III. URBAN FAUNA: INVERTEBRATES

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State of research into the fauna of Warsaw (up to 1990)

Abstract. Warsaw is among the cities in which studies on urban fauna are most advanced. There are an estimated 250–300 publications and extensive reports in manuscrips which include results of studies on the fauna of Warsaw from the last three decades. There are fairly rich historical data in publications, as well as in museum collections.

Of the zoological groups making up the Warsaw fauna, it is birds that are the best studied, followed by mammals and several groups of terrestrial invertebrate. Where habitats are concerned, the best studied faunas are those of the various types of urban green space. Complex studies of many zoological groups have been carried out in several areas. In many cases, the results of the investigations have been applied in urban planning, the management of urban green space and in nature conservation. However, this aspect has not been considered sufficiently in the study projects to date.

Future investigations should be aimed at completion (where the study of zoological groups and zoocoenoses is concerned) and integration of the data collected already – as in many cases these are fragmentary and non-comparable. An integrated picture of zoocoenoses should be developed – for the whole city and also for its various habitats. The results should not only provide a description of the composition of the fauna, but should also evaluate its ecological and practical role. Indication should also be given of the aims of the protection and management of urban fauna, and the possibilities for doing these things. The rapid growth of urbanization will increase the need for various applications of the knowledge of urban fauna. The studies in Warsaw should meet this demand.

INTRODUCTION

The aim of this article is to review the research on the fauna of Warsaw that has been carried out up to 1990, to assess its achievements and its level of advancement, and to indicate directions which should be considered in future research program-

mes. The subject of this work is all the various studies concerning the species composition of the fauna of Warsaw as a whole, as well as that of its various areas and environments; researches concerning the distribution of various animal groups, as well as the ecological conditioning of their occurrence in Warsaw, and also studies on specific synurbic adaptations observed amongst animal populations occurring in Warsaw. The article has been presented previously as a working paper (LUNIAK, PISARSKI 1990) and it refers to the situation at the begining of 1990.

Several reviews on similar themes have appeares previously: the paper of MIKOŁAJCZYK (1980) considering the state of knowledge of the insect fauna of Warsaw and the Mazowsze Region; a cycle of articles presenting the state of research on the fauna of towns and cities in Poland (ANDRZEJEWSKI 1977, LUNIAK 1977, PIECZYŃSKA 1977, PISARSKI 1977); a review article by ZIMNY (1990) as well as an article by LUNIAK (1990b) devoted to the research on the fauna of the city conducted at the Institute of Zoology of the Polish Academy of Sciences; CZECHOWSKI (1990) compiled a bibliography of works in the field under discussion which had been done at the Institute of Zoology up to 1988.

EARLY STUDIES

It was at the end of the 18th century that the first attempts of a scientific nature were made to get to known the fauna of what is now Warsaw. Particular mention should be made of Karol H. DE PERTHÉES, who was court geographer to King Stanisław August, but who also turned his attention to the collection of entomological material (mainly butterflies, beetles, and orthopterans) in the environs of Warsaw between 1764 and 1798. If his comprehensive collections, and scientifically-competent descriptions had been circulated more widely amongst the scientists of the time, in the form of publications and museum collections, the environs of Warsaw would then have been one of the best-researched areas in Europe from the point of view of its entomofauna. Today, after some 200 years, the material from PERTHÉES – preserved only in manuscripts and in the writings of other authors – constitutes an interesting documentation of the fauna, albeit a very fragmentary one. Amongst other things, it is possible to learn from these of the recording of cicadas *Cicada sanguinolenta* "five miles from Warsaw", as well as of the occurrence of the rare butterfly *Parnassius mnemosyne* in Kabaty.

Data from the first half on the 19th century are also fragmentary reports on single species and refer almost exclusively to areas that at that time were suburban rather than truly urban. One of the first such mentions comes from Feliks Paweł JAROCKI, who, in a review of native representatives of *Orthoptera* published in 1827, referred to a number of species from what were then the environs of Warsaw. The Bielański Forest now – one of nature reserves in Warsaw is mentioned with particular regularity in the faunistic records of the time, as well as in museum material from the 19th century. This was an attractive and oft-visited area for nature study, both at that time and subsequently. A wider review of the history of faunistic research carried out in Bielański Forest is contained in a monograph of this area (BAUM, TROJAN 1982) and in a paper by LUNIAK (1990c). Among those researching this area,

mention should first be made of Antoni WAGA – one of the main characters in Warsaw zoology at that time. Working with the Russian entomologist M. W. MOCZULSKI, WAGA discovered *Thoracophorus corticinus* – a species of beetle new to science – on the escarpment of the Bielański Forest in 1837. In 1841 he published news of the discovery of *Rhisodes europaeus* – another very rare beetle – in this area. Another piece of information from WAGA that is sensational for the modern reader concerns the nesting of cormorants at that time in Saska Kępa, which is now a central district of Warsaw. In 1835, a collection of descriptions of beetles by Kazimierz J. STRONCZYŃSKI also appeared which included data from the environs of Warsaw, amongst other things.

There is considerably more material from the second half of the 19th century. Worthy of note is a monograph on *Diptera* by Jan SZNABL, which was published in 1881 and which included, amongst other things, much information from the area of Warsaw proper (e. g. from the Botanic Garden) as well as from its environs. Much information on snails and slugs (*Mollusca*) was provided by Antoni ŚLUSARSKI's works (published in the 1880s) and his collection, which no longer exists. Similarly, Władysław TACZANOWSKI provided a lot of information on birds, and about their occurrence in the city itself. We are also indebted to him for information on *Arachnoidea* (from the Bielański Forest, amongst other localities). Also from this period was what was probably the first faunistic work devoted to Warsaw in particular. This is the extensive work by Antoni WAŁECKI (1881) entitled "The Mammalian Animal Fauna of Warsaw and its Relationship to the Fauna of the whole Country". For 100 years this was the only full review of the mammals of Warsaw. Particularly important amongst the museum materials of that period are the collections of invertebrates of the Zoological Cabinet of Warsaw University – which include many specimens obtained in the Warsaw area (e. g. from the Botanic Garden), and for which lists were published by N. NASONOV in 1892 and 1894, as well as the collection of beetles made by Wojciech MACZYŃSKI in the years 1884–1910 – which contains, amongst other things, specimens of 227 carabid species from what were then the environs of Warsaw (including Bielany). The latter collection is kept in the Museum of Upper Silesia in Bytom. Aleksander M. BYKOV served in Warsaw from 1891–1900 as an officer in the Russian army, and put together a collection which included ca 1873 specimens of bird from Warsaw and its environs (including ca 190 from the Bielański Forest) and numerous specimens of eggs and nests. These collections are in the Institute of Zoology of the Polish Academy of Sciences and the Zoological Institute of the Russian Academy of Sciences in St Petersburg.

In the years between the World Wars, fragmentary references to the occurrence of various animal species in Warsaw were included in a number of faunistic works (e. g. by Janusz DOMANIEWSKI, Stanisław FELIKSIAK, Marian GIEYSZTOR, Władysław POLIŃSKI and Jerzy WISZNIEWSKI). These were augmented by a monograph "Molluscs of Warsaw" (JANKOWSKI 1933, 1938) – which also included suburban areas. Several popular science publications also appeared – "A Zoological Guide around the Environs of Warsaw" (SUMIŃSKI, TENENBAUM 1921), the review article "The Fauna of Warsaw" (SUMIŃSKI 1922) and two booklets devoted to the Bielański Forest which considered the fauna as well as other aspects. Museum collections (for instance ornithological, malacological, coleopterological) were also built up and the preserved

collections are kept in the Institute of Zoology of the Polish Academy of Sciences. Special mention should also be made of the studies of Szymon TENENBAUM, who collected beetles mainly in the environs of Warsaw (e. g. Bielany) between 1905 and 1941. The collection he put together contained several hundred thousand specimens. He also wrote an extensive monograph (reckoned to have had about 1000 printed pages) on the beetles of the environs of Warsaw, which was to have been published at the initiative of the city's president. Unfortunately, the manuscript was destroyed during the War and its author perished in the Jewish Ghetto in 1941.

After the War, there was no special research into the fauna of Warsaw during the 1940s and 1950s, except for the works of Stanisław ADAMCZEWSKI (1951) on butterflies and PIELOWSKI (1957) on the avifauna of Łazienki Park. However, additional data on the occurrence of various species in Warsaw can be found in various faunistic works and in the collections of the Institute Zoology of the Polish Academy of Sciences.

THE RESEARCH OF THE LAST 30 YEARS

The first faunistic research to be focussed particularly on Warsaw and carried out on a larger scale was the ornithological team programme of the Institute Zoology of the Polish Academy of Sciences which was begun in the years 1960–1962. The result of this was the monograph on the birds of Warsaw by LUNIAK et al. (1964). More detailed faunistic research in Warsaw began in 1974 and was carried out mainly by the Institute of Zoology of the Polish Academy of Sciences (see above). This consisted of the five programmes listed below:

"The fauna of Warsaw's urban green areas" (1974–1976). Research provided data on the composition of the fauna of various types of urban green areas, amongst other things in relation to the way in which they were managed. Amongst other places, the results were presented in two collected works (Ogród Botaniczny PAN 1979, SZCZEPANOWSKA 1984) as well as in an ornithological synthesis (LUNIAK 1982).

"The fauna of Warsaw" (1976–1980). The subjects of this research were the species composition, origin, zoogeographical and ecological structure of the fauna of a large city – as exemplified by Warsaw. The results of this research were the first in the world's scientific literature to give such a broad and in-depth picture of the fauna of terrestrial invertebrates in a city. It was published in the form of five collections (CZECHOWSKI, PISARSKI 1981, CZECHOWSKI et al. 1981, CZECHOWSKI et al. 1982, CZECHOWSKI, PISARSKI 1986a, 1986b, and also in the proceedings of the international symposium summarizing the programme (LUNIAK, PISARSKI 1982).

"The Zoocoenological basis for the development of the natural environment of the Białołęka Dworska housing estate in Warsaw" (1976–1980). Involving cooperation with urban planners and specialists from various disciplines of natural history, the aim of this programme was to create a housing estate that was optimal from the ecological point of view. In this programme, the Institute made studies which gave a picture of the actual state of the fauna in the area of the future housing estate. Prognosis was made regarding the changes in the fauna to be expected with variants

of the design and opinions were given on design projects. The results of this research were published in a large collection of papers (GARBARCZYK, PISARSKA 1981) as well as in a synthesis work (BAŃKOWSKA et al. 1985).

"The zoocoenoses of selected Warsaw housing estates" (1981–1985). This programme was a more detailed continuation of the earlier studies into the fauna of Warsaw from the years 1976–1980. The results were presented by CHUDZICKA and CHOLEWICKA (1990) and LUNIAK and GŁAŻEWSKA (1988), amongst other papers.

The 1986–1990 research programme of the Institute of Zoology of the Polish Academy of Sciences embraced 4 themes: the use of nestboxes in the development of the avifauna of city parks (LUNIAK 1992), the threats to urban green space posed by certain groups of insects, the inventory of the avifauna of Warsaw (LUNIAK 1990) and the occurrence of certain species of mammal in Warsaw (LUNIAK, NOWICKI 1990).

Work carried out within these programmes from the Institute of Zoology of the Polish Academy of Sciences up to 1988 contains a bibliographical list by CZECHOWSKI (1990). This mentions about 200 publications devoted to urban fauna – mainly that of Warsaw – including 10–20 extensive monographs or subject collections.

Of other studies on the fauna of Warsaw carried out within the last 30 years, the only one of a broader and clearly "urban" nature was the detailed programme devoted to the synurbization of the Striped Field Mouse *Apodemus agrarius* in Warsaw (ANDRZEJEWSKI et al. 1982). Research on the butterflies of Warsaw by Stanisław ADAMCZEWSKI continued in the years 1963–1983). Following the author's death, material – including over 36 000 specimens – was stored and studied in the Institute of Zoology.

THE STATE OF RESEARCH ON PARTICULAR ANIMAL GROUPS

The research done to date provides a wealth of information on the species composition, abundance and distribution of the fauna of Warsaw. However, particular taxonomic groups differ in the degree to which they have been researched. Some animal groups (such as birds) are known relatively well, but very little is known abaut others – even such economically-important groups as aphids. The level of knowledge of the fauna of particular habitats is similarly variable – the fauna of urban green areas having been relatively well-studied, whilst that of derelict areas rather poorly so. The aim of this review presented is to show where the information at our disposal about the fauna of Warsaw is rich, and where it is insufficient.

Terrestrial invertebrates

In-depth research on the terrestrial invertebrates of Warsaw has been carried out from 1974 – as part of successive research programmes concerned with the fauna of urban green areas. These took into consideration the basic types of green space: parks, street greenery (both isolated and in the vicinity of large green complexes) and the green spaces of housing estates in areas that were more heavily built-up or less so. The research also embraced the suburban area of the Białołęka Dworska district.

Material embracing the entire fauna was collected in the course of this research – consideration was given to all taxonomic groups from all habitat layers – soil, the

undergrowth and the tree canopy. All material was collected using standardized quantitative methods. Not only did this allow work to be carried out on particular taxocoenoses, but it also provided for entire zoocoenoses to be characterized by reference to their structure, their differentiation from area to area in relation to the type of management, and the degree of technical development, the type of change induced within them by urbanization and their capacity for self-regulation. The origins of the Warsaw fauna could also be determined through comparisons of the species composition and structure of the zoocoenoses in urbanized and natural areas. To date work has been carried out on the following animal groups:

Protozoa – work has been done on the species composition and structure of the communities of the soil-dwelling *Testacea* and *Gregarina* which parasitize the earthworms of the city's green space.

Oligochaete worms – work has been carried out on the species composition, and structure of the communities, of the potworms *Enchytraeidae* and earthworms *Lumbricidae* of urban green space and suburban areas.

Woodlice *Isopoda* and Millipedes *Diplopoda* – studies have been made of the species composition in urban green space.

Arachnoidea – within this group, work has been done on the species composition of the communities of spiders *Aranei* and harvestmen *Opiliones* of urban green space and suburban areas, as well as on the species composition and community structure of the soil-dwelling mites *Acari* of urban green space and suburban areas. Research has also been carried out on the complex of mites occurring in the lime trees growing in green areas.

Apterygota – work has been done on the species composition, and structure of the communities, of the springtails *Collembola* of urban green space and suburban areas, and also on the influence of urbanization on this animal group.

Insects *Insecta*:

Homopteran bugs *Homoptera* – work to date has focussed only on leafhoppers *Auchenorrhyncha*. Many studies have described the species composition and structure of communities of leafhoppers, as well as the influence of urbanization on these insects, in both urban green space and suburban areas.

Beetles *Coleoptera* – the majority of beetle families have been studied, with the following being of considerable significance: *Carabidae*, *Scarabeidae*, *Elateridae*, *Coccinellidae*, *Cerambycidae*, *Chrysomelidae* and *Curculionidae*. Work on species composition has been carried out for all families, the structure of the communities in urban green space for the majority of families (except *Coccinellidae*, *Cerambycidae* and *Curculionidae*), and the structure of communities in suburban areas for families other than *Cerambycidae* and *Chrysomelidae*. The influence of urbanization on groupings of *Carabidae* and *Elateridae* has also been studied.

Lacewings *Neuroptera* – the species composition and structure of communities in urban green space has been worked on, as has the influence of urbanization on the occurrence of these insects.

Scorpionflies *Mecoptera* – the species composition of this small group in urban green space has been studied.

Ants, bees and wasps *Hymenoptera* – from this large order, studies of the species composition in urban and suburban green space have been made for the following

families and superfamilies: *Ichneumonidae*, *Braconidae* (only in suburban areas), *Proctotrupoidea*, *Tiphiidae* and *Myrmosidae* (only suburban areas), *Chrysididae*, *Formicidae*, *Vespidae*, *Sphecidae* and *Apoidea* (only urban green space). The structure of communities and the influence of urbanization have also been studied in the cases of the following families: *Ichneumonidae*, *Formicidae*, *Vespidae* and *Sphecidae*.

Butterflies and moths *Lepidoptera* – work has been done on only one family from this large order – albeit one of great significance – the moth family *Noctuidae*. Studies considered both species composition and populations, the structure of communities and the influence of urbanization on these insects in urban green space and in suburban areas.

Flies *Diptera* – 60 families of this order have been studied. Studies have been carried out in the green space of Warsaw on the species composition of flies from 22 families: *Culicidae*, *Rhagionidae*, *Tabanidae*, *Stratiomyidae*, *Cyrtidae*, *Bobyliidae*, *Therevidae*, *Scenopinidae*, *Asilidae*, *Dolichopodidae*, *Syrphidae*, *Conopidae*, *Pipunculidae*, *Anthomyidae*, *Muscidae*, *Sarcophagidae*, *Calliphoridae*, *Tachinidae*, *Gasterophilidae*, *Hypodermatidae*, *Hypoboscidae* and *Nycteribiidae*. The majority of these families are very poorly-represented in Warsaw. Higher populations are attained only by *Dolichopodidae*, *Phoridae*, *Syrphidae*, *Anthomyidae*, *Muscidae*, *Sarcophagidae* and *Calliphoridae*. In suburban areas, work was done on the species composition of 45 families: *Bibionidae*, *Phoridae*, *Syrphidae*, *Anthomyidae*, *Muscidae*, *Calliphoridae*, *Sarcophagidae*, *Tachinidae*, as well as the whole of the group *Acalyptratae*, with its 35 families.

Aquatic invertebrates

Research into aquatic fauna was not included within research programmes and it is poorly-known in consequence. In the last 30 years, the few studies of the aquatic fauna were carried out mainly in the course of degree theses (for the Laboratory of Hydrobiology of Warsaw University) which have not been published.

Synanthropic and parasitic fauna

Some groups of hemisynanthropes, such as flies of the families *Anthomyidae*, *Muscidae*, *Calliphoridae* and *Sarcophagidae* have been studied as part of the research into the fauna of urban green areas. Research on eusynanthropes has mainly been conducted by the State Institute of Hygiene – and mainly in relation to sanitary-epidemiological aspects. The results of this research have been summarized in the work of BRODNIEWICZ et al. (1979). Research into parasitic animals has been dominated by the medical and veterinary services and is mainly of a sanitary-epidemiological character. A few studies by the Institute of Parasitology of the Polish Academy of Sciences have involved the parasitic worms of corvid birds and rodents.

Fish, amphibians and reptiles

The occurrence of these animals in Warsaw has not been researched contemporarily. A little fragmentary information about certain species may be found in broader herpetological and ichthyological studies (e. g. the catalogue of the fish of Poland). More data could certainly be extracted from angling magazines.

Birds

Of the fauna of Warsaw, this is the best researched animal group. There is a relatively large amount of data in the literature and in museum collections from the second half of the 19th century. This is mainly thanks to W. TACZNOWSKI and

A. M. BYKOW. There is not much original information from the first half of the 20th century. All of this old material was presented, along with a picture of the avifauna at the beginning of the 1960s, in the monograph "The Birds of Warsaw" (LUNIAK et al. 1964). Since that time, the considerable progress of research may be shown by around 60 works relating to the avifauna of Warsaw which have been published or submitted for printing, and in more than 20 typed texts of degree theses or extensive expert reports. In the years 1965–1977 and 1983–1985, quantitative inventories were made for the breeding avifauna (on 60 areas covering a total of 760 ha) and for the wintering avifauna (on 40 sites covering about 640 ha). These studies included seven built-up areas, 44 parks and cemeteries, 10 allotment gardens, a lake and large suburban area section (at Białołęka Dworska). Some of these areas were studied several times in the aforementioned period. Quantitative studies were also made of the aquatic birds wintering on the Warsaw stretch of the Vistula. An ornithological inventory of the whole administrative area of Warsaw (485 km) was carried out between the years 1986 and 1990 (LUNIAK 1990d). This inventory gave a picture of the species composition, population sizes and distribution of the avifauna of the whole city and is the basis for the ornithological atlas of Warsaw, which is in preparation. This period also saw 12 pieces of work carried out inventorying and analyzing the occurrence of 24 species of birds in the city as whole, or in various parts of it. Research was also done (in nine works) on the reproduction and ecological conditioning of seven species. A large scale study nearing completion is concerned with the reproduction of, and the causes of breeding losses amongst, the house sparrows and tree sparrows of Warsaw parks. Changes in the avifauna of the Warsaw of the past, and in the last 20 years, have been discussed by LUNIAK (1972) and NOWICKI (1990) respectively. Since 1983 research has been carried out, and pilot studies made, of the use of nestboxes in the development of the avifauna of Warsaw parks (LUNIAK 1992).

Mammals

The starting point for knowledge of the mammals of Warsaw, and also a rich source of data from the past, is the monograph by WAŁECKI (1881) "The Mammalian Animal Fauna of Warsaw". Material from the first half of the present century is very scarce. A complex programme of research on the synurbization of the striped field mouse *Apodemus agrarius* in Warsaw implemented in the late 1970s and early 1980s (ANDRZEJEWSKI et al. 1982). This study included issues of population, morphology, physiology and parasitology among others, and its results were presented in more than 10 publications. The research of the last 10–20 years has also considered the occurrence of Red Squirrels, Beech Martens and bats and has included an estimate of the populations of wild mammals, dogs and cats by winter tracking. The material collected from some green complexes (the Bielański Forest, Łazienki Park and Białołęka Dworska) gives a picture of the whole theriofauna there. The works of LUNIAK and NOWICKI (1990a, 1990b) provide a full review of the mammals of Wasaw as well as informaton on the current (1990) state of research. An inventory has been made since 1986 in the Institute of Zoology of the Polish Academy of Sciences, and research into the small mammals of Dolny Mokotów district has been conducted by the Institute of Spatial and Communal Management.

EVALUATION OF THE STATE OF RESEARCH

From the point of view of its fauna, Warsaw is one of the best-researched cities in the world. Certainly there is no other urban area in which profound research has been carried out on the occurrence of such a great variety of terrestrial inveretebrate groups. In the last 30 years, an estimated 250–300 publications, larger expert reports and degree theses have included the results of research into the fauna of Warsaw. These include some 10–20 large monographs, subject collections or cycles of work devoted to given issues (e. g. the synurbization of the Striped Field Mouse). The historical material represented in the literature and in museum collections is also quite rich, although in general fragmentary.

Of the zoological groups making up the fauna of Warsaw the best researched is the occurrence of birds. Mammals and a number of terrestrial invertebrates groups, such as *Collembola*, *Homoptera-Auchenorrhyncha*, *Carabidae*, *Elateridae*, *Neuroptera*, *Formicidae*, *Vespidae*, *Sphecidae* and *Noctuidae* are quite well known. There is little information on many groups of invertebrate, or on parasites, the aquatic fauna (except birds and mammals), amphibians and reptiles.

In evaluating the research conducted to date in a cross-section of environments, it may be claimed that the fauna of green space is the best-researched. The fauna of built-up and derelict areas is less well-known, and that of the inside of buildings and water is very poorly known. Areas with the best-known faunas as a whole are those of the Bielański Forest (with rich historical documentation), the suburban area in Białołęka Dworska (data from the years 1976–1980) and Łazienki Park. In addition, in-depth research into terrestrial invertebrates has also been carried out in seven other areas of urban green space.

In many cases the results of research into the faua of Warsaw have found practical application – in urban planning (the project for the housing estate in Białołęka Dworska, the study into the management of Dolny Mokotów), in the management of urban green space, in the establishment of nature reserves and in other activities serving the protection of nature. However, insufficient consideration has been given to this aspect in the programmes of research to date.

Future research programmes involving the fauna of Warsaw should give consideration to the need to supplement the existing material (which is already rich but dispersed and incomplete) and to integrate it into a complete picture of the zoocoenoses of the city and of its various environments. These studies should not merely be descriptive. They should also lead to estimates of the natural value (or degradation) of the zoocoenoses described, as well as evaluation of the ecological and practical roles of fauna in urban ecosystems. They should justify the need for protecting (and emhancing the urban fauna, and should indicate the possibilities for doing so. In these plans, account should be taken of the fact that the rapid of urbanization will lead to an ever greater need for ecological knowledge to be considered in the various fields of urban management. There will also be an increasing need to popularize this knowledge among the inhabitants of the city. Being so advanced, the attainments of the research in Warsaw may be useful in this respect, at both the national, and the international, level.

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