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WOJCIECH CZECHOWSKI, WALDEMAR MIKOŁAJCZYK

METHODS FOR THE STUDY OF URBAN FAUNA

ABSTRACT

The series of contributions concerned with the species composition and origin of the fauna of Warsaw is based mainly on the data collected at the Institute of Zoology PAS in 1974—1978. The following methods of animal sampling were used: extraction from soil samples, dislodging from soil by means of formalin, biocoenometer, Barber's pitfall traps, aspirator, sweep-net, shaking animals from trees and shrubs, Moericke's traps.

Zoogeographical and ecological analysis of the material involves origin of the fauna, geographical ranges of the species, ecological amplitude, habitat preferences, food habits, expansiveness, abundance, and degree of synanthropization.

METHODS

In 1974—1978, the Institute of Zoology in Warsaw, Polish Academy of Sciences, carried out zoocoenotic studies entitled "The effect of urban pressure on the fauna of Warsaw". The earliest results are presented in this volume in the form of a series of contributions entitled "Species composition and origin of the fauna of Warsaw".[1]

Since the study was of a complex character, the methods of data collecting were largely diversified, adapted to the specificity of the occurrence and biology of particular fauna groups. Four layers were distinguished in each of the habitats under study: soil, soil surface, herbs, shrubs and tree crowns. Specific character of the study area imposed some limitations on the methods applied. It was related to the fact that any visible and persistent damage could not be done to carefully grown green of parks, housing estates, and similar structures performing also decorative functions. Particularly restricted were the methods for studying the fauna of soil.

Each year the field work was started early in April and continued through October.

[1] Basic premises of these contributions and environmental characteristics are presented in introductory papers [8, 11, 15].

SOIL FAUNA

Soil fauna was dislodged from soil cores by means of the Macfadyen and Murphy apparatus (mesofauna) and Tullgren apparatus (macrofauna). Soil cores were taken by means of standard devises with different cylinder sizes. The number of samples and frequency of sampling varied according to the group.

To estimate the number of *Enchytraeidae*, 10 soil samples of a surface area of 9.5 or 20.0 cm^2 were taken from each plot two times a season (in spring and autumn). To estimate the density of *Acarina*, the same number of 11.3 cm^2 soil cores were taken on the same dates, and to find the number of *Collembola*, 10 soil cores 20.0 cm^2 in surface area were taken from each plot seven times a season, i.e., every month.

The methods presented above (small soil cores) are commonly used in the studies of mesofauna inhabiting the soil [3, 4, 12]. In the studies of soil macrofauna usually much larger samples are taken [6]. However, because of a specific character of the habitats under study, also the soil macrofauna was analysed in small soil cores, a total of 200 soil cores of a surface area of 20.0 cm^2 being taken from each plot [10].

All the soil fauna groups under study were extracted from the soil cores, except for earthworms. The latter group was assessed by the Satchell method especially for earthworms [14]. This method lies in dislodging earthworms from soil directly by means of 0.03% formalin solution. Biocoenometric metallic frames of a surface area of 0.33 m^2 driven into the ground, were used for this sampling. Three samples were taken from each plot three times a season.

FAUNA OF THE GROUND LAYER

Biocoenometric frames and Barber's pitfall traps were used to catch animals occurring on soil surface. The frames delimited a surface area of 0.25 or 0.10 m^2. In wooded areas, where litter covered the soil and it was not possible to catch animals directly, litter samples were taken from the areas enclosed by biocoenometric frames, and then selected by hand. Four series of the biocoenometric sampling were done over the season, in 10 replications on each of the plots.

Glass cylinders 4 cm in diameter and about 10 cm deep, thus very small, were used as pitfall traps. They were put into the holes made with a soil sampler of a corresponding size, and filled with ethylene glycol by one-third of their volume. There were 10—20 traps per plot working for 14 days each month [1, 2].

FAUNA OF THE HERB LAYER

Samples of the fauna associated with the herb layer were taken by means of an aspirometer, entomological sweep-net, and Moericke's traps [9].

In the aspirometric method a metallic biocoenometer of a surface area of 0.25 m^2, and with the framework covered by gauze was used [5]. Eight samples were taken from each plot once a month. The time of each sampling was 5 minutes, this being sufficient to explore the space delimited by the biocoenometric framework.

The sweeping method was used according to general indications set up by Gromadzka and Trojan [7]. A series consisted of 25 sweeps, 8 series being done on each plot. The frequency of sweeping depended on weather conditions. At the best weather it was done every ten days.

Moericke's traps, used mainly to catch flying insects, contained aqueous solution of ethylene glycol with an admixture of detergent "Kokosal". They were put in the grass, and considered as a supplementary method [9]. Since they drew attention and were readily accessible, they could not be commonly used in the town.

FAUNA OF SHRUBS AND TREE CROWNS

Tree crowns and shrubs were sampled by means of Mericke's traps and by shaking fauna from branches onto an entomological umbrella or into a sweep-net. Samples of 100 leaves were taken from selected plant species (limes and oaks) to determine the numbers of aphids and piercing lepidopteran larvae.

Moericke's traps suspended among branches were the basic sampling method for most of the fauna groups. They ran throughout the growing season and were emptied every 5 and 10 days, alternately. The traps were mainly located on limes, 3 traps on each of the trees selected in particular plots. Some fauna groups (e.g. *Neuroptera, Coccinellidae* and others) were sampled not only in the plots of the urban green areas but also in allotments, traps being suspended on various fruit trees such as apple-trees, pear-trees, and plum-trees [11].

Shaking fauna from branches onto an entomological umbrella was carried out once a month in 1974—1975. Then the umbrella was replaced by a sweep-net and sampling was done at 2-week intervals (in the case of tall trees, a hydraulic elevator was used).

ADDITIONAL METHODS

In addition to the quantitative methods described above, also qualitative sampling was conducted. Insects flying at night, mainly *Lepidoptera,* were caught by means of a light trap located on the fifth storey of the Institute of Zoology PAS building (centre of the town).

CRITERIA FOR CLASSIFICATION OF THE FAUNA

It was difficult to evaluate and characterize the collected materials, as well as to unify their description, because of considerable differences in the

knowledge of various taxons. The distribution of some species and groups over the country is not exactly known, their bionomics, ecology, abundance, etc., have not been studied.

A characteristic of the fauna should cover the following topics: origin of the species, its geographical range, ecological amplitude, habitat preference and vertical distribution, food habits, range of food specialization, trophic groups, type of feeding, abundance, expansiveness, and the degree of synanthropization. In practice, however, not all of these elements and not with the same degree of accuracy could be considered.

Zoogeographical and ecological characteristics are related to an increasing gradient of urban pressure.

ORIGIN OF THE FAUNA

The invertebrate fauna of Warsaw consists of native species and of the species carried or arrived from other regions of Palaearctic or from other zoogeographical regions. To native species belong those living in Poland before it was largely influenced by human activity. To obtain a more complete characteristic, it may be added whether a species occurs within boundaries of its continuous range, or in isolated groups, beyond the continuous occurrence. To the introduced species belong those which are present in the area as a result of the intentional or nonintentional human activity and related direct of indirect changes in this environment.

GEOGRAPHICAL RANGE

The geographical range is considered as an actual distribution of a species which is here a geographical element in the chorological and not genetic sense.

It is difficult to determine the exact limits of the occurrence of particular geographical elements since they may differ for various species. Thus the division of the fauna into geographical elements has to be sufficiently general to involve all taxonomic groups. The following geographical elements have been distinguished:

Cosmopolitan (geopolitan). Distributed all over the world or at least wider than in Holarctic;

Holarctic. Cold and temperate climatic zones of the Northern Hemisphere extending to the tropic of Cancer;

Palaearctic. Part of the Old World within the boundaries of the Holarctic region;

Boreal. Close range covering in fact the zone of taiga but sometimes considerably exceeding its boundaries. In Europe, numerous, dispersed stands in the mountains (boreal-mountain type of distribution), frequently in lowland moors;

Euro-Siberian. Europe, except for northernmost regions (northern parts of the Scandinavian Peninsula) and southernmost regions (Iberian Peninsula,

Apennine Peninsula, and southern part of the Balkan Peninsula), Palaearctic part of Asia. It covers the zones of taiga, mixed forests, broad-leaved forests, and forest-steppes, i.e., it extends from tundra to the zone of steppes in southern Europe and central Asia (Palaearctic without the Arctic and Mediterranean regions);

South-Euro-Siberian. The northern boundary of the close range of this element runs along the southern boundary of taiga, and its southern boundary reaches the zone of steppe. The species occurring here are associated with the biomes of broad-leaves forests and forest-steppes. Here are included amphipalaearctic and Euro-Caucasian species with different ranges in Asia but similar in Europe, and associated with the same biome;

European. This one is a very large concept. These may be both the species occurring almost throughout Europe or slightly exceeding its boundaries, and the species the distribution of which is not known exactly but which have not been recorded outside Europe as yet;

Subatlantic. It covers western and northwestern Europe: Ireland, Great Britain, northern part of the Iberian Peninsula, France except for southern parts, the Benelux area, Federal Republic of Germany, German Democratic Republic, Denmark, and northwestern part of Poland;

Submediterranean. Close range covering the zones of Mediterranean scrub of the macchia type, submediterranean broad-leaved forests with some evergreen plant species, and further to the east the zones of forest-steppes and steppes. The northern limit of the close range goes from northwestern France, through southern part of the Alps, along the Danube, to the Black Sea and the Caspian Sea. The southern limit follows northwestern edge of Africa, the Mediterranean Sea, Asia Minor, and southern coast of the Caspian Sea;

Mediterranean. Covers the zone of the scrub of the macchia type in the region of the Mediterranean Sea;

Southeastern (Pontic). Associated with the zone of steppes, running evenly with a parallel of latitude from the northern coast of the Black Sea, through Central Asia, almost to the Pacific;

Unknown. Concerns the groups and species very rare and little studied.

ECOLOGICAL REQUIREMENTS

Ecological amplitude.

From the point of view of the range of ecological amplitude of various, the following groups are distinguished:

Eurytopic. The species occurring in both open and wooded terrains, without a distinct preference to any biotope, living in various habitats: dry and wet, oligo- and eutrophic;

Polytopic. The species occurring in environments of many types, e.g.,

colonizing all types of forests or open habitats, all terrestrial dry and moist habitats, or all fertile and very fertile sites;

Oligotopic. The species occurring in some similar biotopes, e.g., coniferous forests, or wet forests, or dry open areas;

Stenotopic. The species occurring almost exclusively in biotopes of one type.

Plant communities and habitat preference

To characterize the environment, an attempt was made to consider possibly typical formations, and to reconcile the forest or meadow typologies with phytosociological units. The terrestrial ecosystems were classified on the basis of the type of their management, into four groups: wooded, open, agricultural and urban areas.

After Matuszkiewicz [8], they are covered with the following vegetation types: 1 — natural forests, 2 — modified forests, 3 — forest clearings, 4 — scrub, 5 — xerothermal grasslands, 6 — meadows and pastures, 7 — grain crops, 8 — root crops, 9 — orchards and vegetable gardens, 10 — ruderal plants, and 11 — urban green areas. Their occurrence depends on a set of environmental factors, including moisture and fertility (see Matuszkiewicz Tab. 1, and others).

The group of wooded habitats involves natural forests, cultivated stands, and scrub.

Natural forests of central Poland consist of coniferous forests ranging from dry, through moist and very moist to bog forests, mixed forests moist and wet, oak-hornbeam forests, swamps, and carrs. Potentially most common forests are moist mixed forests and oak-hornbeam forests.

Natural biotopes are the starting point and the basis for characteristics and evaluation of the fauna living in habitats modified by man to different degrees.

The group of open habitats consists of the communities of herbaceous plants and shrublets (excluding agricultures), including the communities of ruderal plants.

Agricultural land. It includes crop fields (without synanthropic, semi-natural communities included to the group of terrestrial open habitats), orchards and vegetable gardens (the latter group involving small plots of ground adjoining homes, allotments, etc.), wooded areas among crops, and double rows of trees.

Urban areas. Here are included buildings and green areas subdivided into parks, green areas of housing estates, and streetside green areas.

According to their habitat preference, particular groups of insects have been classified either as ubiquitous, that is, occurring in most of the habitat types listed above, or as associated with specific plant communities or their groups.

Food habits

Trophic characteristics of a species, very important as defining its role in a zoocoenosis, are illustrated by the range of food specialization, the type of feeding, and by the trophic groups.

The range of food specialization involves the following groups: pantophages — animals living on both animal and plant food, and sometimes also saprophagous; polyphages — either phyto- or zoophages in the broad sense; oligophages — e.g. living on the species belonging to one family; monophages — living on one plant or animal genus or species, often on their definite parts.

According to the type of feeding, such groups were distinguished as:

a) exophages
   — biting (e.g. caterpillars, cockhofers);
   — sucking (licking) — many dipterans, lepidopterans, hymenopterans;
b) endophages
   — biting (mining, boring, parasitoids: parasitic hymenopterans, dipterans);
   — piercing (sucking) — drawing liquid food from tissues of an organism attacted (e.g. piercing: aphids, mosquitoes; sucking: spiders, predatory larvae of *Neuroptera*, aphidophagous larvae of *Syrphidae*).

According to the diet, the following trophic groups can be distinguished: omnivorous animals, feeding on both plant and animal food, and sometimes also saprophagous; phytophages (phyllo-, xylo-, and rhizophages, as well as others — feeding on flowers, fruits, seeds, fungi, etc.); zoophages (predators and parasitoids); and finally saprophages, which, because of their sanitary-epidemiological importance, are subdivided into phytosaprophages, necrophages, and coprophages.

ABUNDANCE

Only the number of individuals of particular species in Poland will be considered here. It is difficult to estimate total numbers, even very roughly. Most frequently it will be a subjective estimate in optimum, specific for a given species habitat. The concept of abundance should not be mistaken for the concept of frequency. The species qualified as "common" or "rare", need not be abundant or scarce.

The following scale will be used to determine abundances:

Abundant species. In optimum habitats they occur in large numbers over the country, producing outbreaks;

Locally abundant species. The species producing outbreaks in optimum habitats on a regional scale (geographical but within the boundaries of Poland) or environmental scale (e.g. pest outbreaks in some regions, mass occurrence of an eurytopic species in a definite habitat);

Numerous species. More or less uniformly distributed in large numbers;

Scarce species. Represented by few individuals. These last two groups are estimated in relation to other species of the same family occurring

in Poland; in some particular cases (small number of species representing a given family), in relation to the group of families, or to the order;

Sporadic species. In well-known groups they are limited to single individuals (colonies) or stands;

Species of unknown numbers.

EXPANSIVENESS

The actual state and not the potential possibilities of the species will be considered here, independent of biological or anthropogenic factors responsible for it. The species that does not show large variability in the range, abundance, and number of colonized habitat types, is considered as a stable species. The species extending the range, increasing in numbers, colonizing new habitats, is considered as a expansive one. The species the range of which as well as abundance and the number of habitats is decreasing, is a recessive species. The species decidedly recessive, occurring in single stands, is a threatened species.

SYNANTHROPIZATION

On the basis of the classification of organisms occurring in urban habitats [13], the following simplified scale may be used to determine the degree of their association with man:

Asynanthropic species (also called apparent synanthropic species). They have no contacts, except for casual, with man, and their occurrence is not conditioned by the specificity of anthropogenic habitats.

Hemisynanthropic species. They occur in human habitats, utilize man-made trophic and microclimatic conditions, although they do not depend on man directly. Here there are included the so-called facultative synathropic species, hemisynanthropic species, and a part of synanthropic hemophages.

Synanthropic species. They are permanently associated with man, occur exclusively in his direct surrounding. Thus they are close, obligatory synanthropic species.

Instytut Zoologii,
Polska Akademia Nauk
ul. Wilcza 64, 00-679 Warszawa
Polska

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METODYKA BADAŃ FAUNY MIEJSKIEJ

STRESZCZENIE

Cykl opracowań na temat składu gatunkowego i pochodzenia fauny Warszawy powstał w oparciu o zoocenotyczne badania Instytutu Zoologii, przeprowadzone w Warszawie, w latach 1974—1978, uzupełnione danymi bibliograficznymi i materiałami z dawnych zbiorów. Podczas ostatnio prowadzonych w Warszawie badań nad wpływem presji osadniczej na faunę stosowano złożoną metodykę odłowów, odpowiednią do specyfiki występowania poszczególnych grup fauny. W badanych środowiskach wyróżniono 4 warstwy biocenotyczne: glebę, powierzchnię gruntu, roślinność zielną oraz korony drzew i krzewów. Faunę glebową (mezo- i makrofaunę) pozyskiwano poprzez ekstrakcję z prób glebowych oraz (dżdżownice) wypłaszanie z gleby roztworem formaliny. Faunę epigeiczną badano metodą biocenometryczną oraz przy użyciu pułapek Barbera. Faunę epifityczną roślinności zielnej odławiano aspirometrem, czerpakiem entomologicznym oraz do pułapek Moerickego. Czerpakowanie, pułapki Moerickego, a także otrząsanie gałęzi, stosowano również przy pobieraniu prób fauny zasiedlającej korony drzew.

Dane opracowano pod kątem zoogeograficznym i ekologicznym. W analizie zoogeograficznej uwzględniono pochodzenie fauny i zasięgi gatunków. Na analizę ekologiczną złożyły się rozważania na temat plastyczności ekologicznej fauny (eury-, poli-, oligo- i stenotopowość gatunków), preferencji środowiskowych (tereny zadrzewione, otwarte, użytki rolne itp.), związków pokarmowych (typ fagizmu, dieta, sposób pobierania pokarmu), stopnia ekspansywności (gatunki ekspansywne, stabilne, recesywne), liczebności (gatunki masowe, liczne, nieliczne itp.), oraz skłonności synantropijnych (asynantropy, hemisynantropy, synantropy).

МЕТОДИКА ИССЛЕДОВАНИЙ ГОРОДСКОЙ ФАУНЫ

РЕЗЮМЕ

Цикл работ, посвященных видовому составу и происхождению фауны Варшавы, создался главным образом на основании данных, собранных во время исследований, которые вёл Институт зоологии ПАН в Варшаве в 1974—1978 г.г. Во время исследований были применены следующие методы исследований: Экстракция фауны из почвенных проб, употребление раствора формалина, биоценометр, ловушки Барбера, аспирометр, энтомологический сачок отряхивание деревьев и кустарников, ловушки Мёрицкого.

Полученные данные были проанализированы зоогеографически и экологически. Принято во внимание: происхождение фауны, географические ареалы видов, экологическая пластичность, требования к условиям среды, пищевые взаимоотношения, экспансивность, численность и склонность к синантропизации.