
		Przełęcz Czywczynu	1935
		Breskuł	1934
		Rozszybenyk	1934
Pardosa wagleri (Hahn, 1822)		Bielowce	1939
Pirata piraticus (Clerck, 1757)		Olszanica	1937
Piratula hygrophila (Thorell, 1872)	*Pirata hygrophilus*	Podlesa	1940
		Trędowacz	1937
Piratula latitans (Blackwall, 1841)	*Pirata latitans*	Lackie	1937
		Buszcza	1939
Piratula uliginosa (Thorell, 1856)	*Pirata uliginosus*	Kniaże	1937
		Buszcza	1939
Trochosa spinipalpis (F. O. P.-Cambr., 1895)		Podlesie	1940
		Gajek	1934
Trochosa terricola (Thorell, 1856)		Smyha	1939
Xerolycosa miniata (C. L. Koch, 1834)		Góra Maślatyn	1938
		Lysa Góra	1937
Xerolycosa nemoralis (Westring, 1861)		Syniak	1934
		Czugale	1937
Pisauridae			
Pisaura mirabilis (Clerck, 1757)		Wószczełówka	1939
Agelenidae			
Agelena labyrinthica (Clerck, 1757)		Trędowacz	1938
		Lysa Góra	1955
Allagelena gracilens (C. L. Koch, 1841)	*Agelena gracilens*	Krzemieniec	1937
Coelotes atropos (Walckenaer, 1830)	***Amaurobiidae***	Trędowacz	1937
Inermocoelotes inermis (L. Koch, 1855)	***Amaurobiidae***: *Coelotes inermis*	Góra Żołoby	1937
		Las Pańkowczyzna	1938
Tegenaria campestris (C. L. Koch, 1834)		Góra Suhilia	1937
Tegenaria domestica (Clerck, 1757)		Lackie Małe	1938
		Ponikowice	1938
		Podlesa	1940
Tegenaria ferruginea (Panzer, 1804)		Lackie Małe	1938
		Gołogóry	1938

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Cybaeidae			
Cybaeus angustiarum (L. Koch, 1868)		Krzemieniec	1937
Cybaeus tetricus (C. L. Koch, 1839)		Góra Żołoby	1937
Hahniidae			
Cryphoeca silvicola (C. L. Koch, 1834)		Krzemieniec	1937
Dictynidae			
Argenna subnigra (O. P.-Cambridge, 1861)		Góra Maślatyn	1938
		Lysa Góra	1938
Cicurina cicur (Fabricius, 1793)		Góra Żołoby	1937
Dictyna arundinacea (Linnaeus, 1758)		Lasy Lackie	1938
		Lysa Góra	1937
		Góra Żulicka	1938
		Góra Maślatyn	1938
		Święta Góra	1938
Dictyna major (Menge, 1869)	-	Żołoby	1938
	-	rz. Ikwa	1938
Dictyna uncinata (Thorell, 1856)		Góra Strachowa	1938
		Góra Kamusik	1938
		rz. Ikwa	1938
		Lackie Małe	1938
		Lysa Góra	1938
		Lasy Lackie	1938
		Gołogóry	1938
		Biały Kamień	1938
Lathys humilis (Blackwall, 1855)		Złoczów	1938
Nigma flavescens (Walckenaer, 1830)		Lysa Góra	1938
		Lasy Lackie	1938
Liocranidae			
Apostenus fuscus (Westring, 1851)		Lasy Lackie	1938
Thomisidae			
Ebrechtella tricuspidata (Fabricius, 1775)	*Misumenops tricuspidatus*	Lysa Góra	1955
		Ożydów	1956
Misumena vatia (Clerck, 1757)		Lysa Góra	1955
		Korczyn	1954
Xysticus audax (Schrank, 1803)		Lysa Góra	1956
Xysticus bifasciatus (C. L. Koch, 1837)		Lysa Góra	1956
Xysticus striatipes (L. Koch, 1870)		Lysa Góra	1956
Salticidae			
Evarcha falcata (Clerck, 1757)	*Evarcha flammata* (Clerck)	Lysa Góra	1955
		Buszcza	1939
		Ożydów	1956

Taxon (according to Platnick, 2014)	*In the inventory description (1993)*	*Place name**	*Data** (year of collection)*
Evarcha laetabunda (C. L. Koch, 1846)	*Evarcha laetabunda* (L.C. Koch)	Lysa Góra	1955
Sitticus dzieduszyckii (L. Koch, 1870)		Zaleszczyki-Wószczełówka	1939

* The localities listed in the table.

** The exact date of collection (day, month, year) and the number of specimens of each species are indicated on the labels of the collection's specimens and in the inventory description (1993).

Biały Kamień (с. Білий Камінь) – vill. Bilyi Kamin' [49°54'N 24°51'E; ≈ 250 m], Zolochiv district, L'viv region;

Bielowce (с. Білівці) – vill. Bilivtsi [48°31'N 26°22'E; ≈ 250 m], Borshchiv district, Ternopil' region;

Boniszyn (с. Бонишин) – vill. Bonyshyn [49°49'N 24°50'E; ≈ 140 m], Zolochiv district, L'viv region;

Boryszkowce [Boryszowce] (с. Боришківці) – vill. Boryshkivtsi [48°33'N 26°21'E; ≈ 190 m], Borshchiv district, Ternopil' region;

Breskuł (г. Брескул, Чорногірський гірський масив) – Breskul Mt. [48°09'04"N 24°30'43"E; 1911 m], mountain massif - Chornohora (Carpathians), Nadvirna district, Ivano-Frankivsk region – Rakhiv district, Zakarpattia region;

Buszcza (с. Буща) – vill. Bushcha [50°15'N 25°50'E; ≈ 225 m], Dubno district, Rivne region;

Chmiele (с. Стінка, ур. Хмелі) – vill. Stinka (Khmeli) [49°47'N 24°43'E; ≈ 265 m], Zolochiv district, L'viv region;

Czarnohora (Чорногірський гірський масив) – mountain massif – Chornohora (Carpathians), Verkhovyna, Nadvirna district of the Ivano-Frankivs'k region, Rakhiv district of the Zakarpattia region;

Czolakin [Czelokin] (г. Чолакін, гірський масив Чивчини) – Cholakin Mt. [47°52'36"N 24°43'24"E; 1450 m], mountain massif – Chyvchyny (Carpathians), Verkhovyna district, Ivano-Frankivsk region;

Czugale (с. Чугалі) – vill. Chuhali [50°06'N 25°48'E; ≈ 360 m], Kremenets' district, Ternopil' region;

Dancerz (г. Данцір, Чорногірський масив) – Dancer Mt., mountain massif – Chornohora (Carpathians) [48°08'06"N 24°31'52"E; 1850 m], Nadvirna district, Ivano-Frankivsk region – Rakhiv district, Zakarpattia region;

Dolina Prutu (долина р. Прут) – flood plain of r. Prut [48°10'40"N 24°34'27"E; ≈ 990 m], (it originates on the eastern slope of Mount Hoverla, in the mountain massif – Chornohora; Carpathians), Nadvirna district, Ivano-Frankivsk region;

Dolina Szypuchy (с. Стінка, долина г. Сипухи) – vill. Stinka (valley of Sypukha hill) [49°47'27"N 24°43'32"E; ≈ 320 m], Zolochiv district, L'viv region;

Fedkowce (с. Федьківці) – vill. Fed'kivtsi [49°53'N 25°44'E; ≈ 340 m], Zbarazh district, Ternopil' region;

Foreszczenka (урочище на р. Форещанка, притока р. Прут) – the tract on the riv. Foreshchanka, tributary of the r. Prut [48°11'20"N 24°33'34"E; ≈ 980 m], Verkhovyna district, Ivano-Frankivsk region;

?Gajek-Gorgan - (гірський масив Ґорґани) – mountain massif – Gorgany, Ivano-Frankivs'k region, Zakarpattia region.

Gliniany (с. Глиняни) – vill. Hlyniany [49°49'N 24°31'E; ≈ 225 m], Zolochiv district, L'viv region;

Gołogóry (с. Гологори) – vill. Holohory [49°45'N 24°43'E; ≈ 355 m], Zolochiv district, L'viv region;

Góra Boratyńska [Góra Boruszyńska](с. Боратин, Боратинська гора) – vill. Boratyn, Boratyns'ka hill [50°00'16"N 25°09'55"E; ≈ 355 m], Brody district, L'viv region;

Góra Kamusik [Góra Kanusik] (м. Кременець, г. Камінна) – Kremenets', Kaminna hill [50°06'50"N 25°45'51"E; ≈ 392 m], Kremenets' district, Ternopil' region;

Góra Łoskotowa (с. Підлипці, г. Лоскотова) – vill. Pidlyptsi, Loskotova hill [49°46'52"N 25°02'54"E; ≈ 383 m], Zolochiv district, L'viv region.

Góra Maślatyn (с. Жолоби, г. Маслятин) – vill. Zholoby, Masliatyn hill [50°04'40"N 25°38'54"E; ≈ 400 m], Kremenets' district, Ternopil' region;

Góra Strachowa (с. Жолоби, г. Страхова) – vill. Zholoby, Strachowa hill [50°05'17"N 25°40'56"E; ≈ 415 m], Kremenets' district, Ternopil' region;

Góra Suhilia [Góra Suhilla] (с. Чугалі, г.Сухілія) – vill. Chuhali, Sukhiliya hill [50°06'45"N, 25°48'29"E; ≈ 370 m], Kremenets' district, Ternopil' region;

Góra Wysoka (с. Білий Камінь, г. Висока) – vill. Bilyi Kamin' (Vysoka hora: hill) [49°52'37"N 24°51'53"E; 360 m], Zolochiv district, Lviv region;

Góra Żołoby (с. Жолоби, г. Жолоби) – vill. Zholoby, Zholoby hill [50°04'19"N 25°41'00"E; ≈ 380 m], Kremenets' district, Ternopil' region;

Góra Żulicka (с. Білий Камінь, г. Жулицька) – vill. Bilyi Kamin', Zhulyts'ka hill [49°52'45"N 24°50'51"E; 364 m], Zolochiv district, Lviv region;

Gorgany (гірський масив Ґорґани) – mountain massif – Gorgany, Ivano-Frankivs'k region, Zakarpattia region;

Howerła [Howerka] (г. Говерла, Чорногірський гірський масив) – Howerla Mt. [48°09'40"N 24°30'00"E; 2061 m], mountain massif - Chornohora (Carpathians), Nadvirna district, Ivano-Frankivsk region – Rakhiv district, Zakarpattia region;

Ikwa (р. Іква, притока р. Стир, басейн Дніпра) – riv. Ikwa, tributary of the r. Styr (basin of the Dnipro), Brody district Lviv region, Kremenets' district Ternopil' region, Dubno-Mlyniv district Rivne region;

Kamienica Wołyńska (з\д ст. Кам'яниця Волинська, с. Підлужжя) – railway station Kam'yanytsia Wolyns'ka, vill. Pidluzhzhia [50°21'03"N 25°42'02"E; ≈ 200 m], Dubno district, Rivne region;

Kniaże (с. Княже) – vill. Kniazhe [49°50'N 24°48'E; ≈ 235 m], Zolochiv district, L'viv region;

Krasne (смт. Красне) – urban-type settlement Krasne [49°55'N 24°37'E; ≈ 220 m], Bus'kyi district, L'viv region;

Korczyn (с. Корчин) – vill. Korchyn [50°20'N 24°24'E; ≈ 210 m], Radekhiv district, L'viv region;

Krawska Góra [Krowska Góra] (с. Лука, г. Кравська) – vill. Luka (Kravs'ka hora: hill) [49°47'03"N 24°59'11"E; 325 m], Zolochiv district, L'viv region;

Krzemieniec (м. Кременець) – Kremenets' [50°06'N 25°44'E; ≈ 315 m], Kremenets' district, Ternopil' region;

Kukul (г. Кукуль, Чорногірський гірський масив) – Kukul' Mt. [48°12'56"N 24°32'43"E; 1539 m], mountain massif - Chornohora (Carpathians), Nadvirna district, Ivano-Frankivsk region;

Kułakowce [Kutakowce] (с. Кулаківці, Заліщицький р-н) – vill. Kulakivtsi [48°38'18"N 25°52'30"E; ≈ 175 m], Zalishchyky district, Ternopil' region;

Lysa Góra (с. Червоне, Лиса гора) – vill. Chervone, Lysa hora: hill [49°48'N 24°43'E; ≈ 375 m], Zolochiv district, L'viv region;

Lackie (с. Червоне) – vill. Chervone [49°48'10"N 24°45'56"E; ≈ 270 m], Zolochiv district, L'viv region;

Lackie Małe (с. Червоне, хут. Мале Ляцьке) – vill. Chervone, small vill. Male Liats'ke [49°48'14"N 24°46'31"E; ≈ 270 m], Zolochiv district, L'viv region;

Las Pańkowczyzna [Las Pańkowszczyzna] (с. Паньківці, ур. Ліс Паньківчизна) – vill. Pan'kivtsi (Lis Pan'kivchyzna) [49°56'43"N 25°15'30"E; ≈ 345 m], Brody district, L'viv region;

Lasy Lackie (с. Червоне, ур. Ляцький ліс) – vill. Chervone (Liats'kyj Lis) [49°48'N 24°45'E; ≈ 340 m], Zolochiv district, L'viv region;

Majdan Gołogórski (с. Майдан-Гологірський) – vill. Maidan-Holohirs'kyi [49°46'N 24°47'E; ≈ 360 m], Zolochiv district, L'viv region;

Majdan (с. Майдан-Гологірський, ур. Майдан) – vill. Maidan-Holohirs'kyi (Maidan) [49°47'N 24°48'E; ≈ 430 m], Zolochiv district, L'viv region;

Młynowce (с. Великі Млинівці) – vill. Velyki Mlynivtsi [50°07'N 25°40'E; ≈ 230 m], Kremenets' district, Ternopil' region;

Nikiticze [Nikiłicze] (с. Микитичі) – vill. Mykytychi [50°20'N 25°39'E; ≈ 200 m], Dubno district, Rivne region;

Nowosiółki (с. Новосілки) – vill. Novosilky [49°47'N 24°39'E; ≈ 255m], Zolochiv district, L'viv region;

Olszanica (с. Велика Вільшаниця) – vill. Velyka Vil'shanytsia [49°48'N 24°40'E; ≈245 m], Zolochiv district, L'viv region;

Ożydów (м. Ожидів) – Ozhydiv [49°58'N 24°49'E; ≈ 235m], Bus'kyi district, L'viv region;

Poczopy (с. Почапи) – vill. Pochapy [49°51'N 24°50'E; ≈ 245 m], Zolochiv district, L'viv region;

Podlesa [Podlewa, Podłysa] (с. Червоне, ур. Підлиса) – vill. Chervone (Pidlysa) [49°48'N 24°44'E; ≈ 390 m], Zolochiv district, L'viv region;

Podlesie (с. Підлисся) – vill. Pidlyssia [49°56'N 24°49'E; ≈ 240m], Zolochiv district, L'viv region;

Ponikowice (с. Пониковиця) – vill. Ponykovytsia [50°03'N 25°03'E; ≈ 230 m], Brodivs'kyi district, L'viv region;

Przejazdy (с. Червоне, ур. Переїзди) – vill. Chervone (Pereyizdy) [49°50'03"N 24°43'29"E; ≈ 240 m], Zolochiv district, L'viv region;

Przełęcz Czywczynu [Pszełęcz Czywczynu](перевал Чивчин) – mountain pass Chyvchyn, massif – Chyvchyny (Carpathians) [47°51'12"N 24°42'09"E; 1570 m], Verkhovyna district, Ivano-Frankivsk region;

Rebrowacz (г. Ребровач, гірський масив Ребровач-Діл) – Rebrovach Mt. [48°18'00"N 24°36'04"E; 1222 m], mountain massif –Rebrovach-Dil (Carpathians), Verkhovyna district, Ivano-Frankivs'k region;

Rozszybenyk (хребет Розшибеник, Чорногірський гірський масив) – mountain chain Rozshybenyk [48°06'00"N 24°36'28"E; ≈ 1720 m], mountain massif - Chornohora (Carpathians), Verkhovyna district, Ivano-Frankivs'k region;

Ścianki (с. Стінка) – vill. Stinka [49°47'N 24°44'E; ≈ 295 m], Zolochiv district, L'viv region;

Smyha (с. Смига) – vill. Smyha [50°14'N 25°46'E; ≈ 230 m], Dubno district, Rivne region;

Syniak (г. Синяк, гірський масив Ґорґани) – Syniak Mt. [48°23'17"N 24°27'36"E; 1665 m], mountain massif – Gorgany(Carpathians), Nadvirna district, Ivano-Frankivsk region;

Szpyń (г. Шпиці, Чорногірський гірський масив) – Shpytsi Mt. [48°07'32"N 24°34'05"E; 1863 m], mountain massif - Chornohora (Carpathians), Verkhovyna district, Ivano-Frankivs'k region;

Święta Góra (с. Білий Камінь, Свята гора) – vill. Bilyi Kamin', Sviata hora: hill [49°53'57"N 24°52'40"E; 387 m], Zolochiv district, L'viv region;

Trędowacz (с. Трудовач) – vill. Trudovach [49°46'N 24°41'E; ≈ 390 m], Zolochiv district, L'viv region;

Wołkowce (с. Вовківці) – vill. Vovkivtsi [48°46'08"N 26°05'34"E; ≈ 215 m], Borshchiv district, Ternopil' region;

Worochta (смт. Ворохта) – urban-type settlement Vorokhta (Yaremche / Municipality) [48°17'N 24°33'E; ≈ 785 m], Nadvirna district, Ivano-Frankivsk region;

Woronienka [Woronieczka](с. Вороненко) – vill. Voronenko (Yaremche / Municipality) [48°17'N 24°30'E; ≈ 875 m], Nadvirna district, Ivano-Frankivsk region;

Wószczełówka (м. Заліщики, ур. Вощелівка) – Zalishchyky (Voshczelivka) [48°39'34"N 25°43'59"E; ≈ 215 m], Zalishchyky district, Ternopil' region;

Zaleszczyki (м. Заліщики) – Zalishchyky [48°38'35"N 25°43'59"E; ≈ 180 m], Zalishchyky district, Ternopil' region;
Zaroślak (туристична база "Заросляк", Чорногірський гірський масив) – tourist base "Zarosliak" [48°09'52"N 24°32'12"E; ≈ 1270 m], mountain massif - Chornohora (Carpathians), Nadvirna district, Ivano-Frankivsk region;
Zarwanica (с. Зарваниця) – Zarvanytsia [49°46'N 24°59'E; ≈ 310 m], Zolochiv district, L'viv region;
Zloczów (м. Золочів) – Zolochiv [49°48'N 24°54'E; ≈ 270 m], Zolochiv district, L'viv region;
Żabie-Stupejka (смт. Верховина) – urban-type settlement Verkhovyna [48°09'N 24°49'E; ≈ 610 m], Verkhovyna district, Ivano-Frankivsk region;
Żeniów (с. Женів) – vill. Zheniv [49°51'N 24°30'E; ≈ 225 m], Zolochiv district, L'viv region;
Żołoby [Żałoby] (с. Жолоби) – vill. Zholoby [50°04'25"N 25°41'33"E; ≈ 300 m], Kremenets' district, Ternopil' region.

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MATERIAŁY DO FAUNY PAJĄKÓW UKRAINY W KOLEKCJI MUZEUM PRZYRODNICZEGO UNIWERSYTETU WROCŁAWSKIEGO (NA PODSTAWIE ZBIORÓW STANISŁAWA PILAWSKIEGO I KAZIMIERZA PETRUSEWICZA)

STRESZCZENIE

Opracowano "Kolekcje pająków Podola" Muzeum Przyrodniczego Uniwersytetu Wrocławskiego, którą utworzono na podstawie wspólnych zbiorów Stanisława Pilawskiego i Kazimierza Petrusewicza) (1937/38 gg.) i osobistych Stanisława Pilawskiego (1933/35, 1939/40, 1954/56 gg.). Reprezentuje ona faunę terytorium współczesnej Ukrainy, w tym regionów: Lwowskiego, Tarnopolskiego, Równieńskiego, Iwano-Frankowskiego i Zakarpackiego. Podczas rewizji kolekcji opracowano toponimy, użyte na etykietach eksponatów. Stworzono ich listę, ustalono zgodność stosownie aktualnych nazw miast, wiosek, regionów administracyjnych i fizjograficznych.

МАТЕРІАЛИ ДО ФАУНИ ПАВУКІВ УКРАЇНИ В КОЛЕКЦІЇ МУЗЕЮ ПРИРОДНИЧОГО ВРОЦЛАВСЬКОГО УНІВЕРСИТЕТУ (ЗА МАТЕРІАЛАМИ ЗБОРІВ СТАНІСЛАВА ПІЛЯВСЬКОГО ТА КАЗИМИРА ПЕТРУСЕВИЧА)

РЕЗЮМЕ

Опрацьовано «Колекцію павуків Поділля» Музею природничого Вроцлавського Університету. Встановлено, що колекція сформована на основі спільних зборів Станіслава Пілявського та Казимира Петрусевича (1937-1938 рр.), а також особистих Станіслава Пілявського (1933-1935, 1939-1940, 1954-1956 рр.). Вона репрезентує фауну території сучасної України, зокрема Львівської, Тернопільської, Рівненської, а також Івано-Франківської та Закарпатської областей. Під час ревізії колекції увага приділена опрацюванню топонімів, ужитих на етикетках експонатів. Створено їхній перелік, установлено відповідність теперішнім назвам населених пунктів та адміністративним і фізико-географічним регіонам.

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ANATOMICAL, HISTOLOGICAL AND HISTOCHEMICAL STUDIES OF THE ALIMENTARY CANAL OF MONKEY GOBY *NEOGOBIUS FLUVIATILIS* (Pallas, 1814)

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Running heading: Alimentary canal of monkey goby

Abstract: Structural and histochemical analysis of the alimentary canal of juvenile monkey goby *Neogobius fluviatilis* was performed.

It was found that anatomically, the alimentary canal of *N. fluviatilis* is a straight tube without a distinct stomach and short intestine, forming two loops. Based on histological analysis, the following segments of the alimentary canal were distinguished: esophagus, residual stomach, small intestine and rectum. Between the small intestine and other segments there are two well-developed sphincters: pyloric and ileorectal. The esophagus is characterized by a large number of goblet cells secreting both acidic and neutral mucopolysaccharides. A smaller number of mucous cells is present in the small intestine and rectum where they secrete predominantly acidic mucopolysaccharides. Located directly behind the esophagus is a short section with walls having a structure characteristic for a stomach. Mucosa of this region holds many compound alveolar gastric glands which, over a distance of 247.00 ± 97.83 μm, form small clusters. The gastric gland cells, as well as the cells of surface epithelium, do not give a positive reaction for the presence of mucus. Histochemical properties of surface and glandular epithelium and small size of the gastric segment indicate that the stomach in *N. fluviatilis* is a residual organ.

Key words: morphology, histometry, histochemical properties, gut

INTRODUCTION

The monkey goby (*Neogobius fluviatilis*) is a Gobiidae fish natively distributed throughout the Ponto-Caspian region (Neilson and Stepien 2011). In recent decades, the monkey goby together with other Ponto-Caspian fish of the Gobiinae subfamily (i.e. *Neogobius melanostomus, Babka gymnotrachelus, Proterorchinus semilunaris*) have spread through Central European waters, including Polish rivers (Kostrzewa *et al.* 2004, Grabowska *et al.* 2010). The opportunistic feeding strategy of this fish is reported in both its natural range and in Poland. Generally, the diet of monkey goby can vary depending on age, season and habitat (Pinchuk *et al.* 2003, Kakareko *et al.* 2005, Grabowska *et al.* 2009). In the majority of habitats in its natural range, monkey goby primarily consume mollusk, while in the Vistula River they feed mainly on chironomid larvae (Pinchuk *et al.* 2003, Kakareko *et al.* 2005, Grabowska *et al.* 2009). Their proven feeding flexibility must undoubtedly be reflected in the structure of their alimentary canal. So far, no studies related to the morphological and histological structure of the alimentary canal of *N. fluviatilis* or attempts to associate it with dietary plasticity of this species, both in invasive areas and in their natural range, have been published. Such studies have only been performed for *B. gymnotrachelus* (Jaroszewska *et al.* 2008). Due to the fact that feeding habits and distribution range of *N. fluviatilis* are similar to those of *B. gymnotrachelus*, as well as because of the close taxonomical relationship of both species (Neilson and Stepien 2009), it can be expected that the alimentary canal of *N. fluviatilis* will have many of the features previously described by Jaroszewska *et al.* (2008) in *B. gymnotrachelus*. In the present study, the alimentary canals of juvenile individuals were used just as in the work by Jaroszewska *et al.* (2008). It should be noted, however, that the alimentary canal of juvenile fish is fully developed and is not different from the alimentary canal of an adult fish (Govoni *et al.* 1986; Domeneghini *et al.* 1998; Banan Khojasten 2012). In precocial fish, which include monkey goby, the alimentary canal is formed very early in ontogenesis and is well-developed at the start of exogenous feeding (Govoni *et al.* 1986; Capova *et al.* 2008).

The aim of this study was to describe the structure of the alimentary canal of juvenile specimens of *N. fluviatilis*. This description is an important supplement to the poor information about the structural organization and physiology of the alimentary canal of *Gobiidae* fish.

MATERIALS AND METHODS

The materials employed in this study consisted of eight juvenile (according to Placha *et al.* 2010), one year old (age determined by scales) individuals of monkey goby *Neogobius fluviatilis* (51.17 ± 6.01 mm total body length, 39.00 ± 3.81mm standard body length and 0.85 ± 0.30 g body weight). Specimens were collected

from Włocławek Reservoir, associated with the lower Vistula River, Poland. The fishes were fixed in 4% buffered formalin and then the alimentary canals were dissected and weighted using an analytical balance (with an accuracy of 0.0001 g). The length of alimentary canal was determined using a stereoscopic microscope with a specialized eyepiece. Images of alimentary canals were projected on paper, and their lengths were traced. Lengths of copied alimentary canals were measured using an electronic curvimeter and calculated to actual values, dividing the results by the linear magnification (14x). The length of the alimentary canal was measured for determining relative length of the gut (RLG) which was calculated as the ratio of alimentary canal length to total body length.

The paraffin method was employed to prepare tissue sections. The tissue was dehydrated in a series of increasing ethanol concentrations, cleared in xylene and embedded in paraffin. Wax blocks were serially cut using a rotary microtome for 5 or 6 μm tissue sections. Alimentary canals of six individuals were cut transversely along the long axis, and two were cut longitudinally. Tissue sections were mounted on glass slides, and stained with Delafield's hematoxylin and eosin (H-E), or histochemically with the combined alcian blue - periodic acid Schiff technique (AB-PAS) for the presence of mucus. Alcian blue (AB, Polyscience Inc.) pH 2.5 stains the acid mucopolysacharides blue while the Schiff's reagent (PAS, Merc Millipore) stains the neutral mucopolysacharides pink to red (Bancroft and Gamble 2008). After staining, the tissue sections were dehydrated, cleared in xylene and embedded in synthetic resin Entellan (Merc Millipore).

Alimentary canals from the two specimens cut longitudinally were used in histological analysis and to distinguish regions and parts of the alimentary canal, whereas specimens of the remaining six individuals were used to measure the thickness of tissue layers composing the alimentary canal wall in particular regions. The following segments of the alimentary canal were distinguished: esophagus, stomach, small intestine and large intestine. Within the esophagus and small intestine, the proximal and distal parts were investigated. For every region, ten measurements of thickness of epithelium, lamina propria, muscularis (with distinction to longitudinal and circular muscle layer) and serosa both in folds and between them were taken. Additionally, in the stomach, height and width of singular glands (ten measurements) as well as the length of the glandular zone were measured. The length of the glandular zone was calculated by counting tissue sections, on which glands were visible, and multiplying the results by thickness of a single tissue section (5 μm). In each region of the alimentary canal, the height of mucosal folds (with a distinction between large and small) was also measured. In each region of the alimentary canal, measurements were made at ten points (ten selected cross-sections) designated by length of the individual region. The measurements were performed using a light microscope Olympus CX21 with calibrated eyepiece.

RESULTS

Anatomical structure of the alimentary canal

The alimentary canal is a straight tube, which forms two loops. There are no anatomical borders between the sections (Figure 1). The mass of the alimentary canal is 5.61 ± 0.78 g, whereas its lengths is on average 16.52 ± 7.59 mm. The ratio between the length of the alimentary canal and total body lengths (RLG) is on average 0.32 ± 0.13 (Table 1).

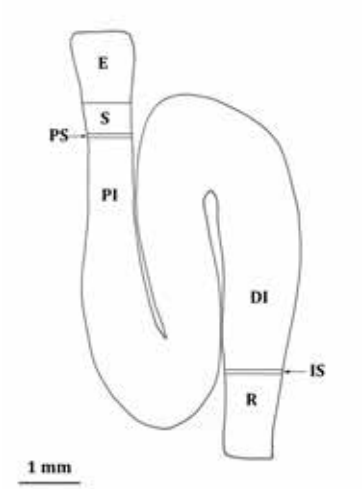

Figure 1. *Schematic view of the alimentary canal of juvenile individuals of monkey goby Neogobius fluviatilis: E-esophagus, S-stomach, PS-pyloric sphincter, PI-proximal small intestine, DI-distal small intestine, IS-ileorectal sphincter, R-rectum.*

Table 1. *The morphometric characteristic of the alimentary canal in the juvenile individuals of monkey goby Neogobius fluviatilis (means±SD)*

Parameter	
Alimentary canal mass (mg)	5.61±0.78
Alimentary canal length (mm)	16.52±7.59
Relative length of gut (RLG)	0.32±0.13

Histological structure of the alimentary canal

Esophagus

The wall of the esophagus of *N. fluviatilis* is made up of mucosa (epithelium and lamina propria), muscularis and serosa. The epithelium is formed by the stratified squamous epithelium. Numerous large goblet cells occur in the surface layer of epithelium (Fig. 2a, b). Most of the goblet cells produce mixed mucus – both

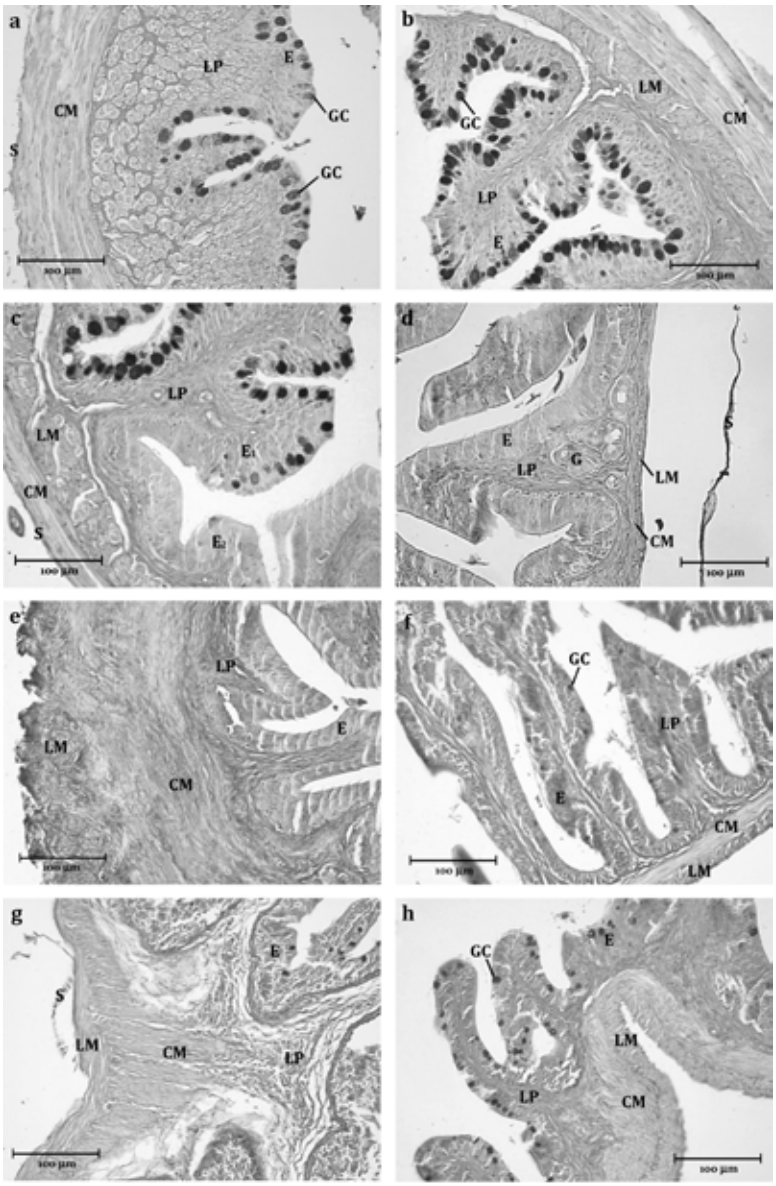

Figure 2. *Histology of the alimentary canal regions of juvenile individuals of monkey goby Neogobius fluviatilis: a) cross section of proximal esophagus b) cross section of distal esophagus c) longitudinal section of transitional zone between esophagus and stomach d) cross section of stomach e) cross section of pyloric sphincter of the stomach f) cross section of small intestine g) longitudinal section of ileorectal sphincter h) cross section of rectum. AB--PAS staining: E-epithelium, E1-esophageal epithelium, E2-gastric epithelium, G-gastric gland, GC-goblet cell, CM-circular muscle layer, LM- longitudinal muscle layer, LP-lamina propria, S-serosa.*

acidic and neutral. Less numerous are the cells with only acidic or only neutral mucopolysaccharides. The lamina propria is made up of loose connective tissue. In the lateral walls of the proximal part of the esophagus, connective tissue is interwoven with bundles of longitudinal striated muscle fibers which can be observed in the tissue section as two crescents (Fig. 2a). In the distal part of esophagus, the lamina propria is made up exclusively of loose connective tissue (Fig. 2b). The mucosa forms folds of different heights and, in the proximal part of esophagus, has a characteristic arrangement. Smaller folds are located on the dorsal and ventral sides of the esophagus, usually in threes next to each other and their height is on average 105.67 ± 45.78 μm (Table 2). Large folds occur in places where the lamina propria bundles of striated muscle fibers (crescents) are located. They are on average 264.42 ± 45.78 μm in height (Table 2). On the other hand, in the distal part of the esophagus, small folds are in between the large ones. Small folds reach a height of 109.17 ± 22.85 μm, whereas large ones are 225.35 ± 39.85 μm (Table 2). The number of folds, both small and large, are from five to nine. Muscularis in the proximal part of the esophagus is made up of a singular layer of circular striated muscles. In the distal part of esophagus, two layers of striated muscles can be distinguished: inner longitudinal and outer circular. In the transition zone between the esophagus and stomach, in the muscularis, smooth muscles can be observed. From the outside, the esophagus wall is covered by a thin layer of serosa.

Table 2. *The sizes (μm) of mucosal structures of the alimentary canal regions in the juvenile individuals of monkey goby Neogobius fluviatilis (means±SD)*

Region	Height of mucosal folds		Gastric glands		
	Large folds	Small folds	Heigth	Width	Length of glandular zone
Proximal esophagus	105.67±45.78	264.42±22.32			
Distal esophagus	109.17±22.85	225.35±39.85			
Stomach	106.38±13.86	246.65±9.13	27.45±5.55	26.24±3.97	247.00±97.83
Proximal small intestine	170.74±54.89	308.33±53.64			
Distal small intestine	105.05±14.64	243.85±21.70			
Rectum	109.50±18.24	226.20±27.80			

The thickness of individual layers forming the esophagus' wall as well as a percentage of individual layers in overall thickness of the esophagus wall of *N.* the *fluviatilis* are presented in Table 3.

Table 3. *The thickness of tissue layers forming the wall of the alimentary canal regions (μm) and the percentage (%) of the layers in the wall thickness of alimentary canal regions in the juvenile individuals of monkey goby Neogobius fluviatilis (means±SD)*

Region	Epithe-lium	Mucosa		Muscularis		Serosa
		Epithelium	Lamina propria	Inner layer	Outer layer	
Proximal esophagus	a	20.96±3.17	203.96±32.72		94.54±13.65	5.00±0.98
	%	6.51±0.96	62.73±2.67		29.22±2.66	1.54±0.30
	b	22.58±3.11	60.33±16.30		84.50±16.73	4.98±0.84
	%	13.39±1.92	34.67±3.77		49.36±2.34	2.59±0.53
Distal esophagus	a	32.81±4.25	255.96±43.44	48.17±18.27	54.46±18.57	3.38±0.26
	%	10.59±1.38	56.07±6.22	15.06±3.55	17.16±3.83	1.12±0.30
	b	22.67±4.96	12.79±2.95	39.58±15.97	52.08±17.62	3.33±0.63
	%	18.49±3.34	7.15±2.33	30.62±5.08	40.98±4.35	2.77±0.70
Stomach	a	29.54±6.20	216.30±24.14	29.58±13.18	38.67±13.75	4.15±1.15
	%	9.40±2.59	68.51±3.60	8.93±3.15	11.87±3.37	1.29±0.31
	b	27.71±6.14	11.95±3.62	27.04±11.95	35.71±18.77	3.71±0.77
	%	28.06±12.49	13.72±2.35	24.22±7.48	30.43±9.74	3.57±0.84
Proximal small intestine	a	24.63±4.69	175.96±33.20	17.38±4.81	20.92±8.49	2.63±0.38
	%	7.91±2.47	79.47±2.52	5.37±1.04	6.42±2.10	0.83±0.16
	b	23.83±6.37	8.54±1.81	11.29±4.41	16.88±7.07	2.79±0.29
	%	35.89±10.80	18.80±1.24	16.51±4.67	24.57±9.27	4.23±0.77
Distal small intestine	a	21.45±2.56	218.54±17.03	20.75±5.84	35.20±13.76	2.75±0.50
	%	7.83±1.16	78.49±4.47	7.48±1.58	5.19±2.72	1.02±0.26
	b	23.10±3.81	14.21±0.93	15.65±6.79	26.85±11.13	2.50±0.66
	%	36.94±7.59	18.44±0.93	23.75±6.29	16.90±2.60	3.98±1.11
Rectum	a	23.60±4.82	194.10±28.62	35.75±7.85	23.35±9.40	2.45±0.21
	%	8.66±1.71	69.11±5.88	12.92±3.38	8.42±3.67	0.88±0.12
	b	23.60±4.82	13.90±2.93	26.65±3.70	19.30±7.32	2.65±0.49
	%	27.51±5.05	16.28±3.52	31.23±4.88	21.91±6.51	3.07±0.37

a-the thickness of the layers within the folds

b- the thickness of the layers between the folds

Stomach

The stomach wall, similar to the esophagus, consists of mucosa, muscularis and serosa. On the border of esophagus and stomach, striated squamous epithelium with a large number of goblet cells suddenly transits into columnar epithelium without mucous cells (Fig.2c). In the stomach epithelium there are many rodlet cells

containing PAS-positive inclusions. The remaining epithelium cells are not mucus positive. Lamina propria is made of loose connective tissue in which few alveolar gastric glands occur (Fig. 2d). They are present over a distance of 247.0 ± 97.83 μm (Table 2). They do not occur in the transitional zone between the esophagus and stomach and in the area of the pyloric sphincter. They are located at the base of large folds, in a cluster of four to six glands, less often two. Their height is on average 27.45 ± 5.55 μm and width is 26.24 ± 3.97 μm (Table 2). Cells in the wall of the glands do not give a positive reaction for the presence of mucus.

The mucosa consists of numerous large (7-8) and small folds (2-6) with a height of 246.65 ± 9.13 μm and 106.38 ± 3.86 μm, respectively (Table 2). Muscularis consists of two layers of smooth muscles. In the transitional zone, between esophagus and stomach, they have the same arrangement as in distal part of the esophagus. A little way further, the arrangement of the two layers changes, the inner layer has a circular arrangement and the outer layer has a longitudinal arrangement. At the end of the stomach, the circular muscle layer thickens significantly and forms the pyloric sphincter (Fig. 2e). The outside of the stomach is covered with a thin layer of serosa. The thickness of the layers forming the stomach wall and a percentage of individual layers in overall thickness of the stomach wall in *N. fluviatilis* are shown in Table 3.

Small intestine

The wall of the small intestine of *N. fluviatilis*, similar to the esophagus and stomach, consists of mucosa, muscularis and serosa.

The mucosa is lined with columnar epithelium, in which mucous cells and rodlet cells occur. In comparison to the esophagus, mucous cells are smaller and less numerous. They secrete mainly acidic mucopolysaccharides. Cells containing mixed mucopolysaccharides, or neutral mucopolysaccharides are in low numbers. The epithelium, along with lamina propria underneath it, form very large folds with a zigzag arrangement. Proximal intestine large folds (10-17) reach 308.33 ± 73.64 μm, while small folds are (4-8) 170.74 ± 54.89 μm. In the distal intestine, the folds are smaller (Table 2). Muscularis consists of two layers of smooth muscles: thinner internal arrangement of circular muscle and thicker external arrangement of longitudinal muscle. Only in the distal parts of the small intestine does the circular muscle layer thicken and forms ileorectal sphincter separating the small intestine from the rectum (Fig. 2g).

The thickness of individual layers creating the intestine's wall as well as their percentage in total thickness of the wall are presented in Table 3.

Rectum

The wall of the rectum is made up of mucosa, muscularis and serosa. The mucosa is covered with columnar epithelium which contributes a smaller percentage in the composition of the wall compared to the intestine (Table 3). In this region of

the alimentary canal, similar to the esophagus and small intestine, mucous cells are present in the epithelium. In comparison to the small intestine, they occur in greater density (Fig. 2g, h). Most of mucus cells contain acidic mucopolysaccharides. Cells containing mixed mucopolysaccharides are less numerous, and cells producing neutral mucopolysaccharides are the least abundant.

Below the epithelium, there is lamina propria which consists of loose connective tissue. Along with epithelium, it forms folds with heights similar to those of the esophagus (Table 2). The muscularis is well developed and significantly thicker than in the small intestine (Table 1). But, unlike in the small intestine, the rectum's inner layer of circular muscles is thicker than outer longitudinal one (Table 3).

Detailed data regarding thickness of layers creating the wall of the rectum, as well as their percentage in overall thickness of the wall is presented in Table 3.

DISCUSSION

Anatomical structure

The present study demonstrated that the alimentary canal of *N. fluviatilis* is poorly differentiated and it has no anatomically separated stomach, similarly to the alimentary canal of *B. gymnotrachelus* investigated by Jaroszewska *et al*. (2008). As reported by Kobegenova and Dzhumaliev (1991), Geevarghese (1983) and Wołczuk *et al*. (2015), poor anatomical differentiation is a feature of the alimentary canal of most goby fish.

In addition to the poor differentiation of the alimentary canal of *N. fluviatilis*, it is also characterized by a short length. As demonstrated by numerous studies, the length of the alimentary canal of fish is closely related to the type of ingested food, and the parameter which describes this dependency in the best way is the RLG coefficient (length of the gut relative to the length of the body). Based on the value of this coefficient, Geevarghese (1983) distinguished among the *Gobiidae* three trophic types including: herbivores, whose relative length of the alimentary canal is above 1.25, omnivores with a tendency to herbivory, whose relative length of the alimentary canal is 1.0-1.25 and omnivores with a tendency to carnivory, whose relative length of the alimentary canal is below 1.0. In the investigated specimens of *N. fluviatilis* the RLG coefficient is 0.32 ± 0.13, which indicates that juvenile specimens are carnivorous. This is consistent with the results of studies of dietary preferences of *N. fluviatilis* (Kakareko *et al*. 2005, Grabowska *et al*. 2009). However, as evidenced by the work of Pogoreutz and Ahnelt (2014), in fish of the *Gobiidae* family the morphology of the alimentary canal is not always reflected by the absorbed food. An example is a herbivorous goby *Austrolethops wardi*, which has a short and simple alimentary canal which does not reflect its high degree of digestion of food having a low nutrient content (Pogoreutz and Ahnelt 2014).

According to Banan Khojasteh (2012) intestinal length is influenced by a number of other factors apart from diet, which include fish size (mass and length) and body shape, recent feeding history, ontogeny, and phylogeny. In the case of *A. wardi*, the length of the alimentary canal most probably reflects the evolutionary history of the species (Pogoreutz and Ahnelt 2014).

Histological structure

The general structure of the alimentary canal wall in juvenile specimens of *N. fluviatilis* coincides with the description presented in the studies by Kobegenova and Dzhumaliev (1991) and Jaroszewska *et al.* (2008) for other *Benthophilinae* fish. In the esophagus, whose role is to transport food, attention is drawn to the particular structure of the mucosa and the muscularis. As evidenced by the studies, longitudinal muscles do not form a continuous layer and are located only in the lateral walls of the esophagus, and their fibers penetrate into the lamina propria and high folds of the mucosa. Thanks to such a structure, the mucosa is extremely thick and constitutes up to 63% of the thickness of the esophageal wall. A similar organization of the mucosa was observed in the esophagus of *Pseudopleuronectes amaricanus*, *Limanda ferruginea* and *B. gymnotrachelus* (Murray *et al*. 1994, Jaroszewska *et al*. 2008). It is assumed that such an arrangement of the muscles allows for the rejection of undesirable substances (Oliviera-Ribeiro and Fanta 2000) and provides high elasticity of this section (Wołczuk *et al.* 2015).

In the esophageal mucosa of *N. fluviatilis*, similarly to other fish, there are numerous mucous cells, whose secretion protects the mucosa against mechanical and chemical injuries (Hur *et al.* 2005, Petrinec *et al.* 2007, Wilson and Castro 2011). In juvenile specimens of *N. fluviatilis,* there are three types of goblet cells, cells secreting only acidic or neutral mucopolysaccharides and mixed, secreting both types of mucopolysaccharides. The main population of goblet cells comprises cells that produce mixed mucus which has also been observed in other fish of the *Gobiidae* family (Kobegenova and Dzhumaliev 1991, Hur *et al.* 2005, Wołczuk *et al.* 2015). The exception is *B. gymnotrachelus*, which has only cells secreting acid mucus in the epithelium of the esophagus (Jaroszewska *et al*., 2008). According to many researchers, the production of mucopolysaccharides serves to moisten and protect the epithelium (Pedini *et al*. 2005; Jaroszewska *et al.* 2008). Mixed mucous cells most likely allow for the activity of the alimentary canal of fish under changing environmental conditions (Abdulhadi 2005; Banan Khojasteh 2012). In contrast, Leknes (2011) suggests that a wide range of goblet cell staining may be associated with their various functions such as moistening, immunological barrier, absorption or even digestion.

Histological passage of the esophagus into the stomach in *N. fluviatilis* can be observed only based on the changes in the type of surface epithelium from the stratified squamous to the simple columnar cells, which was also described in other goby

fish (Kobegenova and Dzhumaliev 1991, Jaroszewska *et al*. 2008, Wołczuk *et al*. 2015). An important feature of the surface epithelium of the stomach of *N. fluviatilis* and many other species of goby fish (Kobegenova and Dzhumaliev 1991, Hur *et al*. 2005, Jaroszewska *et al*. 2008, Wołczuk *et al*. 2015) is the lack of goblet cells. These species also include *B. gymnotrachelus*, wherein in *B. gymnotrachelus* this region of the alimentary canal has been called a secretory oesogaster (Jaroszewska *et al*. 2008). Mucus in *N. fluviatilis* is also not produced by the cells of the surface epithelium, as indicated by a negative result of the AB-PAS reaction. Below the epithelium, in the lamina propria of the gastric mucosa of *N. fluviatilis,* there are multicellular glands gathered in groups of 4-6 glands. Similarly as in *P. semilunaris, R. giurinus, M. batrachocephalus, B. gymnotrachelus, N. melanostomus* and *N. ratan* they are alveolar structures. They occur within a small section of a length of 247.0 ± 97.83 μm. To compare, the glandular zone in *P. semilunaris* is 1870 ± 264 μm long (Wołczuk *et al.* 2015). In contrast to *B. gymnotrachelus* and *P. semilunaris* (Jaroszewska *et al*. 2008; Wołczuk *et al.* 2015), no mucosubstances were found in the lumen of gastric glands in *N. fluviatilis*. Their presence was also found in neither the cytoplasm of the cells forming the wall of the glands, nor in the cytoplasm of surface epithelial cells. Because, according to many researchers, the presence of mucus in the stomach is associated with the protection of the mucosa against aggressive action of hydrochloric acid and pepsin (Al-Hussaini 1949, Barrington 1957, Reite 2005), it can be supposed that hydrochloric acid is not produced in the stomach of *N. fluviatilis*. To sum up, the small size of the glandular portion combined with the lack of evidence for the functionality of the glands may indicate the regression of the gastric segment of *N. fluviatilis* to the residual form. It is possible that the lack of the stomach is compensated by the presence of pharyngeal teeth that can fragment the relatively hard food which is consumed by *N. fluviatilis*. As evidenced by the study of Bogaczyk (1967), pharyngeal teeth in *N. fluviatilis* are developed well enough to allow for crushing food characterized by a fairly high degree of hardness, including crustaceans, insect larvae and mussels.

In the anterior part of the stomach of *N. fluviatilis,* a replacement of striated muscles into smooth muscles takes place. The circular and longitudinal layers of the muscularis change their position relative to the arrangement present in the esophagus. From this point to the anus, the circular layer of the muscles is situated internally, while the longitudinal one is situated externally. A similar structure of the muscularis has been described in other *Gobiidae* fish (Kobegenova and Dzhumaliev 1991, Jaroszewska *et al*. 2008, Wołczuk *et al*. 2015). In the posterior part of the stomach, the inner layer of the muscles is considerably thicker, forming a sphincter. It is also present in *B. gymnotrachelus* (Jaroszewska e*t al*. 2008). Jaroszewska *et al.* (2008) in their study assume that the oesogastro-intestinal sphincter of *B. gymnotrachelus* can be functionally associated with the pyloric sphincter described in fish having a stomach. Among the agastric fish, the sphincter was observed only

in *Gibelion catla* (Kapoor 1958). Based on the presence of the sphincter, it can be excluded that this short gastric segment is an extension of the intestine called an intestinal bulb. In the alimentary canal of *B. gymnotrachelus,* there is also no intestinal bulb (Jaroszewska *et al.* 2008) as is often observed in other stomachless fish, e.g. in Cyprinidae (Rogick 1931, Sinha 1976, Wallace *et al.* 2005).

The boundary between the stomach and the intestine can also be determined based on the structure of the epithelium. In the epithelium of the small intestine, there are goblet cells which are not present in the epithelium of the stomach. The intestine of *N. fluviatilis* contains few goblet cells, as in the intestine of *B. gymnotrachelus* (Jaroszewska *et al.* 2008), and is dominated by cells producing acid secretions while the cells producing mixed and neutral mucus are less numerous. This is different from the study by Kobegenova and Dzhumaliev (1991) who reported that in the intestinal epithelium of *Gobiidae*, there are goblet cells producing mainly mixed mucus. These differences can be related to the habitat, diet and age of the studied fish. These studies demonstrated that the quality of gut mucosubstances is directly related to environmental conditions which in turn indirectly affect the function of the alimentary canal, and additionally the properties of the mucous secretions change during the development of the fish (Domeneghini *et al.* 1998). Therefore, the predominance of mucous cells with acid secretions in juvenile specimens of *N. fluviatilis* can indicate the need to protect the intestinal mucosa against adverse environmental conditions. According to Banan Khojasten (2012) the acidic (sulfated) mucosubstances in the intestine probably regulate the transfer of proteins or a fragment of them. This would explain their large number in the intestine of juvenile *N. fluviatilis*.

In addition to enterocytes and mucous cells in the intestinal epithelium of the study specimens of *N. fluviatilis,* there are also rodlet cells. As evidenced by the study, large numbers of these cells are present in the intestinal wall of *Cyprynidae* and *Labridae* (Al-Hussaini 1949, Barrington 1957, Reite 2005). It should be noted that these are stomachless fish, which do not secret pepsin and hydrochloric acid. It is known that the low pH of the gastric content protects the mucosa against microorganisms and prevents the introduction of pathogens into the intestine. Therefore, the intestine of stomachless fish can be more exposed to them as compared to fish having a stomach. As suggested by Manera and Dezfuli (2004), Reite (2005), and Dezfuli *et al.* (2008), the population of rodlet cells can have a protective function, especially because their number increases significantly during parasitic infections.

The epithelium with the underlying connective tissue forms prominent zigzag folds increasing the digestion and absorption surface of the intestine of *N. fluviatilis*. The present study demonstrated that in *N. fluviatilis,* the largest folds are present in the proximal part of the small intestine and their height decreases along the intestine. Given such a development of the mucosa, the muscularis in the intestine is relatively

thin and in the folds of the proximal and distal part, it constitutes 12% and 13%, respectively, while in the large intestine it is 21% of the total wall thickness. It should be noted that in all parts of the intestine, the epithelial lamina has a large contribution to building the wall in the area between the folds (35% in the proximal part of the small intestine, 36% in its distal part and 28% in the rectum). This may indicate that in the small intestine, in its proximal part in particular, where enterocytes and mucosal folds are the largest, the digestion and absorption processes are most intensive. In turn, in the rectum, the elasticity and peristalsis of this section, which are extremely important for the process of collection of indigested residues and formation and removal of fecal mass, seem more vital. Functional separation of two intestinal regions in *N. fluviatilis* is possible thanks to the presence of a prominent ileorectal sphincter. A distinct differentiation of the intestine was also observed in *R. giurinus* (Hur *et al.* 2005) and *B. gymnotrachelus* (Jaroszewska *et al.* 2008), while there is no information whether a sphincter or ileorectal valvae are present in *R. giurinus*. However, this kind of sphincter was well described in *B. gymnotrachelus* (Jaroszewska *et al.* 2008) and it is also briefly mentioned in the publication by Kobegenowa and Dzhumaliev (1991) relating to several species of goby fish from the Black Sea.

To summarize, the alimentary canal of *N. fluviatilis* has very strong similarities to the alimentary canal of *B. gymnotrachelus*, which is probably related to the type of food ingested and indicates a close relationship between these two species. It is a straight and short tube, which indicates that this species is carnivorous. The alimentary canal has no anatomically separated stomach. This segment can be identified histologically based on: the type of epithelium, the presence of gastric glands and the presence of a pyloric sphincter. However, the stomach has a residual nature, as indicated by: its small size, a small area of occurrence of gastric glands and lack of features indicating the functional activity of the gastric glands. The lack of a functional stomach can be compensated by the presence of pharyngeal teeth that allow for the fragmentation of hard food (crustaceans, insect larvae). In the epithelium of the alimentary canal, mainly in the esophagus, goblet cells are present which produce three types of mucous secretions: mixed, acid and neutral. Production of various types of mucus can favor adaptation to changing environmental conditions and food.

STRESZCZENIE

Badania anatomiczne, histologiczne i histochemiczne przewodu pokarmowego babki szczupłej *Neogobius fluviatilis* (Pallas, 1814)

Przeprowadzono analizę strukturalną i histochemiczną przewodu pokarmowego młodych osobników babki szczupłej *Neogobius fluviatilis*.

Stwierdzono, że pod względem anatomicznym przewód pokarmowy *N. fluviatilis* ma postać prostej rury, bez wyraźnie odcinającego się żołądka, a krótkie jelito tworzy dwie pętle.

Na podstawie analizy histologicznej w przewodzie pokarmowym wydzielono przełyk, szczątkowy żołądek, jelito cienkie i jelito grube. Pomiędzy jelitem i pozostałymi odcinkami występują dwa dobrze rozwinięte zwieracze: odźwiernikowy i ileorektalny. Przełyk charakteryzuje się obecnością dużej liczby komórek kubkowych produkujących jednocześnie kwaśne i obojętne mukopolisacharydy. Mniejsza liczba komórek śluzowych występuje w obrębie jelita cienkiego i grubego, gdzie wydzielają głównie kwaśne mukopolisacharydy. Bezpośrednio za przełykiem występuje krótki odcinek, którego ściana ma budowę typową dla żołądka. W błonie śluzowej tego odcinka obecne są wielokomórkowe gruczoły żołądkowe typu pęcherzykowego. Tworzą one niewielkie skupiska na odcinku o długości 247,0 ± 97,83 μm. Komórki tworzące ścianę gruczołów, podobnie jak komórki nabłonka powierzchniowego, nie dają pozytywnego wyniku reakcji na obecność śluzów. Właściwości histochemiczne komórek nabłonka powierzchniowego oraz gruczołowego w połączeniu z niewielkimi rozmiarami tego odcinka wskazują na to, że żołądek *N. fluviatilis* jest narządem szczątkowym.

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DISTRIBUTION AND HABITAT PREFERENCES OF EURASIAN BITTERN *BOTAURUS STELLARIS* AT NATURAL LAKES OF ŁĘCZNA–WŁODAWA LAKELAND

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Abstract: A census of booming Eurasian Bittern males at all 61 natural lakes of Łęczna-Włodawa Lakeland (Lublin Region, eastern Poland) was conducted in the years 2010-2011. A maximum number of 34 Eurasian Bittern territories at 15 lakes was recorded (as a sum of maximum number of territories during both seasons at each lake). A comparison with the historical data indicates relative stability of the local population. The analysis of some morphometric and environmental parameters of lakes with reference to their occupation by Bitterns showed the species preference for large lakes characterised by low values of bottom slope angle, considerably covered by vegetation beds.

Key words: *Botaurus stellaris*, habitat preferences, lakes, population dynamics, Poland

INTRODUCTION

The Eurasian Bittern *Botaurus stellaris* is an ecologically flexible heron species inhabiting a wide range of wetland habitats. The bird occupies widespread and rather uniform emergent vegetation patches of various types, preferably flooded by quite shallow water pools (Puglisi *et al.* 2003, Adamo *et al.* 2004, Gilbert *et al.* 2005, Poulin *et al.* 2005, Polak *et al.* 2008, Poulin *et al.* 2009). The lack of such habitats constitutes the main factor limiting its occurrence (Kloskowski *et al.* 2010). The species is an opportunistic predator foraging on the most abundant prey in each ecosystem. Its diet consists mainly of fish, amphibians, crustaceans and insects, but also small mammals, reptiles and birds (Polak 2007, Poulin *et al.* 2007). The Eurasian Bittern's polygynous mating system and lack of any paternal chicks care (Gauckler

and Kraus 1965, Kasprzykowski and Polak 2013) constitute an exception among generally monogamous herons with biparental care. Due to its uniqueness, intriguing secretive habits and remarkable population declines, the species has recently attracted attention of researchers. However, owing to degradation of natural biotops of Eurasian Bittern, occurring especially in Western Europe, most studies on biology, ecology and habitat preferences of this species were conducted in semi–natural habitats of anthropogenic origins, such as fish ponds, polders, retention basins and rice fields (Puglisi *et al.* 2003, Adamo *et al.* 2004, Gilbert *et al.* 2005, Poulin *et al.* 2005, Polak *et al.* 2008, Poulin *et al.* 2009). Habitat selectivity in such substitutive environments could not reflect the species' real preferences due to a lack of complex habitat diversity and limited gradient of parameters. The investigation of original preferences in historical or only slightly altered conditions can be very important for effective conservation of existing habitats, as well as for proper wetland management in Eurasian Bittern's habitat restoration programs, conducted mainly in Western Europe.

Dramatic declines of the European population caused by habitat loss in the 20th century, which has not ceased yet, resulted in the species' high protection status (SPEC 3, BIRDLIFE INTERNATIONAL 2004). While in many Western European countries, populations of the species are only residual (White *et al.* 2006), Poland with a stable population of 3300–4200 booming males constituting 7.5% of the European population and even 26% of EU population (Chodkiewicz *et al.* 2015) appears to be a Eurasian Bittern stronghold. The maintenance of this positive state, however, demands both proper conservation and regular population monitoring.

The aim of this study was to establish the number and distribution of Eurasian Bitterns on natural lakes of Łęczna–Włodawa Lakeland (Lublin Region, eastern Poland). This region is an area where a booming males census was conducted about 15 years ago (Piskorski 1999), which gives the opportunity to assess local population strength and to discover potential threats against its stability. We also analysed some parameters of lakes to detect their influence on species' occurrence in such biotops.

STUDY AREA

The Łęczna–Włodawa Lakeland, covering 1,300 km^2 of Western Polesie, is located in the Lublin Region in eastern Poland (Kondracki 2013). The area is characterized by the shallow levels of groundwater what results in the presence of many lakes, marshes and bogs.

Among the 67 lakes located in the study area, 61 could be recognized as natural or close to a natural state. The remaining six lakes have been technologically enlarged, bordered, converted into storage reservoirs or included into the Wieprz–Krzna Canal system since 1950s and 1960s (Harasimiuk *et al.* 1998), thus

they are excluded from the analyses. The natural lakes can be defined as small, since the area of the biggest one equals 284.1 ha and the total area of the 61 lakes sums up to about 2,128 ha. Shore lines are not complicated so the shapes of these lakes are close to oval. Most of the lakes are shallow, however depths vary much with one reaching a depth of 38.8 m (Piaseczno Lake). The diversity of bottom slope angles results in different extents of emergent vegetation between lakes. The lakes are also diverse in terms of their trophy, however eutrophic ones outnumber mesotrophic and distrophic examples. The current eutrophication process is mainly caused by agriculture intensification and increasing use of lakes for recreation, and is additionally enhanced by the dense drainage system supporting biogenes transport from even distant sources leading to their allocation in the lakes (Harasimiuk *et al.* 1998).

The lakes qualified as natural or quasi–natural are generally not modified by hydro–engineering treatment. However, at some of them, strong human pressure can be observed. Lakes, such as Białe Włodawskie, Krasne, Łukcze, Piaseczno, Bialskie, Rotcze and Zagłębocze, constitute locally popular recreation centres which have resulted in the creation of resorts in the close proximity to the water bodies. Around these particular lakes high noise levels are generated, especially during summer. Moreover, the natural state is violated by people swimming, canoeing, windsurfing and yachting. The use of motorboats at Białe Włodawskie Lake seems to constitute the most aggressive form of recreation. Many lakes, like Głębokie Uścimowskie, Uścimowskie, Maśluchowskie, Krasne, Sumin, Głębokie and Zienkowskie are adjacent to villages. At the majority of inspected lakes, many piers are disuniting previously uniform vegetation beds. Most of the lakes are used by amateur anglers, to various extents.

Lakes undisturbed by people due to their impenetrability are also present in Łęczna–Włodawa Lakeland. Some of them are partially covered by floating carpets of vegetation which greatly increases the risk of drowning, e.g. Nadrybie Lakie. Others are fringed with dense willow bushes or marshy birch forests, e.g. Brzeziczno Lake, or surrounded by water meadows or peat bogs, e.g. Kleszczów Lake and Hańskie Lake. Many lakes are located in protected areas, four of which are in Poleski National Park (Łukie, Karaśne, Moszne and Długie) and even more in nature reserves (e.g. Orchowe, Brzeziczno, Wspólne, Łukietek, Obradowskie). The whole study area is located in the borders of the International Biosphere Reserve "Polesie Zachodnie (Western Polesie)."

Lowering of surface water levels due to meliorations has a great impact on changes in the vegetation of lakes. In most of them, the extension of the littoral zone and acceleration of overgrowth with emergent vegetation has been observed. The emergent vegetation is composed mainly by *Phragmites australis*, *Typha latifolia* and *T. angustifolia*, and to a lesser extent by *Schoenoplectus lacustris, Acorus calamus, Equisetum fluviatile, Carex* spp. and *Sparganium* sp. (Małysz 2007, Chmielewski 2009).

In the last decade of the 20th century, the lakes in the study area were inhabited by 35 fish species, 28 of which were native, represented by roach *Rutilus rutilus*, tench *Tinca tinca*, crucian carp *Carassius carassius*, common bream *Abramis brama* and pike *Esox lucius* in the highest numbers (Harasimiuk *et al.* 1998). During last decades, two invasive species, the prussian carp *Carassius gibelio* and the brown bullhead *Ameiurus nebulosus,* have become dominant in the majority of water bodies in the region (Chmielewski 2009). In Poleski National Park, 23 fish and 13 amphibian species were recorded (Grądziel *et al.* 2008).

METHODS

Due to the considerable size of the study area, we concentrated on the distribution of territorial Eurasian Bittern males only, thus nests and breeding females were not investigated. The presence and number of territories at each lake was established on the basis of booming male records. The methodology was developed with remarks of Piskorski (1999), Poulin and Lefebvre (2003), Polak (2006) and Chylarecki *et al.* (2009) taken under consideration.

The study took place from 15th April to 22nd May 2010 and from 31st March to 6th June 2011. In each season all of the lakes were surveyed, the vast majority of them at least two times, the first time before the end of April and second after the beginning of May. At those lakes where more than two territories were recorded, up to four surveys were conducted to minimize the risk of inaccurate assessment of male numbers. In the case of small lakes (up to 20 ha) each listening session was lead from one location at the shore, while the bigger ones were walked around or surveyed from several locations. Some particularly big and inaccessible lakes (Uściwierz, Sumin, Bikcze) were explored with the use of a pontoon boat.

Four lakes located in Poleski National Park (Łukie, Długie, Moszne, Karaśne) were surveyed by Grzegorz Grzywaczewski and his team in 2010, but they were not surveyed in 2011, thus those lakes are excluded from the analysis of population trends. However, the results from 2010 were included to the analyses of habitat preferences. Four lakes, Laskie, Orzechówek, Hańskie and Maczółki, were excluded from the analyses of habitat preferences due to shallowing and total overgrowth by vegetation, or considerable discrepancy between area obtained from the literature data and observed in current satellite photos.

With reference to the research by Poulin and Lefebvre (2003) pointing out increased booming activity at dawn and dusk, mid–day controls were avoided. Each control lasted for at least 25 minutes, thus their duration was prolonged comparing to indications by Chylarecki *et al.* (2009), what probably compensated the lack of recommended third control in terms of male detectability.

Precise location of single booming male was marked on satellite picture of each lake. The crossing azimuths method was used to establish accurate locations and numbers of birds at lakes with high Eurasian Bittern densities.

Data on lakes morphometry was taken from the study by Harasimiuk (1998). For some small and shallow lakes in cases where data was lacking, the average depth of 1 m and the bottom slope angle of 0.8 were assumed. Five environmental parameters of each lake (the total area, shoreline development, average depth, average bottom slope angle and the ratio of vegetation beds area to open water area was calculated using orthophoto maps from http://www.geoportal.gov.pl/) were taken under consideration in statistical analysis of habitat preferences of Eurasian Bittern. Due to the strong correlation between average bottom slope angle and average depth ($r=0.80$, $p<0.05$) the latter parameter was excluded from the multiple regression model. The computations were performed using Statistica 12.0.

RESULTS

Distribution of territories

During the two seasons at 57 natural lakes of Łęczna–Włodawa Lakeland (4 lakes in Poleski National Park were excluded) the maximum number of 27 Eurasian Bittern territories at 14 lakes was recorded (as a sum of maximum number of territories during both seasons at each lake; 22 territories at 12 lakes in 2010 and 26 territories at 13 lakes in 2011). Additionally, out of four lakes located in Poleski NP which were surveyed in 2010, Łukie Lake was occupied by 7 booming males. The maximum density of booming males calculated for the total area of 61 lakes was 1.6 males / 100 ha. The area of occupied lakes ranged from 10.6 to 284.1 ha and the density at each occupied lake varied between 0.7 and 9.4 males / 100 ha. The distribution of territories is shown in Figure 1.

Habitat preferences

The Mann–Whitney test used for comparison of occupied and unoccupied lakes in terms of five environmental parameters showed that only two, the area of the lake and the average bottom slope angle, were significantly different between the two groups. The occupied lakes were bigger and were characterized by lower bottom slope angle values. They were also more strongly covered by vegetation beds, the difference being nearly significant (Table 1).

Table 1. *Comparison of environmental parameters of inhabited and uninhabited lakes of Łęczna–Włodawa Lakeland.*

Parameter	Inhabited lakes (n=15)		Uninhabited lakes (n=42)		Mann–Whitney Test	p value
	Mean ± SD (range)	Median	Mean ± SD (range)	Median		
Area (ha)	81.62 ± 68.728 (10.60–284.10)	65.30	20.73 ± 22.730 (2.20–106.40)	11.50	U=74.0	**p <0.001**
Average bottom slope angle	1.33 ± 1.299 (0.50–4.92)	0.75	1.94 ± 1.427 (0.80–5.67)	1.21	U=181.5	**p = 0.014**
Ratio of vegetation beds area to open water area	0.24 ± 0.171 (0.09–0.74)	0.20	0.17 ± 0.156 (0.00–0.54)	0.13	U=213.0	p = 0.065
Shoreline development	1.15 ± 0.129 (1.02–1.45)	1.10	1.11 ± 0.093 (1.00–1.45)	1.09	U=264.0	p = 0.364
Averae depth (m)	2.89 ± 2.730 (1.0–10.8)	1.60	2.85 ± 2.87 (0.5–14.1)	1.75	U=283.0	p= 0.572

The multiple regression model with the number of males considered as a dependant variable showed that three parameters: lake area, ratio of reedbeds area to open water area and average bottom slope angle, significantly influenced the distribution of Eurasian Bitterns at natural lakes of Łęczna–Włodawa Lakeland. Territorial males preferred bigger lakes considerably covered by vegetation beds, with low bottom slope angle values (Table 2).

Table 2. *The results of multiple regression model with the number of males considered as a dependant variable, showing the influence of each environmental parameter on the lake occupancy by Eurasian Bitterns.*

Parameter	B	SE	p value
Area	0.025193	0.002158	**p < 0.001**
Ratio of vegetation beds area to open water area	2.838749	0.601137	**p < 0.001**
Average bottom slope angle	-0.169798	0.069072	**p = 0.017**
Shoreline development	-0.402224	1.002006	p = 0.690

DISCUSSION

The historical data on Eurasian Bittern population numbers at lakes of the region dates back to the 1970s. The study by Dyrcz *et al.* (1973) indicates the occurrence of four territories at four lakes. However, these results seem to be much underestimated and due to different methods applied for population survey they were not taken under consideration in the population trends analysis. The Lublin Ornitho-

logical Society files point out the occurrence of at least 13–14 males at 11 lakes in the years 1983-1994, but for many lakes any data is lacking. The first complex investigation to focus on the Eurasian Bittern population in the studied region was done by Piskorski (1999), who recorded 30 males at 15 natural (or semi–natural) lakes out of Poleski NP (and additionally 7-8 males at Łukie Lake). The author surveyed the majority of lakes in the region, at least those which comprised suitable habitats for the species. In the present study, during 2010-2011 we recorded a maximum number of 27 males at 14 lakes (and additional 7 males at Łukie Lake in 2010). These results indicate a 10% decline, but considering normal fluctuations documented for the species (Polak and Kasprzykowski 2009) together with the short duration of the present study, the population seems to be quite stable. Although the numbers of both territories and inhabited lakes in both studies are similar, the distribution of males is a little different (Table 3).

Table 3. *Eurasian Bittern population dynamics at historically occupied natural lakes of Łęczna–Włodawa Lakeland ("–" means, that no data is available)*

No.	Lake	1968-1971 (Dyrcz et al. 1973)	1983-1994 (Lublin Ornithological Society files)	1995-1998 (Piskorski 1999)	2007-2009 (Chmielewski 2009)	2010-2011 (present study)
1	Kleszczów	–	1	0	1	1
2	Miejskie	–	1	1	–	1
3	Ściegienne	–	–	1	–	0
4	Białe Sosnowickie	–	–	2	–	1
5	Czarne Sosnowickie	–	1	0	–	0
6	Czarne Uścimowskie	–	–	1	–	1
7	Głębokie Uścimowskie	–	–	0	–	1
8	Uścimowskie	–	–	0	–	2
9	Krasne	–	–	–	–	1
10	Zagłębocze	–	–	1	–	1
11	Nadrybie	1	1	1	–	2
12	Bikcze	–	1	1	2	2
13	Uściwierz	1	3 – 4	12	7	8
14	Rotcze	1	1	0	–	0
15	Sumin	1	–	4	–	4
16	(Łukie)*	–	–	(8 – 9)*	–	(7)*

No.	Lake	1968-1971 (Dyrcz et al. 1973)	1983-1994 (Lublin Ornithological Society files)	1995-1998 (Piskorski 1999)	2007-2009 (Chmielewski 2009)	2010-2011 (present study)
17	Płotycze k. Urszulina	–	1	1	1	1
18	Laskie	–	1	1	–	0
19	Hańskie	–	1	0	–	0
20	Czarne	–	–	1	–	0
21	Białe	–	1	1	0	0
22	Wspólne (Spilno)	–	–	0	–	1
23	Syczyńskie	–	–	1	–	0
24	Tarnowskie	–	–	1	–	0
	Total	4	13 – 14	30 (38–39)*	11	27 (34)*

* - data including Łukie Lake, in the present study surveyed only in 2010

In 2010-2011 Eurasian Bittern territories were recorded at five lakes, not occupied in the 1990s, these are: Uścimowskie (2 ♂), Kleszczów (1 ♂), Krasne (1 ♂), Głębokie Uścimowskie (1 ♂, only in 2011) and Wspólne (1 ♂, only in 2010). The reasons for this may be complex. The first is the ongoing eutrophication and shallowing of lakes leading to the expansion of the litoral area, which results in increasing Eurasian Bittern habitat. It is also possible that feeding conditions at some lakes have improved due to stocking with some fish species for anglers and, paradoxically, due to the expansion of two small invasive fish species (the Brown Bullhead and the Prussian Carp) which form part of the diet of Eurasian Bitterns at fish ponds and may appear to be appropriate prey for them (Polak 2007). It is also worth noticing that Krasne Lake was one of those not surveyed by Piskorski (1999) and might have been inhabited in the 1990s.

We did not record booming males at six lakes occupied previously: Białe Włodawskie, Czarne Włodawskie, Laskie, Syczyńskie, Ściegienne and Tarnowskie. In each case the abandonment might have been caused by different factors. At Białe Włodawskie Lake, the progressing human pressure seems to be the main reason. This mesotrophic lake with its clear water constitutes the most popular recreation centre in the whole region. In contrast to other lakes visited by tourists from the late June, at Białe Włodawskie the holiday season starts in early May and the pressure of tens of thousands of people, including the use of numerous motorboats, yachts and canoes, generate very high noise levels during day and night around the lake. It is possible that this increased pressure also led the Eurasian Bittern to retreat from Czarne Włodawskie, a lake located only a few hundred meters from

Białe Włodawskie Lake. The reason for forsaking the Laskie Lake by Eurasian Bitters is most likely the fact of advanced shallowing and overgrowth by the vegetation, which have lead to the total disappearance of open water. Such a hydroseral succession was identified as a main determinant of Eurasian Bittern population decrease in England (Tyler *et al.* 1998). Reasons for abandonment of the other three lakes are hard to assess. However, due to their small size, these lakes may constitute only sub–optimal habitats and may be occupied only in the years of population peaks when the competition for high–quality habitats is greater. Comparison of the present results with those from the 1990s suggests that in 2010-2011 the Eurasian Bittern population was not reaching its peak and thus some low–quality habitats might have remained unused.

We observed some inter–seasonal changes in the number of territories at six lakes. In the case of five of them, the number of males was higher in 2011 than in 2010 resulting in the total number of territories being 14% greater in 2011. Such fluctuations can be explained by weather conditions during the preceding winter, which many authors point out to be the determinant of the Eurasian Bittern numbers in the breeding season (Cramp and Simmons 1977, Polak and Kasprzykowski 2009). The species is partially migratory and the sedentary fraction is obviously more prone to hard winter impact, however its proportion in the whole population is unknown. In the study area, such an influence was observed by Piskorski (1999) who noticed that many territories unoccupied in 1996 after a tough winter were inhabited in the following two successive years after mild winters. The present study seems to confirm those observations as the mean temperature of first quarter of year was lower in 2010 than in 2011 (–2.9° C and –1.0° C, respectively) corresponding with lower numbers of males in 2010 (22 ♂♂) compared to 2011 (26 ♂♂). The same parameter in 1996 reached –5.4° C confirming particularly hard conditions, and increased to –1.1° C and +1.0° C in 1997 and 1998, thus even higher than in 2011 which could partially explain the lower number of territories detected in the present study in comparison to late 1990s (http://en.tutiempo.net/ – data from Lublin Radawiec meteorological station). It is worth pointing out that two small lakes uninhabited in 2010 and providing probably lower–quality habitats were occupied in 2011, the season when the competition in optimal habitats was probably stronger due to the higher total numbers of males in the study area. A slight increase in the number of territories in 2011 was also observed in the Eurasian Bittern "hotspots" – Uściwierz (7 vs. 8 males) and Sumin Lake (3 vs. 4 males).

Despite the fact that Uściwierz is still the most inhabited lake in the region, the 33% decrease in Eurasian Bittern males numbers at this lake comparing to the 1990s is alarming. It is much more puzzling considering the clearly irregular territories distribution among rather uniform and much widespread reed beds of the lake (four males concentrated in SE, two males in NE, and single males in the S and W part of the lake). This distribution might be due to unequal spatial availability of food

resources or varied pressure of predators. However, changes causing the decrease must have occurred a few years before as data from 2007 revealed the presence of only seven territories (Chmielewski 2009).

Nevertheless, lakes occupied by the largest numbers in the 1990s have still maintained their importance for Eurasian Bitterns. Three lakes, Uściwierz, Łukie (considering results from 2010) and Sumin, constitute a stronghold for 56% of the population in natural lakes (64% in 1990s). The above confirms that those lakes comprise proper habitats and demand adequate conservation as Eurasian Bittern population hotspots.

The Eurasian Bittern is known to be an ecologically eclectic species and opportunistic predator (White *et al.* 2006). The main factor limiting its occurrence is the presence of large, uniform patches of emergent vegetation beds. The present study shows the species' strong preference for bigger lakes. This preference is predictable since an average home range of a male Eurasian Bittern covers an area of tens of hectares (Puglisi *et al.* 2003, Gilbert *et al.* 2005).

Another parameter that appeared to be important for booming males was the proportion of emergent vegetation to open water area. The birds preferred lakes covered more intensively by vegetation beds. This parameter affects the abundance of suitable habitat as well as the abundance of prey and was found to be significant in some previous studies of the species' preferences. It influenced the nesting pattern of Eurasian Bittern at fish ponds where females tended to nest in clusters at ponds with a higher ratio of vegetation area to open water area comparing to ponds where females nested solitarily (0.71 and 0.36, respectively) (Kasprzykowski and Polak 2013), however the values of this parameter differ strongly between the two habitats (mean value at inhabited lakes equals 0.24). The proportion of open water was also important for Eurasian Bitterns in French Mediterranean seasonally flooded reed-marshes where the birds preferred areas with no open water (Poulin *et al.* 2005). The area of reeds positively affected the number of booming males in modelling the species population numbers at various sites in England (Tyler *et al.* 1998).

In some previous studies, the water depth appeared to be one of the most significant determinants of Eurasian Bittern occurrence, important for nesting females, as well, as for territorial males (Poulin *et al.* 2005, Gilbert *et al.* 2005). The present study indicates that Bitterns prefer lakes characterised by low values of bottom slope angle. Such a shape of basin results in the presence of shallow water far away from the lakeside, thus a widespread littoral zone with an extensive reach of emergent vegetation creating a large area of Eurasian Bittern habitat. Moreover, such a construction generates a wide belt isolating foraging and breeding areas from ground predators, as Eurasian Bitterns prefer to occupy the reed beds zone 30 m from open water (Gilbert *et al.* 2005). Generally, the low value of bottom slope angle provides a full gradient of water depths in a useful zone of reed beds, creating patches of optimal microhabitats.

The results of the present study conducted at lakes are similar to those obtained at fish ponds, where the occurrence of Eurasian Bitten territories were positively related to the amount of emergent vegetation and pond size (Kloskowski *et al.* 2010).

SUMMARY

The study shows, that the Lublin Region population of Eurasian Bitterns living in natural habitats is still quite stable. Lakes of Łęczna–Włodawa Lakeland seem to comprise appropriate habitats, especially large, eutrophic ones, considerably covered by emergent vegetation and characterised by low values of bottom slope angle. This flexible species tolerates human encroachment, at least activities of moderate impact like extensive fishing, occurring at nearly all lakes occupied by Eurasian Bitterns. However, concerning increasing anthropogenic pressure that becomes more and more intrusive, continued monitoring of the population is required.

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ROZMIESZCZENIE I PREFERENCJE SIEDLISKOWE BĄKA *BOTAURUS STELLARIS* NA NATURALNYCH JEZIORACH POJEZIERZA ŁĘCZYŃSKO-WŁODAWSKIEGO

STRESZCZENIE

W latach 2010-2011 przeprowadzono cenzus buczących samców bąka na wszystkich 61 naturalnych jeziorach Pojezierza Łęczyńsko-Włodawskiego, gdzie stwierdzono występowanie 34 terytoriów na 15 jeziorach (suma maksymalnych liczebności dla każdego jeziora z dwóch lat badań). Zestawienie z danymi historycznymi wskazuje na względną stabilność badanej populacji. Analiza wybranych parametrów morfometrycznych i środowiskowych jezior w odniesieniu do ich zajęcia przez bąki wykazała, iż gatunek ten preferuje jeziora o dużej powierzchni, charakteryzujące się łagodnie nachylonym dnem, w znacznym stopniu porośnięte roślinnością szuwarową.

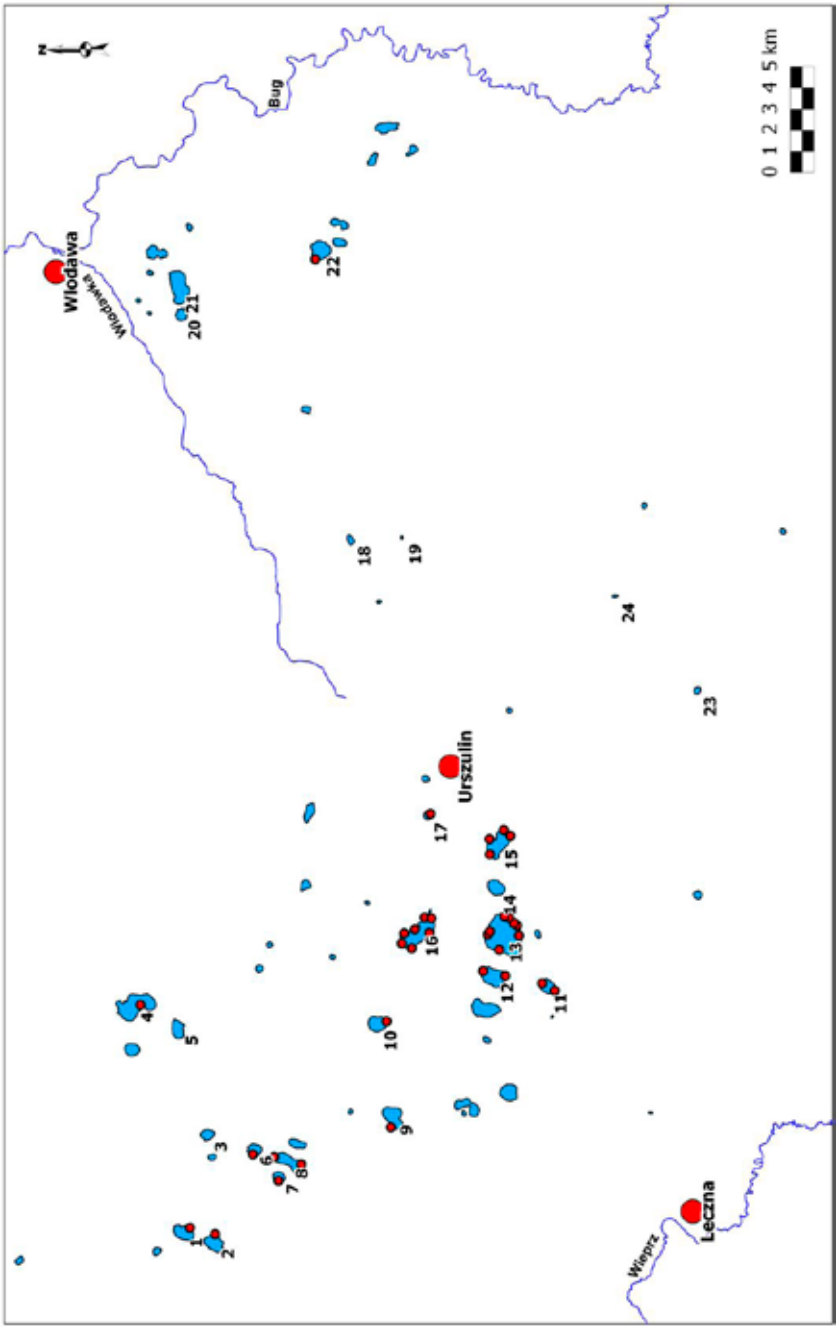

Fig. 1. *Distribution of Eurasian Bittern territories at natural lakes of Łęczna–Włodawa Lakeland in 2011 (additionally: territories at Łukie Lake (16) surveyed only in 2010 and Wspólne Lake (22) occupied only in 2010).*

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BAT FAUNA OF THE POLESKI NATIONAL PARK AND SOME ADJOINING AREAS

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Abstract: Research on the composition of the bat fauna in the Poleski National Park was carried out in the summer seasons of 2013-2014. Mist netting, ultrasound detection, and inspections of summer roost sites were conducted. Thirteen bat species were recorded in the study area: *Myotis nattereri, Myotis dasycneme, Myotis daubentonii, Myotis brandtii, Myotis mystacinus, Eptesicus serotinus*, *Eptesicus nilssonii*, *Pipistrellus nathusii*, *Pipistrellus pygmaeus*, *Pipistrellus pipistrellus*, *Nyctalus noctula*, *Nyctalus leisleri*, *Plecotus auritus*. The most widely distributed among mist netted bats were: *N. noctula, M. daubentonii* and *P. nathusii*; these species were also the most numerous (ca. 25%, 17% and 15%, respectively). Ultrasound detection showed very common occurrence of *M. daubentonii*, *P. pygmaeus*, *P. nathusii, N. noctula and E. serotinus.* Only at one site, Wytyckie Lake (outside of the Park borders), was *Myotis dasycneme* detected. Additionally, sparse flights of *Eptesicus nilssonii* and *Nyctalus leisleri* were recorded. Comparison of species composition among different habitats revealed that in natural forest communities, bats were twice as numerous (68.8%), than at sites in "altered forest communities" (31.2%). Moreover, species richness was higher in natural forest communities than in "altered forest communities" (10 and 7 species respectively).

Key words: Bats, species composition, Poland, Poleski National Park.

INTRODUCTION

Poleski National Park is a part of the Polesie physiogeographical region in eastern Poland. It is linked to similar Polesie regions in Belarus and Ukraine and considered a very valuable area in respect to zoology as well as botany. The Park was established to protect wetland ecosystems of Polesie that survived after most of the wetlands in the region were drained which began in the 1950s and intensified in the 1960s. Intensive meliorations of this area have led to a total land drainage and devastation of huge areas of marshes and wet meadows (e.g. Łąki Pociągi, Krowie

Bagno, etc.). This resulted in complete changes in the environment. It was planned to improve agriculture ability of the area and all the wetland drainage was carried out through a project creating the "Wieprz – Krzna Canal". This drained the area drastically but did not result in land improvement (Radwan 2002). Drainage works stopped and restoration efforts were undertaken since the Poleski National Park was established in 1990 (Radwan 2002).

Exceptional and extraordinary flora is represented here with at least 107 rare, protected or threatened species, mainly of boreal, but also of atlantic and pontic origin (Fijałkowski 1993; Radwan 2002). Wetlands also make the Park a perfect refuge for many animals. At least 290 species of the inhabiting animals are rare, protected or threatened, and listed in a Polish Red Data Book of Animals (Głowaciński 2001; Radwan 2002; Rąkowski 2002).

Investigations of bat fauna in Poleski National Park have not previously been undertaken. Little information on the mammal groups of this region are available in just a few publications. The "Atlas of Mammals of Poland" (Pucek and Raczyński 1983) contains information about five species of bat inhabiting the park, but the data is based on bone material extracted from owl pellets or museum exhibits and all data is derived from 1977. The mentioned atlas lists the following species as being recorded within the Park: Natterer's bat *Myotis nattereri*, serotine *Eptesicus serotinus*, common pipistrtrelle *Pipistrellus pipistrellus*, Nathusius's pipistrelle *Pipistrellus nathusii* and brown long-eared bat *Plecotus auritus*. The record of Nathusius's pipistrelle comes from Załucze, but all other species were recorded in the Durne Bagno Reserve. Similar information is replicated in the "Environmental Monography of the Park" (Radwan 2002), listing four of the above mentioned species. It is based on a study by Pucek and Raczyński (1983) and omits serotine. Additionally, in a popular science book "Poleski National Park – Environmental Guide" (Różycki *et. al*. 2002), it is said that park personnel stated the presence of four species apart from the mentioned serotine, common pipistrelle and brown long-eared bat, they also claim noctule *Nyctalus noctula*.

In conclusion it was assumed that there is very incomplete or misleading data on bat fauna for the area of the Park. Hence, it was very important to conduct a study on species composition and occurrence of bats inhabiting the discussed region.

STUDY AREA

The research was carried out in the area of the Park that is situated in the northeast part of Lublin voivodeship. The investigated area covered the park administrative borders with an area of ca. 10 000 ha. Some adjoining grounds were also incorporated into the study area: Wytyckie Lake, Urszulin village and Wola Wereszczyńska village. The study area belongs to the East Baltic-Belorussian Lowlands ecoregion, subprovince Polesie, macroregion West Polesie, mesoregion Łęczna-Włodawa Plain

(Kondracki 2000). The landscape has a glacio-fluvial and riverine origin and is poorly diversified.

Soils of the study area are hydrogenic or sandy and are chalky only in the southern portions of the park (Turski *et al.* 1993). That's why predominating habitats in the whole Park are oligotrophic or dystrophic due to low soil fertility and only small patches are characterized by higher richness. In addition eutrophication proceeds as a result of agriculture pressure and water drainage related to the Wieprz – Krzna canal system (Radwan 2002).

Hydrogeographically, the area belongs to the watershed of the Bug River. At present only three small streams which have been reformed into channels go thrugh the study area: Włodawka, Piwonia and Mietiułka, but there are additional smaller canals that feed into these channels (Radwan 2002). There were five lakes in the study area, four within the park borders (Łukie – 137 ha, eutrophic; Moszne – 17 ha, dystrophic; Długie – 30 ha, dystrophic; Karaśne – 3 ha, eutrophic) and Wytyckie Lake which has been altered into a storage reservoir (487 ha, eutrophic). Furthermore there were an additional two pond complexes in Pieszowola (121 ha) and partially Brus Stary (81 ha), (Wilgat 1998; Radwan 2002). All these waters were predominately boggy with inaccessible banks. Additionally, there were numerous small peat bog ponds that remain from peat excavations (Radwan 2002). Marshes and peat bogs in the study area are of all types (low, raised, alkaline) their flora is represented mainly by bulrush or meadow alternatively bodge or mossy vegetation (Radwan 2002).

Forests cover ca. 49% of the park area (4948 ha). Forests growing on drained or meliorated peat-bogs are "altered forest communities" and constitute about half of the entire woodland area (2627 ha) (Radwan 2002). The most dominant species within these forest are downy birch *Betula pubescens* is (39.5%), common Scots pine *Pinus sylvestris* (32.3%) and black alder *Alnus glutinosa* (20.3%). Other tree species that contribute a lesser proportion of these forest include European white birch *Betula pendula* (3.5%), pedunculate oak *Quercus robur* (3.0%), European aspen *Populus tremula* (1.3%) and common spruce *Picea abies* (0.1%) (Radwan 2002). Natural forest communities cover less than half of entire woodland area (1,836 ha). These stands consist of continental mixed coniferous forest *Querco roboris-Pinetum* (30.1%), birch bog wood *Betuletum pubescentis* (23.2%) and alder forest *Ribo nigri-Alnetum* (14.6%). Very small areas are covered with forest of European hornbeam *Carpinus betulus* (2.2%) (Radwan 2002). A majority of the forest stands are of young age classes, up to 47% represent young stands up to 50 years old, a further 35% are ripening stands (early phase of maturing up to 80 years old), 12% are mature stands over 80 years of age, and only 5% are old growth forest stands over 100 years of age (Radwan 2002). The remaining ground surfaces are mainly various types of marshes, meadows and pastures, which cover approximately 40% of the Park (Radwan 2002).

Climate of the region is temperate exhibiting a number of oceanic features mixed with some continental characteristics (Harasimiuk *et al.* 1998; Radwan 2002). Mean yearly temperature is 7.3° C but the seasonal variation is large – approximately 22° C (– 4.1 °C in January and 17.9° C in July). The mean yearly precipitation is rather low ca. 575 mm, which makes this region of considerable continental influence (Kaszewski 2002).

Human settlements are numerous in the study area (Fig. 1) but are mainly located outside of the park borders and consist of different types of buildings. Houses and livestock buildings in villages (ex: Pieszowola, Wola Wereszczyńska, Załucze Stare etc.) and also a few schools, with blocks of flats and churches in larger villages. In additional, there are many recreational summer houses located outside the borders of the park.

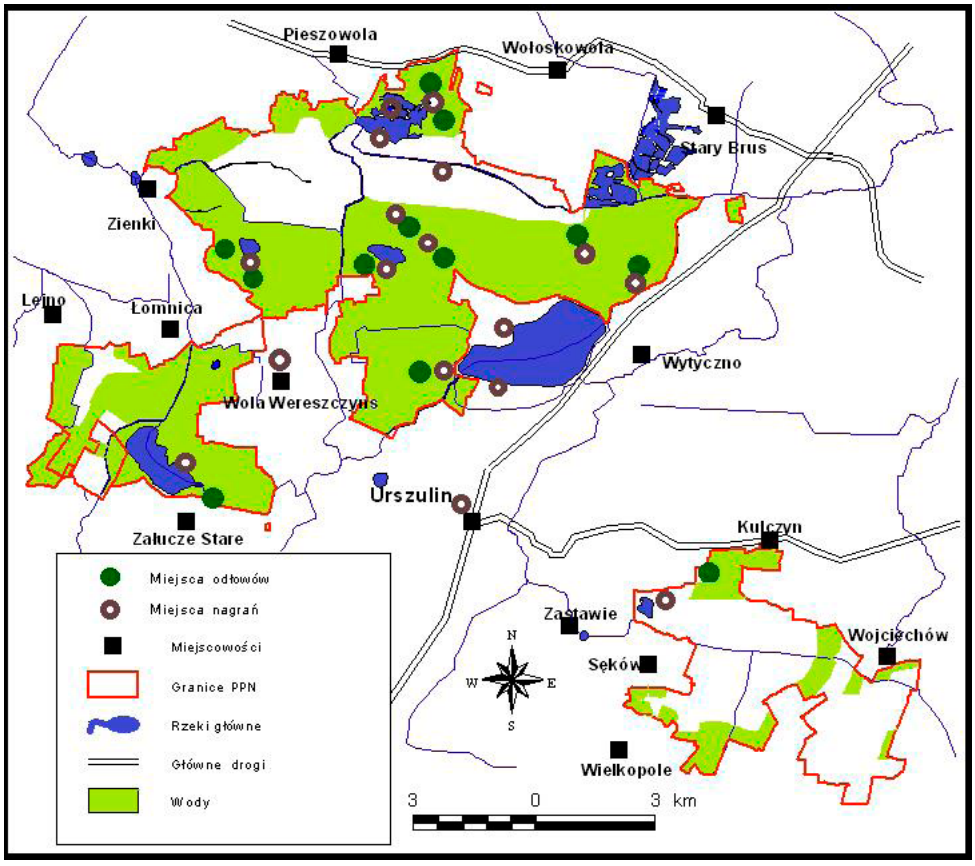

Figure 1. *Map of the study area with mist-netting and detector monitoring sites.*

MATERIAL AND METHODS

The research was conducted during 2013-2014. Data from 2013 was obtained during work on the Protection Plan of Poleski National Park and NATURA 2000 protected areas (within the park borders). Mist-netting of bats and investigation of buildings was carried out in order to find breeding roosts. During the summer season of 2013 between July 25 to August 15 at 12 sites within the Park, night mist netting of bats was carried out. Mist nets were set on forest roads, forest edges, over peat bog pits, or canals depending on the specific site, and four to six nets were used at each site. Mist netting sites were chosen in a way to be spread evenly throughout the park area and to be representative of protected habitats.

Collection sites:

1. Pieszowola – Dobry Las Forest adjacent to ponds (A.1)
2. Pieszowola – forest roads between ponds on the east end of the park (A.2)
3. Forest Łowiszów – forest cross roads (A.3).
4. Dominik Oak – forest cross roads on a nature educational trail (A.4)
5. Lake Długie – forest cross roads (A.5)
6. Lipniak – forest cross roads and canal on "Obóz powstańczy" educational trail (A.6)
7. Mietiułka – Forest Tatarski – forest cross roads (A.7)
8. Wólka Wytycka – Forest Zielone Grądy – forest cross roads (A.8)
9. Jamniki – peat-bog pits on a nature educational trail to Moszne Lake (A.9)
10. Forest Brzeziny – forest cross roads (A.10)
11. Lake Łukie – Spławy – forest cross roads and canal (A.11)
12. Bagno Bubnów – forest road adjacent to a peat-bog (A.12)

A survey of some roost sites was conducted which encompassed investigations in three buildings in Załucze Stare (park buildings and chapel), three in Urszulin (school and block of flats), two in Wola Wereszczynska (church and school) and one church in Wytyczno. In addition, 10 bat boxes and 16 bird blinds and raised hides used by hunters were checked. Survey of roost sites was undertaken on a small scale as most of the villages were outside the borders of the park.

Acoustic monitoring was conducted both in 2013 and in 2014. For this, two detectors recording unprocessed ultrasound (Batlogger and EchoMeter 3+), and two *frequency division* detectors (Petterson 230D connected to digital sound recorders Roland R06 or Zoom H1 recording ultrasound as WAV files) were used. This enabled continuous recording of echolocation signals and social calls of bats in real time. Species were identified based on the spectral analysis of the signal structure, frequency, length of pulses, duration, rate of emission, and rhythm using the bioacoustic program BatSound 4.01 (Pettersson Elektronik AB, Sweden) or BatScan ver. 9 (Batbox LTD, Great Britain). Night detector monitoring was conducted at 16 sites chosen in a way to be spread evenly throughout the park area and to be representative of protected habitats.

Collection sites:

1. Pieszowola – Dobry Las Forest along forest roads (B.1)
2. Dominik Oak – forest roads on a nature educational trail (B.2)
3. Mietiułka – Forest Tatarski along forest roads (B.3)
4. Łowiszów Forest – along forest roads (B.4)
5. Wólka Wytycka – Zielone Grądy along forest roads (B.5)
6. Forest Brzeziny – along forest roads (B.6)
7. Lake Moszne – on the banks of the lake (B.7)
8. Lake Łukie – on the banks of the lake, forest and peat bog (B.8)
9. Lake Długie – along forest roads (B.9)
10. Lake Wytyckie – on the banks of the lake (B.10)
11. Pieszowola – on the banks of the ponds and along dikes (B.11)
12. Lipniak – forest roads on "Obóz powstańczy" nature educational trail (B.12)
13. Bagno Bubnów – north-west parts of the peatbog (B.13)
14. Meadows Pociągi – along Mietiułka river (B.14)
15. Urszulin – village buildings (B.15)
16. Wola Wereszczyńska – village buildings (B.16)

RESULTS

In total, during the entire study period, 13 bat species were recorded at the study area (Tables 1 and 2): *Myotis nattereri*, *Myotis brandtii*, *Myotis mystacinus*, *Myotis daubentonii*, *Myotis dasycneme, Eptesicus serotinus*, *Eptesicus nilssonii, Nyctalus noctula*, *Nyctalus leisleri, Pipistrellus nathusii*, *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, and *Plecotus auritus*.

As a result of mist netting, 93 individuals of 10 bat species were caught (Table 1): *M. nattereri*, *M. brandtii*, *M. mystacinus*, *M. daubentonii*, *E. serotinus*, *N. noctula*, *P. nathusii*, *P. pipistrellus*, *P. pygmaeus*, and *P. auritus*. The most frequently occurring and most widely distributed species were: *N. noctula* (23 ind.), *P. nathusii* (14 ind.), *P. auritus* (12 ind.) and *M. daubentonii* (16 ind.). Other species were less numerous or netted only at a few localities. Adult lactating females or the current year's juveniles were caught for all of the above mentioned 10 species which confirms their reliable reproduction.

Table 1. *Results of mistnettig of bats in Poleski National Park in 2013.*

The following acronyms of bats species names were used: MYN – Natterer's bat *Myotis nattereri*, MYB – Brandt's bat *Myotis brandtii*, MYS – whiskered bat *Myotis mystacinus*, MDA – Daubenton's bat *Myotis daubentonii*, MDS – pond bat *Myotis dasycneme*, ESE – serotine *Eptesicus serotinus*, ENI – northern bat *Eptesicus nilssonii*, NYN – noctule *Nyctalus noctula*, NYL – Leisler's bat *Nyctalus leisleri*, PIN – Nathusius' pipistrelle *Pipistrellus nathusii*, PIP – common pipistrelle *Pipistrellus pipistrellus*, PIG – soprano pipistrelle *Pipistrellus pygmaeus*, PAR – brown long-eared bat *Plecotus auritus*.

	Locality	Date	Species										Σ
			MYN	MYB	MYS	MDA	ESE	NYN	PIN	PIP	PIG	PAR	
Sites on natural forest communities													
A.1	Pieszowola – forest Dobry Las	25.07.2013	1			4		1				1	7
A.2	Pieszowola – forest and ponds	26.07.2013		1	1	2	7	2	1	1	2		17
A.3	Forest Łowiszów – forest roads	12.08.2005		1		6	3	10	6			1	27
A.4	Dąb Dominik – forest roads	08.08.2013	1	1		2			1		1	1	7
A.5	Lake Długie – forest cross roads	09.07.2013		1	1			1	2		1		6
	Σ		2	4	2	14	10	14	10	1	4	3	64
	dominance (%)		3,1	6,2	3,1	21,8	15,6	21,8	15,6	1,5	6,2	4,6	100
Sites on substitute forest communities													
A.6	Lipniak – forest cross roads	13.08.2013						2			1		3
A.7	Mietiułka – Tatarski forest roads	11.08.2013						1	1				2
A.8	Wólka Wytycka – Zielone Grądy	14.08.2013	1					1	1				3
A.9	Jamniki – peatbog pits	05.08.2013				1		1	1	1	1		5
A.10	Brzeziny – forest cross roads	10.08.2013						2					2
A.11	Lake Łukie – Spławy	07.08.2013										9	9
A.11	Lake Łukie – forest cross roads	15.08.2013				1			1				2
A.12	Bagno Bubnów	06.08.2013						2		1			3
	Σ		1	-	-	2	-	9	4	2	2	9	29
	dominance (%)		3,4	-	-	6,8	-	31,0	13,8	6,8	6,8	31,0	100

Comparison of species composition among different habitats revealed that in natural forest communities, bats were twice as numerous (68.8%), than on sites in "altered forest communities" 31.2%. Moreover, species richness was higher in natural forest communities than in "altered forest communities" (10 and 7 species respectively).

Detector monitoring carried out at 16 sites showed the presence of 9 species: *M. daubentonii*, *M. dasycneme*, *E. serotinus*, *E. nilssonii, N. noctula*, *N. leisleri, P. nathusii*, *P. pipistrellus*, and *P. pygmaeus*. Most frequently recorded were *N. noctula*, *P. pygmaeus, P. nathusii,* but also *M. daubentonii* and *E. serotinus* (16 and 12 sites respectively). Moreover *P. pipistrellus* were recorded at seven localities. *E. nilssonii* and *N. leisleri* were recorded only at a single site each (Table 2). The occurrence of *M. dasycneme* was not confirmed within the park, but was recorded only at Wytyckie Lake in the buffer zone near the park. Despite the fact that this species was not recorded in the park in this study, it may still occur at the water bodies within the park.

Table 2. *Results of detector monitoring of bats in Poleski National Park in 2013-2014. Acronyms of species names and sites as stated in the description to table 1.*

Locality		Species								
		MDA	MDS	ESE	ENI	NYN	NYL	PIN	PIP	PIG
B.1	Pieszowola – forest roads	+		+		+		+	+	+
B.2	Dąb Dominik forest roads	+				+		+		+
B.3	Mietiułka – Forest Tatarski			+	+	+	+	+	+	+
B.4	Forest Łowiszów					+		+		+
B.5	Forest Zielone Grądy			+		+		+		+
B.6	Forest Brzeziny				+	+	+	+		+
B.7	Lake Moszne	+		+		+		+		+
B.8	Lake Łukie	+		+		+		+		+
B.9	Lake Długie	+		+		+		+		+
B.10	Lake Wytyckie	+	+	+		+		+		+
B.11	Pieszowola – ponds	+		+	+	+	+	+		+
B.12	Lipniak – forest roads	+		+		+		+		+
B.13	Bagno Bubnów	+		+		+		+		+
B.14	Meadows Pociągi along Mietiułka	+		+		+		+		+
B.15	Urszulin – buildings			+		+		+		+
B.16	Wola Wereszczyńska - buildings			+		+		+		+
	Razem									

The survey of roost sites was undertaken on a small scale and revealed little information as most of the villages were located outside the borders of the park. Only two small colonies of *E. serotinus* (11 ind. in a chapel in Załucze Stare and 14-16 ind. in a small block of flats and 3-4 in an adjacent school in Urszulin). All other roost sites checked were not occupied.

DISCUSSION

Polish bat fauna is currently composed of 26 species (Sachanowicz *et. al*. 2006; Uhrin *et. al.* 2015), thus the 13 species reported from the study area consists of 50% of the national bat fauna. Some species, such as the greater horseshoe bat *Rhinolophus ferrumequinuum*, greater noctule *Nyctalus lasiopterus*, Kuhl's pipistrelle *Pipistrellus kuhlii*, lesser mouse-eared bat *Myotis oxygnatus*, and Savi's bat *Hypsugo savii,* were reported in Poland by only single records. Other species such as the lesser horseshoe bat *Rhinolophus hipposideros*, Geoffroy's bat *Myotis emarginatus*, and greater mouse-eared bat *Myotis myotis* do not have distribution ranges in the study area (Sachanowicz and Ciechanowski 2005; Sachanowicz *et. al*. 2006). Thus, the bat fauna of lowland Poland presently consists of 18 species (Sachanowicz *et. al.* 2006). Therefore, the study area is represented by 13 out of the 18 species, which is about 70% of the possible bat fauna for the region. Potential bat fauna of a particular region reflected in the local inventory research in approximately 70% were manage to access in only few studies. Furthermore there is also the possibility to indicate a few new species for this area (e.g.: *M. bechsteinii*, *M. alcathoe, Plecotus austriacus, Vespertilio murinus* and *Barbastella barbastellus*), however determined by intensifying research. The species listed above may only form small populations or visit the park only periodically.

Among the species representing Polish lowland bat fauna, the investigation failed to confirm *M. bechsteinii*, although it is strictly silvan and sedentary species requiring old growth and differentiated forests which are prominently deciduous (Baagøe 2001). However summer localities in Sobibór and Włodawa Forests, but also winter sites in Różanka near Włodawa are the most northeastern for the species range in east Poland (Piskorski *et. al.* 2000; Piskorski 2008). Even though it is classified as "near threatened" in Poland (Wołoszyn 2001) and listed in Appendix II of Habitats Directive in can sometimes be relatively numerous locally in the forest of southeastern Poland, and regularly has been reported as breeding regularly in some woodland areas reaching a significant share and high representation among mist-netted bats (Piskorski 2008; Piskorski *et al.* 2009). Some parts of the park are characterized by richer soil and covered with old stands of hornbeam forests e.g. near Pieszowola village and there this species can be expected.

An analogous situation exist with *Barbastella barbastellus*. Additionally appropriate environmental conditions exist in the nearby Włodawa Forests where both

species are know to be present (Piskorski *et al.* 2008; Piskorski 2009) providing access to good foraging habitats may increase the possibility of this species occuring in the park.

A similar situation also exist for *M. alcathoe,* a species that has recently been reported from some areas of southeastern Poland (Bashta *et al.* 2011, Piskorski unpublished data).

The discovery of *M. dasycneme* in the area of the Park is broadly plausible because that region has abundant water bodies such as lakes, rivers and ponds that are favored by this species as feeding sites (Limpens *et al.* 2000). Styka (2000) reported this species in neighboring Sobibor Forests based on skeletal remains from owl pellets, a small colony of males was found there and has regularly been identified from detector findings (Piskorski 2008). Thus it is a permanently present species in this part of Polish Polesie. Moreover this bat has been recorded from the Lublin region several times (Skuratowicz 1939; Skuratowicz 1948; Jurczyszyn 1994) and during recent years was regularly observed in winter shelters or acoustically detected (Piskorski *et al.* 2001; Piskorski *et al.* 2002; Piskorski unpublished data).

With some probability *Myotis myotis* can be expected to occur in the study area. Nevertheless detection of this species is rather unlikely because the northeastern limits of its range encompasses Lublin Upland and Roztocze, but does not include Polesie or Western Volyn (Sachanowicz and Ciechanowski 2005), has never been detected, at present from the Łęczna-Włodawa Lakeland due to lack of optimal wetland habitats. It has been detected from single sites in the Podlasie region, but has not been confirmed as a breeding species (Pucek and Raczyński 1983, Sachanowicz *et al.* 2007).

The discovery of *Vespertilio murinus* is also very likely. This species is quite common in the Lublin region (towns and cities), even including areas directly surrounding the park, such as the Włodawa Forests or in the vicinity of Chełm (Piskorski and Urban 2003; Piskorski 2008; Piskorski *et al.* 2009, Piskorski unpublished data).

Similar numbers of species are reported from other regions of Poland, e.g.: 8 species from Tenczyn Landscape Park (Gałosz and Labocha 2000), 9 species from the Lower Silesian Forests (Wojtaszyn *et al.* 2002), 12 species from Czestochowa and Wieluń Upland, forests in the area of Płońsk on Mazovia, Strzeleckie Forests, Krotoszyn Oak Forests (Gas and Postawa 2000; Ignaczak 2002; Lesiński *et. al.* 2007; Piskorski *et al.* 2009; Gottfried *et. al.* 2014), 13 species from Łódź Hills Landscape Park (Hejduk *et al.* 2000) and Białowieża primeval forest (Rachwald *et. al.* 2001, Ciechanowski *et. al.* 2007). However species composition of some areas is different because *R. hipposideros* and *M. emarginatus* are present in west Poland. Similar species numbers although not the same species composition in bat assemblages were shown from the eastern parts of Poland – Bialowieża, Mazovia and Strzelce Forests (Rachwald *et. al.* 2001, Lesiński *et. al.* 2007, Piskorski *et al.* 2009).

More than in Poleski National Park – up to 17 species of bats have been reported from Middle Roztocze (Skuratowicz 1939; Skuratowicz 1948; Jurczyszyn 1994), 16 species from Kozienice Forest (Kowalski *et al*. 1996), 15 species from Przedborski Landscape Park (Hejduk *et al.* 2002), and 16 species from Janowskie forests (Piskorski 2007).

Other studies have foun very similar species composition (11 species) have been found in Wigierski National Park (Postawa and Gas 2003), the Briansk region (Sitnikova *et. al.* 2009), the vicinity of Moscow (Albov *et. al*. 2009), in eastern Ukrainian forests (Gukasova and Vlaschenko 2011), and in western Russia in Smoleńsk Lakeland National Park (Gukasova *et. al*. 2011). This fact makes Poleski National Park bat fauna refering to eastern European and boreal ones.

The fairly wide distribution of *M. daubentonii* (12/15 sites), proven on detector monitoring seems to be linked to high abundance of water bodies, that are preferred as foraging habitats of this species (Bogdanowicz 1994). It was recorded both on lakes, channels and ponds. The high abundance of *M. daubentonii* , compared to other forest complexes of south-east Poland is probably related to the exceptional abundance of various types of open water (mainly lakes and ponds) in the entire Łęczna-Włodawa Lakeland.

Very similar distributions, but more numerous when netting,were found for *N. noctula*, a dominant species also indicated in many other forest complexes of east Poland in other studies (Jurczyszyn 1994, Kowalski *et al*. 1996, Rachwald *et al.* 2001, Piskorski *et al.* 2009,). Five of the other most numerous species indicated during mist-netting are largely associated with human settlements using different building's cervices for day and breeding roosts (e.g.: house timbering, lofts etc.) in addition to tree holes. This applies mainly to the most frequently caught in the discussed area, pipistrelles, serotines and long eared bats. Survey of roost places were undertaken on small scale as most of the villages are outside the borders of the park and were later omitted.

Species composition if compared with other regions of southeast Poland shows quite a poor level. For example, the percentage structure of bats in Strzeleckie and Janowskie Forests shows quite a high frequency of *M. bechseinii* and *B. barbastellus* (4-18% and 6-10% respectively) which has not been indicated in Poleski Park as of yet. More numerous species like *N. noctula* or *P. auritus* had lower or alternatively similar frequencies similar to Janowskie Forests or Sobibór Forests (4-20.7% and 33-42% respectively) (Piskorski 2007, Piskorski 2008, Piskorski *et al*. 2009).

Among the rare or threatened species listed in Polish Red Data Book of Animals (Wołoszyn 1992) the northern bat *Eptesicus nilssonii* and Leisler's bat *Nyctalus leisleri* were recorded . Although their determination based on ultrasound recordings alone is difficult or in some cases even impossible, some details observed, allowed us to determine signals recorded with the Batlogger full spectrum detector.

E. nilssonii was detected at three sites. FM (frequency modulated) signals that were

identified as belonging to this species had a peak frequency of about 28-30khz (bats were foraging over the ponds in Pieszowola) or around 30-32khz (when detected on the wide forest's roads in Tatarski and Brzeziny Forests). These FM calls were repeated in blocks of a few pulses in a quite regular rhythm, whereas *E. serotinus* at the same sites and conditions emitted lower frequency FM calls of irregular rhythm. Additionally bats in Tatarski Forest were also observed at dusk foraging over a forest clearing not far away from the netting site (but unfortunately weren't caught).

Nyctalus leisleri was identified based on typical for all noctules an alternating rhythm in which 25-28khz FM calls interchanges with 22-24khz qCF calls (quasi Constant Frequency). In addition a few times these bats were simultaneously observed over Pieszowola ponds at sunrise or dusk while foraging together with *N. noctula* which reveled visible difference in the size of the two species. Sonograms of both species were later compared to descriptions in the literature (Rydell 1990, Russ 2012, Baratraud 2015).

The conducted research revealed a medium level of bat species diversity but with a quite interesting assemblage. The specificity of the study area as the combination of the habitats, soil and climatic conditions which characterize the park in relation to its geographical origin is obviously influenced the obtained results. Our result are very similar to north-east Poland e.g.: Wigierski National Park – (Postawa and Gas 2003), or in west Russia e.g.: Briansk region, vicinity of Moscow or Smoleńsk Lakeland (Sitnikova *et. al.* 2009, Albov *et. al.* 2009, Gukasova *et. al.* 2011), and in east Ukrainian forests (Gukasova and Vlaschenko 2011). This facts makes Poleski National Park bat fauna refering to eastern European and boreal ones.

It appears therefore that forests of the park are very poorly inhabited by bats. The main reason for that is caused largely by the young stage of forests age and low tree species diversity (main forests composed of species of pine, birch and alder) but also by the high percentage of "altered forest communities" (Radwan 2002).

The results of these omissions are a small number of hollow and decayed trees, that are essential to provide suitable roosts for bats (Dietz *et. al.* 2009). This primarily concerns typically forest species such as barbastelle *Barbastella barbastellus*, Bechstein's bat *M. bechsteinii* or Alcathoe whiskered bat *M. alcathoe*, that weren't recorded in the study area.

Therefore, future efforts should be made to improve the attractiveness of the park by preserving appropriate forests conditions and creating artificial roost sites for bats. The first of these aims is possible to achieve in the long term, with the assumption of maintaining hollow and decayed trees and to allow forests stands to reach mature stages. But, until that happens, it is necessary to create alternative roosts by building bat boxes, adjusting hunter's shooting stands, etc. as these do not currently meet the relevant criteria for bats currently, but can be achieved with relatively small effort.

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STRESZCZENIE

FAUNA NIETOPERZY POLESKIEGO PARKU NARODOWEGO I NIEKTÓRYCH TERENÓW PRZYLEGŁYCH

Badany obszar niemal w całości pokrywał się z administracyjną Poleskiego Parku Narodowego, ponadto do badan włączono jezioro Wytyckie oraz okolice miejscowości Wola Wereszczyńska. Omawiany teren charakteryzuje się małym zróżnicowaniem rzeźby. Występujące tu równiny są pochodzenia lodowcowo-rzecznego, rzecznego oraz jeziornego. Dominują gleby hydrogeniczne oraz piaski, z przewagą ubogich siedlisk oligotroficznych lub dystroficznych (Radwan 2002).

Badania były prowadzone w latach 2013-2014. W sezonie letnim 2013 roku badania prowadzono od 25 VII do 15 VIII na 12 stanowiskach na terenie PPN przy użyciu sieci chiropterologicznych przeprowadzono nocne odłowy nietoperzy. Były one ustawiane na drogach leśnych, liniach oddziałowych, nad torfiankami lub kanałami.

Nasłuchy detektorowe przeprowadzono na 16 stanowiskach zarówno w 2013 jak i w 2014 roku. W tym celu wykorzystywano 2 detektory rejestrujące nieprzetworzone ultradźwięki (Batlogger oraz EchoMeter 3+), a także przy użyciu 2 detektorów Petterson 230D pracujących w systemie „*frequency division*". Do których podłączono rejestratory (Roland R06 lub Zoom H1 zapisujące nagrania jako pliki WAV). Umożliwiało to rejestrację sygnałów echolokacyjnych i głosów socjalnych nietoperzy w sposób ciągły (w czasie rzeczywistym).

Łącznie w ciągu całego okresu badań stwierdzono występowanie 13 gatunków nietoperzy na całym badanym terenie (Tab. 1 i 2). Były to: nocek Natterera *Myotis nattereri*, nocek Brandta *Myotis brandtii*, nocek wąsatek *Myotis mystacinus*, nocek rudy *Myotis daubentonii*, nocek łydkowłosy *Myotis dasycneme,* mroczek późny *Eptesicus serotinus*, mroczek pozłocisty *Eptesicus nilssonii,* borowiec wielki *Nyctalus noctula*, borowiaczek *Nyctalus leisleri,* karlik większy *Pipistrellus nathusii*, karlik malutki *Pipistrellus pipistrellus*, karlik drobny *Pipistrellus pygmaeus*, gacek brunatny *Plecotus auritus*.

W czasie odłowów nocnych schwytano 93 osobniki nietoperzy z 10 gatunków (Tab. 1) Najliczniej występującymi i jednocześnie najszerzej rozmieszczonymi

gatunkami były: borowiec wielki (23os.), karlik większy (14os.), gacek brunatny (12os.) i nocek rudy (16os.). Pozostałe gatunki były mniej liczne lub odławiano je na pojedynczych stanowiskach. Dla wszystkich powyższych 10 gatunków stwierdzono pewny rozród – odłowiono dorosłe karmiące samice bądź tegoroczne młode osobniki.

Nasłuchy detektorowe przeprowadzono na 16 stanowiskach. Na tej podstawie wykazano obecność 9 gatunków. Najczęściej stwierdzano żerujące borowce wielkie, karliki większe, karliki drobne a także nocki rude i mroczki późne (odpowiednio po 16 i 12 stanowisk). Ponadto na 7 stanowiskach stwierdzono karliki malutkie. Prowadząc nasłuchy nad jeziorem Wytyckie stwierdzono kilkakrotnie przeloty nocka łydkowłosego. Jedynie na pojedynczych stanowiskach występowały mroczki pozłociste i borowiaczki (Tab. 2).

Mimo podjętych starań występowania nocka łydkowłosego udało się potwierdzić jedynie nad jeziorem Wytyckim w otulinie PPN, gdzie zarejestrowano pojedyncze stwierdzenia tego gatunku. Wskazuje to na możliwość pojawienia się tego nietoperza również nad wodami w granicach parku.

Spośród innych gatunków rzadkich i narażonych na wyginięcie, wymienianych min. w Polskiej Czerwonej Księdze Zwierząt (WOŁOSZYN 1992) zanotowano występowania mroczka pozłocistego *Eptesicus nilssonii* oraz borowiaczka *Nyctalus leisleri*.

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