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Impact of settlement pressure on communities of noctuid moths (*Lepidoptera, Noctuidae*) in linden-oak-hornbeam forests on the Mazovian Lowland

[With 2 figures and 2 tables]

Abstract. Noctuid communities in natural linden-oak-hornbeam forests reacted to increasing settlement pressure by changes in the species composition, abundance and domination structure. Weak pressure brought about a reduction in the number of species but the domination structure, characteristic of the noctuid fauna in natural habitats, was the same. In habitats under strong pressure, in urban green, there took place a complete remodelling of the domination structure connected with a change in the species composition and a reduction in the number of species and abundance.

INTRODUCTION

Settlement pressure has a vital impact on the structure of particular animal communities. It influences zoocenoses occurring the natural environment in two ways: directly by physical and chemical changes in the environment and indirectly by bringing about changes in the climate (its warming up and drying up) and in the species composition and plant production.

The structure of zoocenoses changes under the impact of settlement pressure. Increasing intensity of this factor results in a decrease in the number of animal species, but their abundance rises at first, and only in areas under very great pressure does it gradually fall (PISARSKI, TROJAN 1976a, b, c, PISARSKI 1979).

Changes due to increasing settlement pressure take a different course in different insect groups. In some of them there appears a domination system of a degradation type characterized by species impoverishment with a simultaneous increase in the abundance of one or several species. Such changes give proof that the previously existing system has been degraded by a stress factor (here: settlement pressure) and that the defensive machanisms of the system are weak (TROJAN 1980). In other groups a qualitative remodelling of communities takes place and old ones are replaced by new ones (DĄBROWSKA-PROT 1985, TROJAN 1980).

The present study is an attempt at establishing the directions of changes due to settlement pressure that occur in noctuid communities in natural linden-oak--hornbeam forests of the Mazovian Lowlands. The character and course of these

changes were studied by comparing the species composition, abundance and domination structure of noctuid moths recorded in three types of habitat: in natural habitats, in transformed ones within the suburban zone and in urban ones. The study sites marked out in these habitats could be ranked from the least affected to those most affected by settlement pressure. Since the investigations were carried out in a linden-oak-hornbeam habitat the successive links of the series were as follows: natural linden-oak-hornbeam forests of the Mazovian Lowlands, a linden-oak--hornbeam forest in a transformed suburban habitat at Białołęka Dworska and Warsaw urban green on the left bank of the Vistula, with a linden-oak-hornbeam forest as its original habitat.

Within the natural linden-oak-hornbeam forests the studies were conducted in: the Dębina reserve near Klembów, the Cyganka reserve near Truskaw in the Kampinoska Forest, the Modrzewina reserve near Belsk within the Radziejowice forest district, and King Jan III Sobieski reserve on the outskirts of the Warsaw district – Praga-Południe.

The transformed habitats included: Białołęka Dworska, a suburban part of the Warsaw district – Praga-Północ, some parks on the left bank of the Vistula: Łazienki Królewskie, the park at the Cemetery of Soviet Soldiers, the Saski Garden and the green of loosely built-up housing estates (Wierzbno, Muranów) and that of a closely built-up one (MDM).

The description of the study sites and the phytosociological characteristics of the vegetation have been given in papers by Bańkowska, Garbarczyk (1981), Kotowska, Nowakowski (1989), Kubicka et al. (1986) and Roo-Zielińska (1981).

The material was collected from 1974–1982. About 10.000 imagines of noctuid moths were collected. They were caught mainly into Moerick's traps placed in tree canopies on all the study plots, but two addition all methods of collecting imagines: luring to light and to scent bait were applied, though not systematically, in natural habitats.

The basic method (Moerick's traps) has been used by research workers of the Institute of Zoology PAS since 1974 in their studies on insect communities in natural and transformed habitats. This method is fairly successful when comparative material must be collected from several study sites at the same time (Czechowski, Mikołajczyk 1981).

The material collected was a basis for determining the species composition, abundance and domination structure of noctuid moth communities in natural and modified linden-oak-hornbeam habitats of the Mazovian Lowlands. It was also possible to determine the changes that take place within these communities under the impact of settlement pressure (Winiarska 1981, 1987 and in print).

Noctuid communities of natural linden-oak-hornbeam forests reacted to settlement pressure by changes in the species composition, abundance and domination structure.

It seems that increasing pressure induced a two-stage transformation of noctuid communities. During the first stage when the settlement pressure was weak, in

transformed suburban habitats of the linden-oak-hornbeam type at Białołęka Dworska there occurred a reduction in the number of species but the domination structure characteristic of noctuid communities in natural linden-oak-hornbeam forests was retained and the abundance increased (Fig. 1). During the second stage, in habitats under strong impact of settlement pressure, there took place a complete remodelling of the domination structure connected with a change in the species composition and a considerable reduction in the number of species, and there also was a decrease in the abundance. (Fig. 2). The maximum reduction in the number of species and in the abundance of noctuid moth communities was about 60%, with the number of species decreased by 57% and abundance by 64% (Tab. I). A decrease in the number of species during the first and second stage of remodelling of noctuid communities was by about 30% in the chain of habitats: natural linden-oak--hornbeam forests, a modified suburban linden-oak-hornbeam forest and park vegetation in the city (Tab. I).

Table I. Parameters of the community structure of noctuid moths in natural and transformed (suburban and urban) habitats
S – number of species (total and from... to), *n* – abundance index (mean and from... to), *d* – species richness (from... to)

Habitat / Parameter	Natural linden--oak-hornbeam forests	Suburban habitat	Urban habitat (parks)
S	90 (18–84)	60	38 (23–25)
n	14,4 (3,0–40,0)	23,3	5,2 (3,5–7,9)
d	3,4–82,0	12,7	8,9–12,3

Changes in the abundance had a different course. During the first stage there occurred a twofold abundance increase in noctuid communities from the transformed suburban habitat in comparison with the mean abundance of communities from the natural linden-oak-hornbeam forests. But a decrease in the mean abundance of communities in the park green in comparison with the abundance of communities from the suburban habitat by over 60% took place only during the second stage (Tab. I., Fig. 1).

Therefore there were two definite ecological zones for noctuid communities: one optimum for the species composition and the other as an optimum for the abundance (Tab. I). Similar correlations were also recorded in other insect groups e.g. *Sphecidae* and *Vespidae* (Skibińska 1986a, b).

In habitats renked according to the gradient of increasing settlement pressure the highest values of the index of species richness were recorded for the communities from the natural habitats which provided the best conditions for most species of noctuid moths (hence the optimum species richness). In the transformed suburban

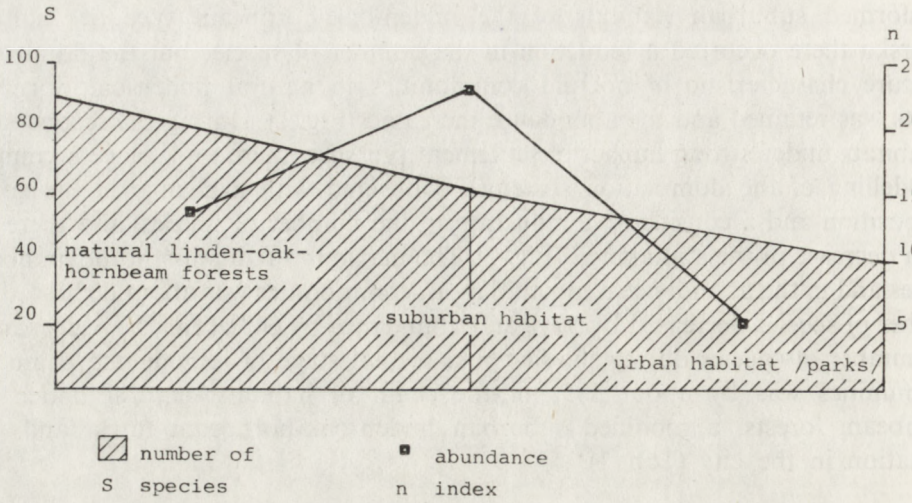

Fig. 1. Changes in the number of species and abundance of noctuid communities due to settlement pressure

and urban habitats there was a decrease in the number of species with noctuid communities connected with deteriorating habitat conditions. In this case the value of the index of species richness dropped by 50% on average (and in the most extreme cases from 82.0 to 8,9%).

The suburban habitat was an optimum zone for abundance. The abundance of noctuid communities markedly decreased only in habitats under the greatest settlement pressure (Tab. I., Fig. 1).

A decrease in the number of species within noctuid communities brought about by growing settlement pressure was followed by changes in the species composition and domination structure. These changes were the simplest homeostatic reactions of adaptation character (TROJAN 1980). By analysing the similarity of the species composition within noctuid moth communities in habitats under increasing settlement pressure it was possible to find out how adaptation mechanisms of the above type operated.

The value of the similarity index of the species composition (JACCARD-SÖRENSEN) for communities from the natural linden-oak-hornbeam forests and the modified linden-oak-hornbeam forest at Białołęka Dworska (with a 30% difference in the number of species) was 64% (Tab. II). Therefore both communities must be considered similar in respect of the species composition.

There was less distinct similarity between communities of *Noctuidae* from the transformed habitats: suburban (the linden-oak-hornbeam forest at Białołęka Dworska) and suburban (the park green). With a 40% difference in the number of species the value of the similarity index of the species composition was in this case 52.2% (Tab. II).

The degree of similarity of the species composition within communities from the habitats under extreme settlement pressure (i.e. from the natural linden-o-

ak-hornbeam forests and the park green) was below the threshold value – only 45%. In this case the difference in the number of species was 67% (Tab. II).

The impoverishment of the species composition within noctuid communities that occurred during the first stage of changes taking place in these communities under conditions of low settlement pressure was small in comparison with the fauna of the natural habitats. That was the reason for a considerable similarity of the species composition within communities from the natural linden-oak-hornbeam forests and that from the transformed linden-oak-hornbeam forest at Białołęka Dworska (Tab. II). During the second stage, in the transformed urban habitat, the adaptation mechanisms led to a considerable reduction in the number of species and fundamental changes in the species composition. Noctuid communities from the natural linden-oak-hornbeam forests and from the urban green were not similar in respect of the species composition (Tab. II).

Table II. Similarity of the species composition (JACCARD-SÖRENSEN index) of noctuid moth communities in natural, suburban and urban habitats

	Natural linden--oak-hornbeam forests	Suburban habitat	Green of the urban parks in Warsaw	number of common species
Natural linden--oak-hornbeam forests	x	49	29	
Suburban habitat	64.0	x	26	
Green of the parks in Warsaw	45.0	52.5	x	
	similarity index			

The above mentioned changes in the species composition are connected with the totally different conditions in natural habitats and in modified ones – urban habitats. Linden-oak-hornbeam forests are fairly dark and moist while urban habitats are over-dry and full of light, which is connected with an entirely different structure of the vegetation and the type of soil. Linden-oak-hornbeam forests are usually characterized by a fairly high density of trees and bushes whereas in urban green (even in parks) the degree of this density is much lower. Natural linden-oak--hornbeam forests have mainly brown soils while highly urbanized habitats have podsolized ones.

The noctuid communities recorded in the natural linden-oak-hornbeam forests consisted, first of all, of species which found optimum life and development

conditions in a habitat of that type. Growing settlement pressure eliminated stenotopic species with a low ecological amplitude and high habitat requirements, and favoured eurytopes. That is why the communities of noctuid moths in the urban habitats had a much higher percentage of eurytopic species which occur both in forest habitats and in open areas. However, the percentage of typical forest species decreased.

There is practically no natural vegetation in the city. Theoretically, parks could be a substitute for the natural forest habitat, but because of their structure and the way they are managed they differ too much from the former.

Moreover, the climate of the urban habitat is completely different from that in natural habitats and this influences the species composition of both the flora and the fauna whose stenothermal and xerophilous species find favourable conditions there.

Changes in the species composition and abundance of noctuid communities due to increasing settlement pressure were followed by a gradual transformation of the domination structure of these communities.

ODUM (1977) has stated that "all stresses result in a decrease in rare species and an increase in importance i.e. stronger domination of a few common species". This opinion was confirmed by the changes in the abundance of particular species in noctuid communities under high settlement pressure.

The transformation in the domination structure of noctuid communities accompanying an increase in settlement pressure were as follows:

	Natural linden-oak--hornbeam forests	Suburban linden-oak--hornbeam forests	Urban parks
Dominants	*C. trapezina* *T. atriplicis* *A. pyramidea* *O. cruda*	*T. atriplicis* *C. trapezina* *A. monoglypha* *A. aceris*	*A. gamma* *D. trifolii* *T. atriplicis* *A. psi*
Accessory species	*A. gamma* *D. trifolii*	*A. gamma* *D. trifolii*	*C. trapezina*

Changes in the domination structure took place in several stages. During the first stage the domination structure remained the same but the sequence of the dominant species changed. During the second there occurred a complete transformation of the domination structure.

The first stage applied to changes taking place in the noctuid communities of the suburban linden-oak-hornbeam forest (Fig. 2). The species composition of this community remained very similar to that of the fauna in the natural linden--oak-hornbeam forests but the sequence of the dominants changes. In the natural linden-oak-hornbeam forests it was: *C. trapezina – T. atriplicis – A. pyramidea,* in the linden-oak-hornbeam forest at Białołęka Dworska: *T. atriplicis – C. trapezina – A. monoglypha* (Fig. 2).

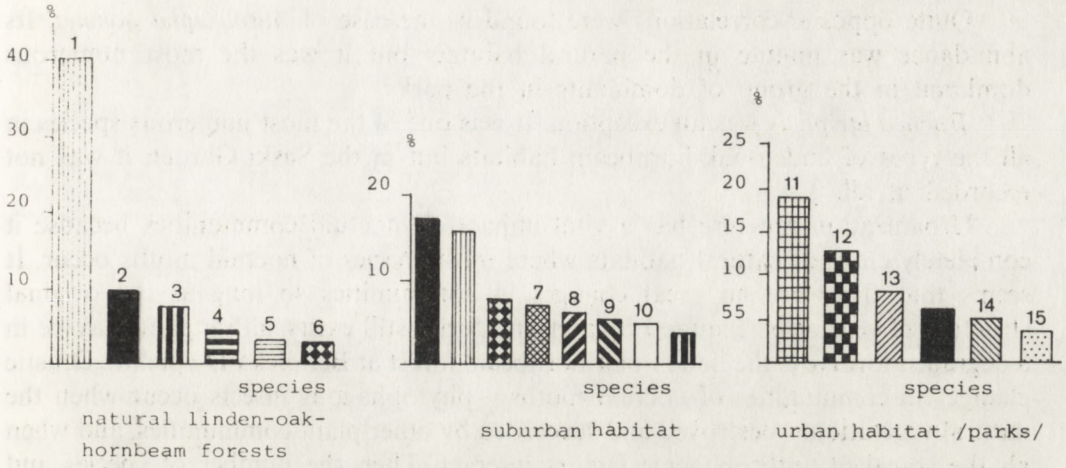

Fig. 2. Changes in the domination structure of noctuid communities due to settlement pressure
1 – *Cosmia trapezina*, 2 – *Trachea atriplicis*, 3 – *Amphipyra pyramidea*, 4 – *Orthosia cruda*, 5 – *Orthosia stabilis*, 6 – *Apamea monoglypha*, 7 – *Acronicta aceris*, 8 – *Mamestra persicariae*, 9 – *Amphipoea fucosa*, 10 – *Agrotis exclamationis*, 11 – *Autographa gamma*, 12 – *Discestra trifolii*, 13 – *Acronicta psi*, 14 – *Mythimna pallens*, 15 – *Mamestra suasa*

The second stage of changes involved transformations in the noctuid communities in the urban habitats. Not only were the species composition and abundance impoverished but there occurred a complete remodelling of the domination structure as well, and this was accompanied by a rapid increase in the abundance of those species that became the dominant ones in the urban green although they were the least numerous in the natural and suburban habitats (Fig. 2).

In the urban green, noctuid communities with a constant species composition and recurring domination structure have been present only in parks (Winiarska 1987). No communities with a stable species composition and domination structure have been recorded in other types of urban green. Only single individuals of a small number of species have been found in other types of urban green besides parks (i.e. in the green of housing estates). Several authors (Razowski, Palik 1969, Skibińska 1987, Wiśniewski 1976) have emphasized the significant role parks play in maintaining many insect groups in the urban environment.

Species dominating noctuid communities in the natural linden-oak-hornbeam forests changed their abundance in the park green so drastically that they either belonged to the group of accessary species or did not occur there at all.

Cosmia trapezina is an example of such a species; it was the dominant in noctuid communities in the natural and transformed suburban habitats. In the urban green it was recorded only in the parks. It was fairly numerous in Łazienki Królewskie but only single individuals were recorded in the Saski Garden. *C. trapezina* is a common species, but in forest habitats. That is probably the reason why it occurred in greater numbers only in Łazienki, an old big park with a stable structure of the vegetation rich in various tree and bush species.

Quite opposite correlations were found in the case of *Autographa gamma*. Its abundance was minute in the natural habitats but it was the most numerous dominant in the group of dominants in the parks.

Trachea atriplicis was an exception. It was one of the most numerous species in all the types of linden-oak-hornbeam habitats but in the Saski Garden it was not recorded at all.

Urbanization pressure has a vital impact on noctuid communities because it completely changes natural habitats where most species of noctuid moths occur. It seems that there are no great changes in communities so long as the original structure of vegetation required by a given species still exists, although it may be in a degraded form (e.g. the linden-oak-hornbeam forest at Białołęka Dworska). Drastic changes in communities of noctuid moths – phytophagous insects occur when the natural vegetation is destroyed and succeeded by other plant communities, and when all the so-called anthropogenic factors interact. Then the number of species and abundance are reduced, and the species composition and domination structure of communities are changed. Forest species are forced out by those from open areas, mono and oligotopes are succeeded by eurytopes (WINIARSKA 1981, 1987 and in print). Within urban green only parks are inhabited by noctuid communities with a stable species structure because parks provide the best habitat conditions. In housing estates and in other types of urban green no stable zoocenosis is created because the intensity of settlement pressure is the highest there. These areas are penetrated by a number of species but their presence is temporary.

Noctuid moths are very sensitive to all factors brought about either directly or indirectly by man's activity. Stable communities that still exist in urban green (namely in parks) give noctuid moths a possibility to survive in habitats transformed by man. Parks are refuges from which many species migrate to penetrate other types of urban green but in which they do not settle because there are no suitable conditions for their life and development.

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STRESZCZENIE

[Tytuł: Wpływ presji osadniczej na zgrupowania sówek (*Lepidoptera, Noctuidae*) lasów grądowych Niziny Mazowieckiej]

Zgrupowania *Noctuidae* naturalnych lasów grądowych reagowały na nasilającą się presję osadniczą zmianami w składzie gatunkowym, liczebności i strukturze dominacyjnej.

W warunkach słabej presji osadniczej, w środowisku przekształconym podmiejskim, w zgrupowaniach sówek następowała w stosunku do zgrupowań naturalnych lasów grądowych redukcja o 30% liczby gatunków, przy zachowanej strukturze dominacyjnej charakterystycznej dla fauny *Noctuidae* środowisk naturalnych (dominanty: *Cosmia trapezina, Trachea atriplicis*) oraz podwyższeniu liczebności o 50%.

W środowiskach poddanych silnemu wpływowi presji, w zieleni miejskiej, następowała całkowita przebudowa struktury dominacyjnej, związana ze zmianą składu gatunkowego i redukcją o około 60% liczebności i liczby gatunków w stosunku do zgrupowań sówek ze środowisk naturalnych. Grupę dominantów w środowisku miejskim utworzyły, przede wszystkim, te gatunki, które w naturalnych lasach grądowych były mało liczebne (np. *Autographa gamma, Discestra trifolii*).

W środowisku miejskim zgrupowania *Noctuidae* o stałym składzie gatunkowym i stabilnej strukturze dominacyjnej występowały tylko w parkach. W innych typach zieleni miejskiej wykazywano tylko pojedyncze okazy z niewielkiej liczby gatunków. Utrzymywanie się ustabilizowanych zgrupowań w parkach stwarza możliwość przetrwania sówek w środowiskach przekształconych przez działalność człowieka. Parki stanowią ostoje, z których wiele gatunków migruje, by penetrować inne typy zieleni miejskiej, ale których nie zasiedla, gdyż brak w nich odpowiednich warunków do życia i rozwoju.

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