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URBAN FAUNA: FAUNISTIC, ZOOGEOGRAPHICAL
AND ECOLOGICAL PROBLEMS

ABSTRACT

Nature is a good model of the environment for man. Town-planning norms based on ecological principles are of great importance to the establishment of a balance between man, engineering, and nature. It is possible to design housing estates in which faunistic relationships could be favourable to both man and ecosystem functioning. The determination of the effect of urban pressure on the fauna of urban green areas on the basis of zoogeographical, ecological and bionomical analysis enables us to characterize the taxons successfully colonizing urban habitats.

The industrialization of Poland during the recent 30-year-period was followed by mass migrations of countryside people to towns. Consequently, the towns have had to be enlarged. The process of the development of large towns raises many questions on the principles of their construction as spatial, urbanistic, technical and biological units concurrently. Architects, geographers, economists, technicians, and biologists face the problem of the establishment of rules, norms and measures enabling a proper control and analysis of the processes occurring as a result of the urbanization of large areas of the country. An important goal is to recognize the factors responsible for relationships within urban structures, and to counteract the negative effects of urbanization, recorded particularly in the field of medical, social and biological sciences.

The aim of the undertaken actions is to develop a system of spatial organization as to promote the development of favourable living conditions in housing estates, that is, enable people to enjoy good health, to restore strength rapidly and to maintain a good frame of mind, the being the necessary conditions for the development of good social relations. In recent years these problems have received much attention at many national and international conferences, the purpose of which was to recognize the main factors responsible for disturbances within urban structures and for negative effects on human organisms [1]. Two such conferences were held by biologists. The first one was a symposium on the protection of urban environment, organized by the Agricultural University of Warsaw on 14—15 November, 1975. The second, on a narrower scale, was centred upon the con-

ditions for the development of tree stands and their fauna in Warsaw. It was organized by the Botanical Garden PAS and the Institute of Zoology PAS in co-operation with the Town Gardening and Cleaning Department. Co-operation of the groups made up of specialists representing various disciplines and of activists in the field of economy yields rather noticeable effects. One of them is concerned with the general diagnosis of the urban environment, which has been formulated by P. Zaremba [1] as follows: "A distinct disturbance of the biological balance is observed in urban ecosystems; man is not able to adapt himself neither biologically nor psychologically to the conditions of life which he created as a result of the technical progress"... "The aim of the technique at present should be the restoration of the disturbed balance among the technique, man and nature. The results of the ecological studies conducted so far enable us to conclude that now there are foundations to speed up this process".

For a biologist a substantial question arises from these considerations: at which stage of the development of biological systems in housing estates this urban-biological unit does begin to have a positive effect on man. Specifying this problem in the categories of bioindication, we may ask if a streetside lawn is sufficient, or if it should be a system in which only chaffinches and sparrows will occur among birds, or perhaps the threshold of the "biological comfort" in man's habitat is reached only when nightingales can nest in the housing estate.

The second effect of the co-operation discussed is an intensified circulation of views, hypotheses and working concepts among disciplines that ten years ago had almost no contact with one another. This exchange of scientific thought stimulates research in the direction of making the results useful not only for particular disciplines, but first of all for the common benefit, that is, for the recognition of the principles of habitat optimization in urban areas. The exchange of ideas promotes still more frequently the establishment of research priorities or views on basic problems concerning urban habitats [2].

Nowadays there is no doubt that the ecological aspect of urban structures, with man as the dominant component, is of great importance to the improvement of living conditions in towns. Discussion on the perception of the habitat quality by man is only at the preliminary stage. It should be stressed, however, that the social perception of the quality of the environment or landscape is now very close to the views of biologists on this matter. Diversified urban structures with large green areas of mosaic spatial structure and vertical layering, approaching that occurring under natural conditions of our geographical zone, are perceived as better than monotonous systems of a simplified structure. Nature is still a good model for man and his frame of mind. The restoration of his physical and psychic energy depends largely on the quality of the natural environment which he confronts every day.

Faunistic and ecological studies on the animals inhabiting our towns, carried out since 1974 at the Institute of Zoology PAS in Warsaw, are supposed to answer a number of theoretical and practical questions concerning the state and the role of the fauna in urban habitats. The scope of this work has been established as a result of the co-operation of a team of workers, including representatives of the Institute of Environmental Engineering, Institute of Geography and Spatial Planning PAS, Agricultural University, and Institute of Geography UW. The study concerned mostly the fauna of urban green areas such as parks, green spaces among buildings, and even small paths of streetside lawns. The habitat-forming role of green spaces is well known at present [3]. Their fauna is a carrier of regulatory processes [4] in relation to phytophages infesting herbaceous plants, trees and shrubs poisoned by chlorine and heavy metals [5, 6]. Grazing by phytophages is an additional critical factor handicapping the development of plants in towns.

An important problem is the recognition of the role of fauna in the processes of the development and functioning of soil in towns. Preliminary results show that a considerable reduction in the biological activity of soil in green areas located near the sources of poison, was caused by engine fumes [7]. Particularly important is evaluation of the state of particular ecosystems within urban biocoenoses, because opinions in this subject suggest improper quantitative relationships among producers, consumers and decomposers [8].

Within towns also the process of synanthropization occurs, which leads to the colonization of urban areas by forms with different ecological specializations. These forms overcome the ecological barriers acting so far and colonize the direct environment of man. Here they enrich the ecological system, forming at the same time new values for people themselves. The synanthropization of blackbirds in Poland, a part of the population adapted to the life in urban parks, nesting even in small gardens around buildings, is perceived as a nice novelty in our environment [9]. Other synanthropic species are more annoying to man. Some of them, such as alien to our fauna black-beetles (*Blatta orientalis* L.) and cockroaches (*Blattella germanica* L.) or pharaoh ants, represent highly undesirable components in dwellings as consumers of foodstuff. Others, like bed-bugs (*Cimex lectularius* L.) and synanthropic flies are carriers of epidemic diseases as they transmit infectious microbes. An increase in their population is usually followed by an epidemic [10].

The processes of the colonization of urban areas by the fauna should be systematically recognized, and the patterns of the fauna development in towns determined. Factors controlling these processes and influencing the development of faunistic relationships in urbicoenoses, i.e., ecosystems of urban areas, should be recognized in order to make forecasts as to evaluate them in the phase of planning housing estates, and to control them in

the way most convenient for man and the ecosystem, as there is no possibility to eliminate the fauna altogether from urban areas. The attempts to eliminate rats failed [11]. Nature does not support vacuum within urban ecosystems. In the town it is not possible to use chemicals against undesirable species at such a rate as in crop fields, and even in the latter habitats the efforts of the plant protection service are only partly successful, the elimination of pests being a postulate not realized so far. More promising is an optimization of the structure of urban fauna so that it could serve a proper functioning of the ecosystem of urban green spaces and be not too annoying to man. This goal seems to be realizable in the nearest future due to developing the plan for the housing estate Białoleka Dworska in Warsaw. This will be an experimental range for architects, technicians and biologists. Ecological premises of this project complement urbanistic concepts of the space organization.

The faunistic aspect of urban studies is a novelty in zoological literature. Few contributions on this subject [12, 13] are either fragmentary or without a programme co-ordinating the efforts of scientists [14], or the methods used do not provide a good basis for comparing results [19], so they are of a limited value for synthesis concerning the whole urban fauna. In the study carried out and co-ordinated by the Institute of Zoology PAS, a large number of animal groups was analysed, including a major part of the urban fauna. Quantitative methods of the material sampling were used so that the results were comparable [15]. Therefore, the materials enable us to draw conclusions on such basic faunistic problems as:

1. The way in which the pressure of urbanization of different degree acts on the possibility of the occurrence of animals in towns;
2. Faunistic composition of the groups of animals successful in the colonization of urban ecosystems and becoming dominants, as well as the composition of groups eliminated from urban ecosystems.

The answer to these questions is of basic importance to the studies on the functioning of the living world under conditions of the urban environment, as it indicates the substance of which ecological systems are made up in different zones of a town. Specificity of the faunistic composition is one of the factors determining functional features of urban ecosystems, determining also the conditions of the ecological balance establishment. Moreover, the faunistic analysis shows which components of the urban structure are abundant in animals being a source of biological diversity, and which urban structures are extremely impoverished as a result of the urban pressure on the living world. Also the degree of the isolation of particular green areas in a town should be analysed, since the suggestions by S. H. Feath and T. C. Kane [16], who argued that the degree of the isolation of parks was similar to the one observed for oceanic islands, seem highly improbable.

The second group of questions concerns a zoogeographical analysis of the species living in urban areas and in their surroundings, in free nature

[17]. Animals occurring in Poland show a considerable differentiation of ranges, varying from those spread over the whole globe, occurring in all geographical and climatic zones, to those whose distribution is limited to a small part of Europe where they occupy very specific habitat types, and due to this are extremely rare. In addition, in towns we can observe the species brought over or introduced from other geographical regions. Frequently these are forms not occurring in Poland in nature, the distribution of which is limited to human settlements. Determination of the contribution of particular zoogeographical elements in zones characterized by different proportions of urban areas, provides basis for explanation of the genesis of urban fauna. This also makes it possible to determine the role of autochthonous fauna and of the processes of the local species adaptation in the development of urban fauna. Moreover, it enables us to determine the role of autochthonous species. Their presence in towns testifies both to the specificity of the urban habitat which differs significantly from the habitats surrounding towns, and to the degree of the opening of the urban ecosystem which can be described as a nonsaturated system, receiving all new elements coming from outside, enriching its structure. This rule, established for agrocoenoses, seems to be also valid for urban ecosystems [18].

The key to understanding the species composition of the urban fauna is provided by an ecological analysis. It enables us to characterize the species successful or not in colonizing urban areas. All contributions presented in this volume are based on a unified system of ecological analysis worked out at the Centre of Faunistic Documentation of the Institute of Zoology PAS, by Dr. W. Mikołajczyk. They involve a large range of ecological features of species, such as the degree of synanthropization, ecological amplitude, expansiveness, abundance, relation to particular types of the environment and to its different structural layers, the range of food specialization, and the diet. This set of ecological properties makes it possible to characterize ecological and bionomical features of individual species successful in colonizing the habitats transformed by the processes of urbanization.

The question arises whether the ecological groups of species eliminated by the impact of urbanization can be successfully replaced by other species with different specialization and bionomics, but with a similar function in the system as far as regulatory processes in a biocoenosis are concerned. In urban ecosystems the presence of species controlling the number of phytophages injuring green plant parts is of particular importance [4]. This function is performed by groups of predators and parasitoids acting concurrently on the populations of phytophages. The recognition of relationships among these three components represents an important field of the study on urban fauna. It delimitates the possibility and the range of ecological manoeuvre which can be planned in urbicoenoses to improve the number regulation in these systems.

Urban pressure as a major factor influencing the fauna represents a clearly-

-cut section of the total impact of human settlement which, in turn, is a part of a complex system of interactions among nature, engineering, abiotic environment, and human population, all this being called the anthropopressure [20]. In urban areas there are five factors contributing to what is called the urban pressure on the world of nature: buildings, the system of underground pipes and cables, communication system, industry, and people. The effect of these factors is responsible for the environmental distinctiveness of the areas subjected to urban and industrial pressures [21].

The impact of building on living nature lies firstly in the limiting of the area covered by the vegetation, which is either completely eliminated, as it is the case in the centres of some towns, or forms islands largely isolated from one another [16]. The history of green areas in European towns shows that they have found their permanent place in urban structures gradually and only in recent years [22]. The density of buildings in towns influence thermal conditions in urban habitats as a result of both the emission of heat from buildings and their exposure to solar radiation. In this way the type of buildings influences the climate of a town, modifying not only thermal conditions but also the internal system of air circulation [23].

The system of pipes, wires and underground devices is coupled with the processes of urbanization. Underground devices cause deep changes in the structure of upper soil layers; they go several or even more than ten metres below the ground surface. As a result the geological system is disturbed and, in particular, water relations are affected. Water table is usually lowered markedly as a result of the urbanization of an area. Natural running waters are either buried or included into the urban sewer system, depending on the geomorphology. In Warsaw it was the case of the Potok Służewiecki and Rudawka flowing through the Bielany Wood. Sometimes troublesome running waters are directed to underground urban channels and as a result they have no more influence on water relations in the area they drained before. This practice leads to drying up the top soil layers and to deterioration of living conditions for plants since their roots have to use rain waters from upper soil layers or reach deeply to use ground waters.

The development of communication system in modern towns is coupled with covering large areas with asphalt or concrete pavement. This excludes a large part of the urban areas from the development of living systems. Only the ant *Lasius niger* can build nests under the pavement and, passing through crevices, reach streetside trees and pavement surface in search of food. Arteries of traffic in towns are, in addition, a source of dangerous emissions in the form of engine fumes floating in the air and polluting the atmosphere of green areas and buildings, as well as the soil, the latter with salts of heavy metals accompanied by magnesium chloride and sodium chloride, both used in winter to make streets less slippery [24]. This factor acts most strongly on the streetside vegetation where the rate and longevity

of plant life are lower than under natural conditions, and the biological activity of soil is markedly reduced.

The effect of industry on the urban habitat depends on the specificity of production. In many fields of industry large amounts of heat are released as a result of coal and coke combustion, this being an additional source of carbon, sulphur and nitrogen oxides or other compounds emitted to the atmosphere. This is accompanied by the emission of smoke which together with the dust generated by traffic and wind-blown soil particles, form above towns an envelope of aerosol modifying atmospheric processes.

The human population is a factor acting through its density. All green systems are frequented by man, their soil being trampled, animals driven away, and plants damaged. The pressure of this type eliminates shy species of birds and mammals, as well as those plants which are susceptible to soil trampling. At the same time these green areas are accessible to synanthropic species, adapted to such a pressure of man. In winter the presence of man improves conditions for the surviving of animals, particularly birds, which at deep snow cover are supplied with food by people.

The drying up and the heating of the urban environment make the habitats of green areas similar to xerothermal ones, and open them to animals with more southern ranges [25]. Important factors attracting synanthropic species to towns are food wastes and the dung of dogs and cats accompanying man in towns. The whole set of factors accounting for the urbanization pressure acts with a different force in particular zones of a town, most strongly in the centre, least strongly in the suburbs. As a result, a double gradient of the urban pressure on the fauna is formed. The first one with an increasing intensity from the suburbs to the centre of a town, the second one from the sources of pollution to surrounding areas. This system eliminates many groups of insects [26], but at a low pressure enriches species composition of some groups of social insects [27]. A detailed analysis of these processes is the subject of the contributions presented in this volume.

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FAUNA MIAST: PROBLEM FAUNISTYCZNY, ZOOGEOGRAFICZNY
I EKOLOGICZNY

STRESZCZENIE

Ostatnie trzydziestolecie w Polsce charakteryzuje się silnym rozwojem aglomeracji miejskich. Opracowanie zasad, norm i mierników pozwalających prawidłowo kształtować i oceniać zjawiska związane z urbanizacją, stanowi ważne zadanie nauki, w tym również biologii. Szczególne znaczenie ma zarówno eliminowanie czynników decydujących o negatywnym oddziaływaniu urbanizacji na człowieka, rośliny i zwierzęta, jak też stwarzanie warunków pozytywnie oddziaływających na organizm ludzki. Głównym celem techniki, zgodnie z twierdzeniem urbanistów, jest obecnie przywracanie zachwianej równowagi między człowiekiem techniką i naturą.

Ekologiczny aspekt struktur urbanistycznych ma duże znaczenie przy programowaniu poprawy warunków życia człowieka w mieście. Autor stawia pytanie: przy jakim stopniu rozwoju układów biologicznych w obrębie zabudowy osiedli mieszkaniowych rozpoczyna się pozytywne oddziaływanie układów urbanistyczno-przyrodniczych na człowieka. Zróżnicowana strukturalnie przyroda pozostaje wciąż dobrym modelem środowiska dla człowieka, zaś jego samopoczucie i regeneracja sił zależą w znacznej mierze od jakości środowiska z jakim się styka.

Badania nad fauną zieleni miejskiej mają duże znaczenie w problematyce ekologii miast, ponieważ zwierzęta stanowią główny nośnik procesów regulacji biocenotycznej i odgrywają zasadniczą rolę w procesach glebotwórczych. Ważnym zadaniem jest ustalenie stanu poszczególnych podsystemów w obrębie biocenozy zieleni miejskiej, ponieważ stan zatrucia tych środowisk sugeruje wadliwe stosunki ilościowe między producentami, konsumentami i destruentami.

Procesy synantropizacji fauny obejmują szczególnie miasta. Niosą one za sobą zarówno zjawiska pozytywne, jak i negatywne. Istniejące zróżnicowanie fauny w różnych układach zieleni miejskiej pozwala na planowanie osiedli w ten sposób, aby stosunki faunistyczne kształtowały się korzystnie dla człowieka i ekosystemu miejskiego.

Badania prowadzone w Instytucie Zoologii PAN mają na celu ustalenie: 1) jak działa presja urbanizacyjna na występowanie zwierząt w miastach, 2) które grupy zwierząt uzyskały sukces przy opanowaniu ekosystemów miejskich. Specyfika układu gatunkowego fauny różnych części miasta określa elementy, z których zbudowane są mechanizmy regulacyjne ekosystemów miejskich.

Analiza zoogeograficzna pozwala określić, jakie elementy mają przewagę w opanowywaniu miast, jak również udział w nim gatunków autochtonicznych i allochtonicznych. Analiza ekologiczna pozwala na określenie takich właściwości, jak stopień synantropizacji gatunków, ich plastyczność środowiskową, liczebność i związki z ekosystemami naturalnymi. Właściwości te można określić zarówno w odniesieniu do tych grup, które w opanowywaniu miast osiągnęły sukces, jak również tych, które zostały z nich wyeliminowane. Na tym tle rysują się także możliwości wyjaśnienia zjawisk zastępowania w układach ekologicznych grup wypartych z miasta przez grupy lepiej wytrzymujące presję urbanizacyjną.

Jednym z ostrzej działających systemów antropopresji jest urbanizacja. Składają się na nią: zabudowa, system przewodów i instalacji podziemnych, układ komunikacyjny, przemysł i ludzkie. Autor omawia te czynniki w odniesieniu do fauny miast.

ФАУНА ГОРОДОВ: ФАУНИСТИЧЕСКИЕ, ЗООГЕОГРАФИЧЕСКИЕ И ЭКОЛОГИЧЕСКИЕ ПРОБЛЕМЫ

РЕЗЮМЕ

Природа остается хорошим моделем среды для человека. Нормы урбанизации, основанные на принципах экологии, имеют значение для установления равновесия между человеком, техникой и природой. Можно так формировать поселения, чтобы фаунистические отношения были благоприятны и для человека, и для функционирования экосистем. Определение воздействия урбанистического пресса на фауну городских зелёных насаждений, основанное на зоогеографическом, экологическом и бионимическом анализе, позволяет охарактеризовать таксоны, которые имели успех при заселении городов.