Lynx (Praha), n. s., **37**: 255–262 (2006). ISSN 0024–7774

Small mammal fauna of the Kraków metropolitan area (southern Poland) – problem of synurbisation (Insectivora, Chiroptera, Rodentia)

Drobne ssaki dawnego województwa krakowskiego – problem synurbizacji (Insectivora, Chiroptera, Rodentia)

Katarzyna STANIK & Bronisław W. WOŁOSZYN

Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, ul. Sławkowska 17, PL–31-016 Kraków, Poland; maukasiek@o2.pl; woloszbr@isez.pan.krakow.pl

received on 6 June 2006

Abstract. Current knowledge regarding the occurrence of small mammal species in the Kraków agglomeration and adjacent areas is presented. Special attention is given to urbanised species and their population characteristics.

INTRODUCTION

Studies in urban ecology have been carried out in Poland for at least 30 years. Their aim is an assessment of the current state and future prospects regarding the natural environment in urban and suburban areas, and its role in creating optimal living conditions for the urban population of people. Therefore the research is focused on three major aspects: soil science, flora and fauna (Karolewski 1981).

The occurrence, abundance and structure of animal assemblages in urbicenosis are not intentionally shaped by man, in contrast to floristic ones (Andrzejewski 1975). However, such factors as climate, technical infrastructure, flora, human population and environmental pollution have a deep impact – termed "urbanisation pressure" – on urban fauna and its distribution (Markowski 1997). Observation of its effects has led to creation of new terms in urban ecology. One of these is "antropopressure" defined as a mode of human impact on natural environment. Another term is "synanthropisation", covering a whole range of changes in flora and fauna. Organisms that are well adapted to new conditions are named "synanthrophic species" (Pietraszewska 1999). "Synurbisation" is defined as an adaptation to populate core urban areas. Synurbisation requires a wide spectrum of ecological tolerance (eurytopic and polytopic species) and considerable species adaptability. From the ecological perspective, the enrichment of relatively homogeneous urban green areas with new species is favourable, because it makes the ecosystem more complicated and thus more stable and self-sufficient (Gliwicz 1980).

The first studies of small mammal fauna in Kraków were carried out already in the 1940s (Kowalski 1950). Nevertheless, the state of knowledge regarding the urban fauna is still insufficient (Karolewski 1981). So far, neither a detailed assessment of changes in the fauna structure caused by urban anthropogenic factors, nor a holistic description of the current state of urban fauna have been made.

Table 1. Climate parameters of Kraków
Tab. 1. Parametry klimatyczne Krakowa

month	temperature [°C]	precipitation [mm]
January	–2.9	34
February	–1.4	34
March	2.6	35
April	8.6	42
May	14.1	57
June	17.5	86
July	19.3	95
August	18.4	83
September	14.4	56
October	8.8	46
November	3.8	42
December	–0.2	34
annual average temperature	8.6	
annual precipitation sum		644

This paper is aimed at the description of species composition of small mammal assemblages in natural and anthropogenic biocenoses of the Kraków metropolitan area. The topographic and climatic differentiation of neighbouring areas has a great impact on the urban environment, which makes it an interesting object to study mammal habitat preferences. Despite the fact that synurbisation of fauna is a dynamic and intensifying process, it is rarely investigated. Therefore, the presented data may be helpful in planning similar studies in other areas.

MATERIAL AND METHODS

Area under study

The Kraków agglomeration lies at the place of contact between several physiographic units: Małopolska Uppland in the north, Krakowsko-Wieluńska Uppland in the northwest (from where the Atlantic air masses flow in), Beskid Zachodni Mts. in the south, and Sandomierz Lowlands in the east (where continental climate dominates, Table 1). Boundaries of the area overlap with the boundaries of the former Kraków voivodship that existed between 1975 and 1998.

Faunal data sources

Information on assemblages of small mammal species in the area comes from a large number of publications listed in Table 2. The Jaccard's index (*Q*), describing similarity between assemblages, was calculated according to the formula: $Q = (c / a+b–c)\times100$, where *Q* = Jaccard's index, a – number of species in assemblage 1 (here: centre of the Kraków agglomeration), b – number of species in assemblage 2 (here: natural areas and semi-natural suburban areas), c – number of species common for both assemblages.

RESULTS

56 species of small mammals occur in Poland, which constitutes 62% of the total number of mammal species (90) of the country. In the study area, 43 small mammal species have been

Table 2. List of small mammal species recorded in the former Kraków voivodship.
Tab. 2. Lista gatunków Micromammalia zasiedlających województwo krakowskie.
A – agglomeration / aglomeracja; V – voivodship / województwo

species \ occurrence in Kraków:	A	V	reference
Talpa europaea (Linnaeus, 1758)	+	+	Kowalski 1950, Rzebik-Kowalska 1972
Sorex araneus (Linnaeus, 1758)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Sorex minutus (Linnaeus, 1766)	–	+	Grodziński et al. 1958
Neomys fodiens (Pendant, 1771)	–	+	Ruprecht 1976
Neomys anomalus (Cabrera, 1907)	–	+	Skuratowicz & Warchalewski 1954
Crocidura leucodon (Hermann, 1780)	–	+	Sałata-Piłacińska 1977
Crocidura suaveolens (Pallas, 1811)	+	+	Simm 1952, Ruprecht 1976
Rhinolophus hipposideros (Bechstein, 1800)	+	+	Harmata 2000
Rhinolophus ferrumequinum (Schreber, 1774)	–	+	Nowak et al. 2001
Myotis myotis (Borkhausen, 1797)	+	+	Harmata 1994
Myotis nattereri (Kuhl, 1817)	–	+	Harmata 1960, 1962
Myotis emarginatus (Geoffroy, 1806)	+	+	Harmata 1969, Harmata & Wojtusiak 1963
Myotis mystacinus (Kuhl, 1817)	–	+	Ruprecht 1974
Myotis brandtii (Eversmann, 1845)	–	+	Ruprecht 1974
Myotis dasycneme (Boie, 1825)	–	+	Biała cave
Myotis daubentonii (Kuhl, 1817)	–	+	Kowalski 1953
Vespertilio murinus (Linnaeus, 1758)	+	+	Kowalski 1957
Eptesicus nilssonii (Keyserling et Blasius, 1839)	–	+	Ojców
Eptesicus serotinus (Schreber, 1774)	–	+	Kowalski 1953, Harmata 1960
Pipistrellus pipistrellus (Schreber, 1774)	–	+	Harmata 1960
Nyctalus noctula (Schreber, 1774)	–	+	Harmata 1962, Markowski & Suskiewicz 1981
Nyctalus leisleri (Kuhl, 1818)	–	+	Harmata 1960
Plecotus auritus (Linnaeus, 1758)	–	+	Harmata 1969
Plecotus austriacus (Fischer, 1829)	+	+	Ruprecht 1971, Harmata 1969
Barbastella barbastellus (Schreber, 1774)	+	+	Kowalski et al. 1957
Sciurus vulgaris (Linnaeus, 1758)	+	+	Kowalski 1950, Udziela 1925
Cricetus cricetus (Linnaeus, 1758)	+	+	
Clethrionomys glareolus (Schreber, 1780)	+	+	Kowalski 1950, Skiba 2005
Arvicola terrestris (Linnaeus, 1758)	+	+	Skiba 2005, Skuratowicz & Warchalewski 1954
Pitymys subterraneus (de Sélys-Longchamps, 1836)	+	+	Skiba 2005, Kowalski 1960
Microtus oeconomus (Pallas, 1776)	–	+	
Microtus agrestis (Linnaeus, 1761)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Microtus arvalis (Pallas, 1779)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Mus musculus (Linnaeus, 1758)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Rattus norvegicus (Berkenhout, 1769)	+	+	Skuratowicz & Warchalewski 1954
Micromys minutus (Pallas, 1771)	–	+	Skuratowicz & Warchalewski 1954
Apodemus agrarius (Pallas, 1771)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Apodemus microps (Kratochvíl et Rosický, 1952)	–	+	
Apodemus sylvaticus (Linnaeus, 1758)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Apodemus flavicollis (Melchior, 1834)	+	+	Skiba 2005, Haitlinger & Szyszka 1977
Dryomys nitedula (Pallas, 1779)	–	+	Grodziński 1959
Glis glis (Linnaeus, 1766)	–	+	Kowalski 1950
Muscardinus avellanarius (Linnaeus, 1758)	–	+	Kowalski 1950

recorded in the last 50 years or so. Most of them represent 4 families: Soricidae, Vespertilionidae, Arvicolidae, and Muridae. Four of the recorded species are considered synurbic: *Sciurus vulgaris*, *Apodemus agrarius*, *Mus musculus*, and *Rattus norvegicus*.

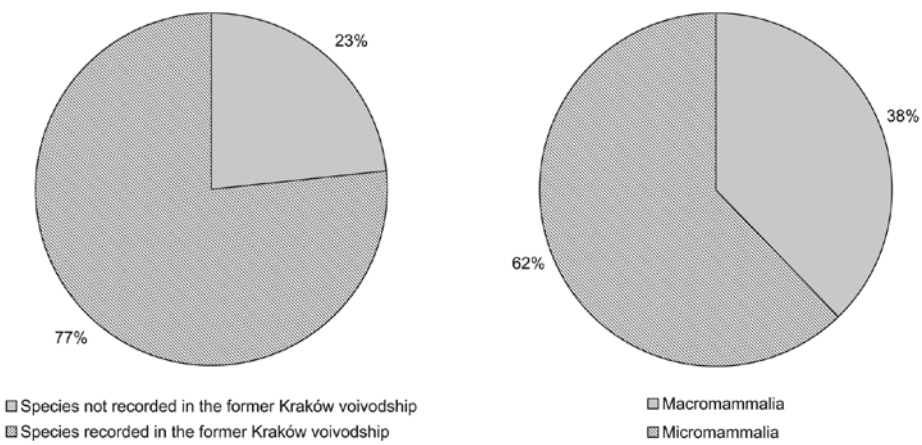
Among Insectivora, three out of seven species are common for both compared areas, within Rodentia the proportion of common species is ⅔ of the total species number and in Chiroptera only ⅓. In total, 21 out of 43 small mammal species inhabit both subareas: city centre and its surroundings.

The Jaccard's index, reflecting a degree of similarity of small mammal assemblages between (a) core urban and (b) suburban and natural areas, equals 48.84.

DISCUSSION

Studies on structural changes in small mammal assemblages in urban areas have two practical aspects. Firstly, mammals as animals living in human settlements are a potential source of zoonoses. Secondly, small mammals may be useful as specific bioindicators of anthropogenic environmental pollution. Another interesting problem is species composition of fauna inhabiting buildings and various urban facilities, dominated by such species as *Mus musculus*, *Rattus rattus* and *Rattus norvegicus* (Andrzejewski 1977).

The urban fauna is dominated by species of wide geographic ranges. Xerophilous and thermophilous species, mostly those characteristic of warmer climatic zones, occur inside buildings (Markowski 1997). For the majority of city dwelling species communal waste is an abundant food source. Urban areas offer free ecological niches but also impose many threats, e.g. in-



Figs. 1, 2. Percentage of small mammal species of the former Kraków voivodship in the whole small mammal fauna of Poland (3, left) and the whole mammal fauna of Poland (4, right).
Rys. 1, 2. Liczba gatunków Micromammalia dawnego województwa krakowskiego na tle ogółu krajowej fauny drobnych ssaków (3, nalevo) i na tle ogółu krajowej fauny ssaków (4, napravo), wyrażona w procentach.

Table 3. Number of small mammal species in the Kraków centre and in the remaining area of the former Kraków voivodship
Tab. 3. Liczba gatunków Micromammalia w centrum Krakowa i na obszarze całego województwa krakowskiego

order	Kraków agglomeriation	Kraków voivodship	Σ
insectivores	3	7	7
rodents	12	18	18
bats	6	18	18
total / ogółem	21	43	43

creased predation risk (presence of cats, dogs and birds of prey) and many barriers limiting migration (highways, walls, fences). Also a high level of pollution reduces species richness of urban biocenoses (Pisarski & Trojan 1976).

The Kraków agglomeration and adjacent areas are situated in the Wisła river valley. Its relatively warm climate is under a strong influence of adjacent physiographic regions. This karstic region is characterised by high faunistic diversity, enriched with several mountain species whose northern distribution limits reach the area. The Wisła river and its tributaries flowing through the Kraków agglomeration contribute to relatively high air humidity and provide feeding grounds and shelters in riparian habitats. The Jaccard's index (Q) for the city centre and suburbs is 48.84, reflecting high faunal similarity of the two areas, probably caused by the presence of a narrow belt of parkland surrounding the old town. Observations in the Las Wolski, a wood situated on the western periphery of Kraków, have brought interesting information on many mammal species from the following families: Arvicolidae, Muridae, Soricidae, and Gliridae (*Glis glis*, *Muscardinus avellanarius*), and a very rare bat species *Nyctalus leisleri* (Harmata 1960).

It is known that synanthropic species show cyclical changes in population. In the years of abundance the range of population is wedge-shaped, narrowing towards the city centre. Currently, *Apodemus agrarius* is regarded as a synurbic species and it is one of the most abundant species in the Kraków centre. Despite the fact that the small mammal assemblage in the suburbs is relatively rich in species, very often, only *Apodemus agrarius* is able to populate the core urban area (Gliwicz 1980). In contrast, Arvicolidae species have been observed more and more rarely in the urban agglomeration, which is due to the small area of open habitats inside the city (Kasprzak & Banaszak 1978). One may assume that the Kraków common grounds (Błonia Krakowskie) and banks of the Wisła river are densely populated by Arvicolidae voles, however, no data is available. Studies carried out so far have shown that the number of species connected with forest, shrub and open habitats has been increasing in the urban areas where they enter a mixture of 'ecotone biocenoses' (Ziomek 1998).

Preference of small mammals towards urban areas depends on season. In spring synanthropic rodent species (*Mus musculus*, *Rattus rattus* and *Rattus norvegicus*) migrate from the city into surrounding areas and in autumn they are forced to come back due to adverse weather conditions and lack of food. Also *Microtus arvalis* migrates into agrocenoses in spring (Chudoba & Humiński 1963). Contrary to them, some Chiroptera hibernating outside the urban area (in caves or tree hollows) tend to establish summer colonies in human settlements (in attics of old houses and churches, crevices in buildings etc.) (Wołoszyn 1981).

STRESZCZENIE

Składem gatunkowym drobnych ssaków Krakowa zainteresowano się już w latach czterdziestych ubiegłego stulecia (Kowalski 1950). Brak jak dotąd nie tylko dokładnej oceny zmian w strukturze fauny pod wpływem miejskich czynników antropogenicznych, ale także całościowego obrazu stanu fauny terenów zurbanizowanych (Kasprzak & Banaszak 1978). Celem niniejszej pracy było określenie składu zespołów drobnych ssaków w zbiorowiskach naturalnych, oraz antropogenicznych obszaru metropolitalnego Krakowa. Teren badań wybrano ze względu na zróżnicowanie topograficzno – klimatyczne obszarów z nim graniczących i mających wpływ na tutejsze środowisko i czyni go dobrym do analizowania preferencji siedliskowych gatunków. Proces synurbizacji fauny jest zjawiskiem dynamicznym i nasilającym się, a mimo to relatywnie rzadko badanym. Drobne ssaki w liczbie 56 gatunków stanowią 62,2% spośród 90 gatunków krajowej teriofauny. W ciągu ostatnich około 50 lat na badanym obszarze zanotowano obecność 43 gatunków drobnych ssaków. Wśród nich dominują gatunki, należące do czterech Rodzin: Soricidae, Vespertilionidae, Arvicolidae i Muridae. Cztery spośród zaobserwowanych gatunków, są uważane za synurbijne. Są to *Sciurus vulgaris* (Linnaeus, 1758), *Apodemus agrarius* (Pallas, 1771), *Mus musculus* (Linnaeus, 1758) i *Rattus norvegicus* (Berkenhout, 1769). Ogółem 21 spośród 43 gatunków drobnych ssaków zasiedlających badany obszar, zasiedla zarówno centrum aglomeracji, jak i tereny otaczające.

REFERENCES

Andrzejewski R., 1975: Problemy ekologicznego kształtowania środowiska w mieście [Problems of ecological forming of the environment in the urban areas]. *Wiadom. Ekol.*, **21**: 175–186 (in Polish).

Andrzejewski R., 1977: Stan badań nad ssakami na terenach miast w Polsce [Current research on small mammals of urban areas in Poland]. *Wiadom. Ekol.*, **23**: 407–409 (in Polish).

Bujalska G., 1970: Reproductin stabilizing elements in an island of *C. glareolus* (Schreber, 1780). *Acta Theriol.*, **15**: 381–412.

Chudoba S. & Humiński S., 1963: Owadożerne i gryzonie w osiedlu ludzkim podczas jesieni i zimy [Insectivores and Rodents in inhabited place in autumn and winter]. *Zeszyty Naukowe Wyższej Szkoły Rolniczej we Wrocławiu*, *Zootechnika*, **11**(52): 11–23 (in Polish, wit a summary in English).

Gliwicz J., 1980: Ekologiczny aspekt synurbizacji myszy polnej *Apodemus agrarius* (Pall.) [The ecological aspect of synurbisation of striped field mouse *Apodemus agrarius* (Pall.)]. *Wiadom. Ekol.*, **26**: 117–124 (in Polish, with a summary in English).

Grodziński W., 1958: The succession of small Mamlian communities on the overgrown clearing and landslip in the Western Carpathians. *Bull. Acad. Pol. Sci., Cl. II, Ser. Sci. Biol., Warszawa*, **6**: 431–439.

Grodziński W., 1959: Sukcesja zespołów drobnych ssaków na zarastającym zrębie i zsuwie górskim w Beskidzie Średnim (Karpaty Zachodnie) [The succession of small mammalian communities on the overgrown clearing and landslip in the Beskid Średni (Western Carpathians)]. *Ekol. Pol. A*, **7**(4): 83–143 (in Polish, with a summary in English).

Haitlinger R. & Szyszka K., 1977: Drobne ssaki Gorców, Beskidu Wyspowego, Pasma Pradziejowej i niektórych obszarów sąsiednich [Small mammals of the Gorce Mts., Beskid Wyspowy Mts., Radziejowa Range and some neighbouring areas]. *Przegl. Zool.*, **21**(2): 155–170 (in Polish, with a summary in English).

Harmata W., 1960: Obserwacje etologiczne i ekologiczne nad nietoperzami (Chiroptera) z Lasu Wolskiego pod Krakowem [Ethological and ecological observations made on the bats (Chiroptera) of the Wolski forest near Cracow]. *Przegl. Zool.*, **5**: 163 – 203 (in Polish, with a summary in English).

Harmata W., 1962: Sezonowa rytmika obyczajów i ekologia nietoperzy (*Chiroptera*) przebywających w niektórych zabytkowych budowlach województwa krakowskiego [Seasonal rhytmicity of behaviour and the ecology of bats (Chiroptera) living in some old buildings in the district of Kraków]. *Przegl. Zool.*, **7**: 149–179 (in Polish, with a summary in English).

Harmata W., 1969: The thermopreferendum of some species of bats (Chiroptera). *Acta Theriol.*, **14**: 49–62.

Harmata W., 1994: Winterschlaf des Mausohrs, *Myotis myotis* (Borkhausen, 1797) in den Festungsanlangen in der Umgebung von Kraków (Südpolen). *Folia Zool*., **43**: 325–330.
Harmata W., 2000: Phenological dynamic of hibernating lasser horseshoe bats *Rhinolophus hipposideros* (Bechst.) (Chiroptera, Rhinolophidae) in a limestone cavern. *Studia Chiropterol*., **1**: 13–28.
Harmata W. & Wojtusiak J., 1963: Podkowiec duży (*Rhinolophus ferrumequinum*, Schreber) nowym ssakiem dla fauny Polski [Greater horseshoe bat *Rhinolophus ferrumequinum* Schreber (Chiroptera), a species new to the fauna of Mammals in Poland]. *Przegl. Zool*., **7**: 154–157 (in Polish, with a summary in English).
Karolewski M. A., 1981: Specyfika i status ekologiczny miasta [Peculiarity and ecological status of a town]. *Wiadom. Ekol*., **17**: 3–35 (in Polish).
Kasprzak K. & Banaszak J., 1978: Fauna terenów zurbanizowanych [Fauna of the urban areas]. *Wszechświat*, **12**: 305–307 (in Polish).
Kowalski K., 1950: Badania nad ekologią drobnych ssaków leśnych okolocy Krakowa [Ecological research of small mammals in the forests of the Cracow surroundings]. *Docum. Physiograph. Polon*., **22** (in Polish).
Kowalski K., 1953: Materiały do rozmieszczenia i ekologii nietoperzy jaskiniowych w Polsce [Material relating to the distribution and ecology of cave bats in Poland]. *Fragm. Faun*., **6**: 541–567 (in Polish, with a summary in English).
Kowalski K., 1957: *Microtus nivalis* (Martins, 1842) (Rodentia) w Karpatach [Snow vole *Microtus nivalis* (Martins, 1842) (Rodentia) in the Carpathian Mountains]. *Acta Theriol*., **1**: 159–182 (in Polish, with a summary in English).
Kowalski K., 1960: *Pitymys* Mc. Murtrie 1831 (Microtidae, Rodentia) in the Northern Carpathians. *Acta Theriol*., **4**: 81–91.
Kowalski K., Krzanowski A. & Wojtusiak R., 1957: Sprawozdanie z akcji obrączkowania nietoperzy w Polsce w latach 1939–1953 [Report from the ringing action of bats (1939–1953)]. *Acta Theriol*., **1**: 109–158 (in Polish, with a summary i English).
Markowski J., 1997: Specyfika synurbijnych populacji zwierząt [Specifics of synurbistic populations of animals]. PWN, Warszawa, 169 pp (in Polish).
Markowski J. & Suskiewicz B., 1981: Ssaki (Mammalia) doliny rzeki Pilicy [Mammals of the Pilica River valley]. *Acta Univ. Lodz. Folia Zool. Anthropol*. (Łódź), **1**: 67–94 (in Polish).
Nowak J., Kozakiewicz K. & Grzywiński W., 2001: Podkowiec duży *Rhinolophus ferrumequinum* (Schreber, 1774), nowy gatunek dla fauny Ojcowskiego Parku Narodowego [Greater horseshoe bat *Rhinolophus ferrumequinum* (Schreber, 1774), a new species for the Ojców National Park fauna]. *Studia Chiropterol*., **2**: 100 (in Polish, with a summary in English).
Petrusewicz K., 1978: Osobnik, populacja, gatunek [An individual, population, species]. PWN, Warszawa, 384 pp (in Polish).
Pietraszewska T., 1999: Miasto jako układ ekologiczny [Town as an ecological system]. Pp.: 278–310. In: Strzałko J. (ed.): *Kompendium wiedzy o ekologii* [*Compendium of the Ecological Science*]. PWN, Warszawa (in Polish).
Pisarski B. & Trojan P., 1976: Zoocenozy obszarów zurbanizowanych [Zoocenoses of urban areas]. *Wiadom. Ekol*., **22**: 4 (in Polish).
Pucek Z. & Raczyński J., 1983: *Atlas of Polish Mammals*. PWN, Warszawa, 188 pp (in Polish).
Ruprecht A. L., 1971: Distribution of *Myotis myotis* (Borkhausen, 1797) and representatives of the genus *Plecotus* Geoffroy, 1818 in Poland. *Acta Theriol*., **16**: 95–104.
Ruprecht A. L., 1974: The occurrence of *Myotis brandtii* (Eversmann, 1845) in Poland. *Acta Theriol*., **19**: 81–90.
Ruprecht A. L., 1976: Über die Verbreitung der Rauhhautfledermaus, *Pipistrellus nathusii* in Polen. *Myotis*, **14**: 25–29.
Rzebik-Kowalska B., 1972: Badania nad pokarmem ssaków drapieżnych w Polsce [Research on the diet of Carnivores in Poland]. *Acta Zool. Cracov*., **17**: 415–506 (in Polish).

Sałata-Piłacińska B., 1977: Ssaki w pokarmie płomykówki (*Tyto alba guattata*, Brehm) z terenu Polski, ze szczególnym uwzględnieniem zachodniej części kraju [Mammals in the diet of *Tyto alba guattata* (Brehm) in Poland with special consideration of the Western Poland]. *Bad. Fizjogr. Pol. Zach., Poznań C*, **30**: 7–27 (in Polish).

Simm K., 1952: Zębiełek karliczek (*Crocidura mimula*, Miller) w Polsce [Lesser white-toothed shrew (*Crocidura mimula*, Miller) in Poland]. *Chrońmy Przyrodę Ojczystą* (Kraków), **6**(3–4): 52–53 (in Polish).

Skiba J., 2005: *Skład gatunkowy drobnych ssaków wybranych obszarów Krakowa na podstawie analizy wypluwek* [Small mammal communities of some areas in Kraków, based on the Long-eared owl *Asio otus* (Linnaeus, 1758) and Tawny owl *Strix aluco* (Linnaeus, 1758) pellets analysis]. MSc. Thesis. Zakład Ekologii Zwierząt Uniwersytetu Jagiellońskiego, Kraków, 60 pp (in Polish).

Skuratowicz W. & Warchalewski E., 1954: Przyczynek do fauny drobnych ssaków Podkarpacia [Contribution to the knowledge of the small mammals fauna in the Carpathian Foothills (Podkarpacie; South-East Poland)]. *Poznań. Tow. Przyj. Nauk, Pr. Kom. Biol.*, **15**: 119–130 (in Polish, with a summary in English).

Udziela W., 1924: Odmiany geograficzne wiewiórki w Polsce, jej rozsiedlenie oraz znaczenie gospodarcze [Geographical forms of red squirrel *Sciurus vulgaris* (Linnaeus, 1758)in Poland – occurrence and economic significance]. *Rocz. Nauk Rol. Leś. Poznań*, **12**: 348–373 (in Polish).

Wołoszyn B. W., 1981: Nietoperze i cywilizacja [Bats and civilization]. *Rocz. Muz. Okręg. Częstochowie, Przyr.*, **2**: 97–108 (in Polish, with a summary in English).

Ziomek J., 1998: Drobne ssaki (Micromammalia) Roztocza. Część I. Micromammalia wybranych biotopów Roztocza Środkowego [Small mammals of Roztocze (Eastern Poland), Part I. Micromammals in some biotopes in the Central Roztocze]. *Fragm. Faun.*, **41**(8): 93–123 (in Polish, with a summary in English).