

ANNA KUBICKA

SCARABAEIDS (*COLEOPTERA, SCARABAEIDAE*) OF WARSAW AND MAZOVIA

ABSTRACT

There were 17 scarabaeid species recorded from green urban areas of Warsaw, such as parks, housing estates, and town centre. They account for merely 19.3% of the scarabaeid fauna occurring in Mazovia. Under specific urban conditions, only the species with wide ecological amplitudes are able to survive (mainly eurytopic and polytopic), ubiquitous, or preferring open and dry areas. They belong to phytophages and coprophages that can switch their food habits to saprophagous feeding. Urban green areas are predominated by the species widely distributed (Holarctic, Palaearctic), or with smaller ranges but thermophilous (south-Euro-Siberian).

INTRODUCTION

Most data on the *Scarabaeidae* of Mazovia were collected in surroundings of Warsaw. This is a relatively small area but phytosociologically diversified to the degree which makes it possible to consider it as representative of the whole Mazovia.

Most of the faunistic data from Warsaw surroundings were collected in rather remote times by such collectors as Hildt [8—10], Tenenbaum [58—64], Makólski, Mączyński, Bartoszyński, and Cizkiewicz [4], Łomnicki [23], and others [12, 21, 29, 49, 66]. Valuable information on scarabaeids is contained in papers by Stebnicka [50—53]. Also the papers by Goljan [7] and Pawłowski [34] should be noted here in addition to other data, as they provide information on the occurrence of scarabaeids in Mazovia. Many materials on the occurrence of phytophagous scarabaeids in Mazovia were collected during the interwar period by stations of plant protection, on the occasion of studies on the distribution and control of most important pests [16—20, 26—28, 36—44, 46, 47, 54]. Now the works of this type are also conducted by agricultural and forest research centres [2, 3, 6, 13—15, 22, 25, 31—33, 35, 45, 48, 55, 56]. Occasionally, important information is given by authors dealing with beetles of other families [1, 57].

The present contribution is concentrated upon comparison of the scarabaeid fauna in Warsaw and in non-urban habitats of Mazovia, in order to recognize some trends in the changes of composition of this family in the areas subjected to urban pressure. The literature data were used, and the materials collected in 1974—1977 at the Institute of Zoology PAS in Warsaw, as well as the materials collected earlier but unpublished so far, available in the collection of this Institute¹.

In many cases, concerning particularly the data from the first half of the 20th century, the areas of past studies, covered at the time with crops and forests, are now located within the boundaries of Warsaw and completely transformed. These transformations are taken into account by including some localities and quarters of the town into the habitats of different categories in various periods.

Major premises, characteristics of the study sites, and methods of sampling have already been published elsewhere [5, 24, 30, 65].

SPECIES COMPOSITION OF THE *SCARABAEIDAE* OF MAZOVIA AND WARSAW

There are 167 scarabaeid species recorded from Poland up to the present, but the occurrence of only 148 species is not dubious; an analysis of the geographical distribution of the remaining species shows that their occurrence in Poland is little probable [50, 52, 53]. They might have been wrongly identified or wrongly labelled. As their specimens are not preserved, it is impossible to decide this doubt.

There are 103 scarabaeid species of 13 subfamilies known from Mazovia (Tab. 7), but only 88 species are present here without any doubt; the occurrence of the other species has not been confirmed. In this relation, the following species recorded from Mazovia many years ago, will not be considered in the present paper:

Bolbelasmus unicornis. A Pannonian species, very rare anywhere. The only information on its occurrence in Mazovia is given by Hildt [9] on the basis of a personal communication by Waga. All other data on the occurrence of this species in Poland come from southern part of the country.

Aegialia sabuleti. A boreal-mountain species. A saprophage living along banks of running waters, particularly mountain streams, from which it reaches the region of Warsaw along the Vistula river. The habitat conditions of the Mazovian Lowland, however, are not suitable for its reproduction, thus it cannot be considered as a permanent component of the fauna of this region [52].

¹ Data on the *Scarabaeidae* of Mazovia based on older materials have been brought up to date by Z. Stebnicka. I wish to express my gratitude for her comprehensive and kind assistance. Grateful acknowledgements are extended to Dr B. Burakowski and Prof. M. Mroczkowski for making their catalogue of the literature available.

Onthophagus furcatus. Common in southern Europe, in Poland known from the region of Zamość, Hrubieszów, and from Silesia. Recorded from Saska Kępa near Warsaw by Hildt [9]. It belongs to the species of the group *Onthophagus ovatus* (L.), which are difficult to distinguish. According to Stebnicka [51] the specimens collected in the region of Warsaw were wrongly identified.

Codocera ferruginea. A south-Euro-Siberian species. The stands nearest to Poland are known from Podole and Slovakia, thus the occurrence of this species at Miłosna near Warsaw, as reported by Hildt [10], is not certain [51].

Ochodaeus chrysoloides. This species does not occur in Mazovia. In they key by Stebnicka [51] there is an erroneous information on its being "known from... the region of Warsaw". These data refer to *Codocera ferruginea* (Stebnicka, personal communication).

Aphodius circumcinctus. A Pontic-Pannonian species; the nearest unquestionable stand occurs in Czechoslovakia. Recorded from Bielany near Warsaw by Łomnicki [23]. Belongs to the subgenus *Melinopterus* Muls. which is one of the most difficult to distinguish within the genus *Aphodius* Ill. The data on its occurrence near Warsaw are probably an effect of its erroneous identification [50, 51].

Aphodius tomentosus. The only information on its occurrence in the region of Warsaw is known from 1801 [12]. Afterwards it has never been recorded from Mazovia.

Aphodius quadrimaculatus. Occurs in western, central, and southern Europe. Hild [9] reports that one specimen was found in Zwierzyniec garden at Skierniewice in 1901 by Hornziel. Afterwards it has not been recorded from Mazovia.

Not only in Mazovia but also in the whole country the family *Scarabaeidae* shows recessive tendencies related to environmental changes caused by man's activity. Even the species considered as very common and numerous, like for example *Anomala dubia*, *Melolontha melolontha*, and *Cetonia aurata*, now are rarer and more local, and many species of a smaller range of ecological tolerance (thermophilous, associated with xerothermal or steppe regions) probably disappeared, or became extremely rare in the Mazovian Lowland. These are *Onthophagus gibbulus* (now occurring in the Lublin region), *O. vacca*, *Aphodius satellitius* (recently recorded from the region of Hrubieszów), *A. luridus* (now occurring in mountains and foothills), *A. depressus* (like the preceding species), *A. lividus*, and *A. lugens* (51, Stebnicka, personal communication). *A. luridus* and *A. depressus* were collected in many sites near Warsaw and rather abundantly, on the turn of the 1940s and 1950s (collection of the Institute of Zoology PAS). All the species quoted above will not be considered in this paper.

In addition, it has been accepted that *Onthophagus joannae*, the species recorded from Plac Broni (a suburb of Warsaw), occurs in Mazovia, since

its numerous although isolated stands are known from the whole lowland. *Potosia metallica*, the species caught in non-urban biotopes and in parks during the recent studies conducted at the Institute of Zoology PAS, is certainly present in the suburbs. It has also been accepted that *Aphodius consputus*, the species recorded only once in 1895 by Hildt in Hoża street in Warsaw 9, does not occur in streetside lawns.

Within the present administrative boundaries of Warsaw, 68 species were recorded. They account for 77.3% of the *Scarabaeidae* of Mazovia. The same number of species occurs in suburban areas. The number of species rapidly drops in urban areas, merely 17 species being recorded there (19.3% of the *Scarabaeidae* of Mazovia, and 25% of those of Warsaw) (Tab. 7). As many as 12 of these species were caught during the studies at the Institute of Zoology PAS in 1974–1977, the other were recorded on the basis of literature data and earlier materials found in the collection of the Institute. Parks were inhabited by 15 species, this accounting for 88.2% of the scarabaeids of the urban green areas, 22.1% of those of Warsaw, and 17.1% of the scarabaeids of Mazovia. Green areas of housing estates were inhabited by 5 species (29.4% of the scarabaeids of urban green areas, 7.3% of those of Warsaw, and 5.7% of the scarabaeids of Mazovia). Streetside lawns in the centre of the town were inhabited by 6 species, the corresponding proportions of the scarabaeids of urban green areas, Warsaw, and Mazovia, being 35.3, 8.8 and 6.8%.

The most common and most numerous species in Warsaw are *Rhizotrogus solstitialis* and *Serica brunnea*. They can be met in urban lawns of all types — in parks, housing estates, and in the centre of the town. In parks, the most numerous species is *Hoplia graminicola*, while in housing estates and in the centre *Rhizotrogus solstitialis*. These three species are also common and numerous beyond the boundaries of the town.

Among 12 rare species recorded from the Mazovian Lowland (*Aegialia rufa*, *Aphodius bimaculatus*, *A. scrofa*, *A. pictus*, *A. contaminatus*, *A. sabulicola*, *A. consputus*, *A. reyi*, *A. niger*, *A. borealis*, *Gnorimus octopunctatus*, and *Potosia aeruginosa*), only one, *Aphodius scrofa*, occurs in Warsaw. It has been caught in a lawn of the housing estate Wierzbno (6–20 May, 1975, Barber's pitfall traps).

Parks and housing estates are inhabited by species occurring in all types of green areas, and also by the species characteristic of these two habitats, and not occurring elsewhere. In parks these are *Onthophagus coenobita*, *O. nuchicornis*, *Aphodius prodromus*, *A. merdarius*, *A. granarius*, *Phyllopertha horticola*, *Hoplia graminicola*, and *Potosia metallica*. They account for 53.3% of all the scarabaeid species occurring in parks. To the species living exclusively in housing estates belong *Geotrupes spiniger* and *Aphodius scrofa* (40% of the total number of species occurring there). All the species recorded from the centre of the town were also captured in green areas of other types. This may suggest that the set of species in the centre of Warsaw

is largely casual and depends on the contact with the fauna of more autonomic green areas in parks and housing estates.

ZOOGEOGRAPHICAL ANALYSIS

Because of extreme differences in the way of life between *Scarabaeidae pleurosticti* (phytophages) and *Scarabaeidae laparosticti* (copro- and saprophages), and the related differences in the history of the establishment of their ranges, each of these two groups will be considered separately.

Using the criteria established by the Centre of Faunistic Documentation [30], the following geographical elements were distinguished in the *Scarabaeidae laparosticti* of Mazovia: cosmopolitan, Holarctic, Palaeartic, Euro-Siberian, south-Euro-Siberian, subpontic, submediterranean and European (Tab. 1).

All the Holarctic species, except for *Aphodius rufipes*, were casually brought to North America. Originally, they were either Palaeartic species (*Onthophagus nuchicornis*, *Oxyomus silvestris*, *Aphodius subterraneus*, *A. erraticus*, *A. haemorrhoidalis*, *A. fimetarius*), or Euro-Siberian (*Aphodius fossor*, *A. prodromus*). *Aphodius granarius*, native also to Palaeartic, is now a cosmopolitan species. Among the 16 Palaeartic species recorded from Mazovia, only three occur through the Palaeartic region. The other are either west-Palaeartic (8 species) or north-Palaeartic (5 species). Similarly, two out of the four Euro-Siberian species (*Geotrupes stercorarius* and *Diasticus vulneratus*) occur in Europe and in western part of Siberia. Among the submediterranean species, only three have the ranges covering this whole region (*Aphodius contaminatus*, *A. foetidus*, and *A. ictericus*), while the other three (*A. pictus*, *A. consputus*, and *A. immundus*) are usually considered as subpontic-mediterranean as their range extends to the Black Sea and even further eastwards.

The scarabaeids of Mazovia are dominated by the Palaeartic element (22.7%) and south-Euro-Siberian element (21.1%). Also the Holarctic (13.6%), European (10.7%) and submediterranean species (9.2%) are rather numerous. The other elements, together with the species of unknown ranges, account for 22.6% of all the scarabaeids of the group *laparosticti*, recorded from Mazovia.

Not all geographical elements recorded from the Mazovian Lowland can also be found in the green areas of Warsaw. The west-Palaeartic, submediterranean, subpontic and the majority of European species are lacking there. Also the proportions between the elements occurring in urban green areas are changed. The proportion of Holarctic, Euro-Siberian, and south-Euro-Siberian species increased, while the proportion of Palaeartic species decreased as compared with their proportion in Mazovia. If, however, all species with large ranges (cosmopolitan, Holarctic, Palaeartic) are considered as one group united by their common origin from the Palaeartic region, it

will be readily seen that their proportion increased in urban areas (particularly in parks where it reaches 50%) as compared with natural habitats. In parks 6 zoogeographical elements were recorded (Tab. 1), while in green areas of housing estates and in the centre of the town where the habitat is most transformed, only three elements occurred: Palaearctic, Holarctic, and south-Euro-Siberian.

Tab. 1. Proportions of zoogeographical elements in scarabaeids of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Zoogeographical element		Mazovia		Warsaw									
				Suburbs		Urban green areas							
						Total		Parks		Housing estates		Town centre	
						N	%	N	%	N	%	N	%
Laparosticti	Cosmopolitan	1	1.5	1	2.0	1	10.0	1	12.5	—	—	—	—
	Holarctic	9	13.6	9	17.6	3	30.0	3	37.5	—	—	1	50.0
	Palaearctic	15	22.7	15	29.4	1	10.0	1	12.5	1	33.3	—	—
	Euro-Siberian	4	6.0	2	3.9	—	—	—	—	—	—	—	—
	South-Euro-Siberian	14	21.1	10	19.6	4	40.0	2	25.0	2	66.7	1	50.0
	Subpontic	2	3.0	2	3.9	—	—	—	—	—	—	—	—
	Submediterranean	6	9.2	3	5.9	—	—	—	—	—	—	—	—
	European	7	10.7	3	5.9	1	10.0	1	12.5	—	—	—	—
	Unknown	8	12.1	6	11.8	—	—	—	—	—	—	—	—
Pleurosticti	Palaearctic	7	31.8	7	41.2	5	71.4	5	71.4	2	100.0	4	100.0
	Euro-Siberian	4	18.2	2	11.8	1	14.3	1	14.3	—	—	—	—
	Subpontic	1	4.5	—	—	—	—	—	—	—	—	—	—
	European	8	36.4	7	41.2	1	14.3	1	14.3	—	—	—	—
	Unknown	2	9.1	1	5.8	—	—	—	—	—	—	—	—

The species with other ranges than that discussed above are so sparse that the attempts to interpret their proportions in particular habitat types could yield erroneous conclusions. This is particularly the case of housing estates and the town centre, both being extremely unsuitable habitats for scarabaeids, where most of the few species are only a casual element.

The species of the group *Scarabaeidae pleurosticti* occurring in Mazovia, represent only four geographical elements: Palaearctic, Euro-Siberian, subpontic, and European.

The occurrence of 4 out of 7 Palaearctic species is limited to the northern part of the Palaearctic region. These are *Maladera holosericea*, *Phyllopertha horticola*, *Rhizotrogus solstitialis*, and *Cetonia aurata*. Such species as *Osmoderma eremita* and *Potosia metallica*, known from southern and central Europe, are considered here as European elements.

Most numerous in Mazovia are Palaearctic species (32.8%) and European species (36.4%). The other species, together with those of unknown ranges, account for 31.8% of all the species recorded from non-urban habitats.

There were large differences in the zoogeographical composition of scarabaeids between Warsaw and non-urban habitats. The two south-European species mentioned above, and a subpontic species, *Anisoplia segetum*, do not occur in the town. The proportion of Palaearctic species considerably increased in the town. In lawns of housing estates and in the centre, only the species of this range were found. The occurrence of an Euro-Siberian species, *Potosia metallica*, and an eastern-central-European species, *Hoplia graminicola*, is restricted to parks.

The number of zoogeographical elements in *Scarabaeidae laparosticti* and *pleurosticti* dropped with increasing urban pressure. There were 6 zoogeographical elements in parks, and only 3 in housing estates and in the centre of the town, the latter group involving most common elements inhabiting Mazovia: Holarctic, Palaearctic, and south-Euro-Siberian.

ECOLOGICAL ANALYSIS

HABITAT PREFERENCE AND ECOLOGICAL AMPLITUDE

Scarabaeids are an ecologically diversified family of the beetles. The most important factors influencing their occurrence in specified biotopes are climatic conditions, vegetation type (density, dominance of herbaceous or wooded plants), food supply, and type of soil.

Since the larvae of many scarabaeids live in soil, its properties can decide on the occurrence or absence of particular species. Agricultural treatments, industry, the development of motor transport, all these factors contribute to deep changes in the structure, chemical composition and reaction of soil of urban lawns, which is in turn reflected in the composition of the fauna living there. As an example, mass occurrence of *Rhizotrogus solstitialis* larvae can be reported in these habitats. In some years they reach a density of 40 individuals/m² in green areas along street sides. This species is little susceptible to changes occurring in soil with sodium and calcium chloride added in winter to clear a street of snow. It also occurs in natural saline soils. In lawns of other types, as well as in meadows and pastures, this species is less numerous (generally from zero to several individuals per m²).

Field observations carried out by Goljan [7] show that also adult beetles can largely depend on the type of soil. He describes the distribution of two species of the genus *Aphodius* Ill. in a meadow. *Aphodius sphacelatus* was very numerous in sites with moist acid clay soil, and only occasionally occurred in higher sites, on drier sandy soil, where the other species, *Aphodius satellitius*, was numerous. Similarly, *Onthophagus taurus* selected sandy sites covered with sparse vegetation, while the occurrence of *Onthophagus vacca* was associated with loam soils.

The density of herbaceous plants and trees, as well as humidity, greatly influence the occurrence of scarabaeid species. (Tab. 2).

Tab. 2. Proportions of groups with different habitat preferences in scarabaeids of Warsaw and non-urban habitats of Mazovia (N — number of species)

Group		Mazovia		Warsaw									
				Suburbs		Urban green areas							
						Total		Parks		Housing estates		Town centre	
N	%	N	%	N	%	N	%	N	%	N	%		
Living in forest	Total	25	28.4	15	22.1	3	17.7	3	20.0	—	—	1	16.7
	Hygrophilous	3	3.4	1	1.5	—	—	—	—	—	—	—	—
	Xerophilous	7	8.0	3	4.4	2	11.8	2	13.3	—	—	1	16.7
	Largely tolerant	9	10.2	7	10.3	1	5.9	1	6.7	—	—	—	—
	Unknown	6	6.8	4	5.9	—	—	—	—	—	—	—	—
Living in open areas	Total	44	50.0	36	52.9	9	53.0	7	46.7	3	60.0	2	33.3
	Hygrophilous	1	1.1	1	1.5	—	—	—	—	—	—	—	—
	Xerophilous	34	38.6	26	38.2	6	35.3	4	26.7	3	60.0	1	16.7
	Largely tolerant	7	8.0	7	10.3	3	17.7	3	20.0	—	—	1	16.7
	Unknown	2	2.3	2	2.9	—	—	—	—	—	—	—	—
Ubiquitous		11	12.5	11	16.2	5	29.3	5	33.3	2	40.0	3	55.6
Unknown		8	9.1	6	8.8	—	—	—	—	—	—	—	—

A half of the species occurring in Mazovia are associated with various types of open areas, and most of the species of this category prefer dry sites. Only one species, *Aphodius sphacelatus* inhabits moist meadows [7].

Most of the species occurring in urban green areas originate from open areas of the type of meadows and pastures. The proportion of the species associated with open areas has reached there 53% which is a little more than in Mazovia. Most of them belong to xerophilous species; they even occur, as the only group, in most transformed urban areas such as lawns of housing estates and town centre. Hygrophilous species, instead, do not invade the town.

Forest species (here the species inhabiting various types of forests, clearings and nurseries being included) accounted for 28.4% of all scarabaeids inhabiting Mazovia. Most of them are highly tolerant of humidity (10.2%); they can be met in both bog pine forests and moist forests, e.g., *Geotrupes stercorosus*, or *Potosia metallica* [34]. There are also species associated exclusively with wet habitats, such as *Aphodius plagiatus*, *A. niger* [51], or with dry habitats, e.g., *Geotrupes vernalis* [51], *Onthophagus coenobita*, and *Aphodius sticticus*.

Only one forest species, *Onthophagus coenobita*, can be found in parks of Warsaw. It occurs on dry sandy soils. *Oryctes nasicornis* (included to the group of forest xerophilous species in Tab. 2) lives in old broad-leaved forests, on dry and warm sites. Young stages feed on decaying wood of dead fallen trees [51]. In Warsaw and Mazovia where such environmental conditions do not exist, it becomes a synanthropic species; its larvae can

live in heaps of sawmill wastes, in tanneries, etc. Some specimens were even caught in the centre of the town.

It is characteristic of the town that, at an almost unchanged proportion of the species associated with open areas and almost complete disappearance of forest species, the proportion of ubiquitous species, little sensitive to changes in environmental conditions, increased. They contributed to 12.5% of the species occurring in Mazovia and to 29.3% of those inhabiting urban green areas. The proportion of ubiquitous species increased with urban pressure (Tab. 2). In the centre of the town it reached 55.6%.

Thus, only a few ecological groups can invade towns. In Mazovia 7 different ecological groups of scarabaeids were recorded, while only 4 in the urban parks and 2 in the housing estates, the latter being ubiquitous species or those associated with dry open areas. In addition, in the centre there was found one species characteristic of open terrains and little susceptible to changes in humidity.

Taking into account the susceptibility of particular species to the set of environmental factors quoted above (where it was possible, also others were considered), the following categories of species were distinguished: eurytopic, polytopic, oligotopic, and stenotopic [5]. In Mazovia 55.6% of the species covered a wide spectrum of habitats (polytopic and eurytopic species). Their proportion in the fauna increased with urban pressure (Tab. 3). They accounted for 93.3% in the parks, and for 100% in housing estates and in the centre (the synanthropic species, *Oryctes nasicornis*, is disregarded here as it is included to oligotopic species). The stenotopic species did not occur in the town at all. Thus, the wider the range of habitats occupied by a species, the higher is the possibility of its successful establishment in the town.

Young stages of scarabaeids occur in three various environments. Soil is inhabited by phytophagous species of the subfamilies *Sericinae*, *Rutelinae*, *Melolonthinae*, and *Hopliinae*, as well as by coprophages of the subfamilies

Tab. 3. Proportions of groups with different ecological amplitudes in scarabaeids of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Group	Warsaw											
	Mazovia				Urban green areas							
	Suburbs				Total		Parks		Housing estates		Town centre	
	N	%	N	%	N	%	N	%	N	%	N	%
Eurotypic	11	12.5	11	16.3	5	29.4	5	33.3	2	40.0	3	50.0
Polytopic	39	44.3	31	45.6	11	64.7	9	60.0	3	60.0	2	33.3
Oligotopic	20	22.7	12	17.6	1	5.9	1	6.7	—	—	1	16.7
Stenotopic	2	2.3	2	2.9	—	—	—	—	—	—	—	—
Unknown	16	18.2	12	17.6	—	—	—	—	—	—	—	—

Coprinae and *Geotrupinae*, the larval development of which occurs in nests burrowed by parent individuals. The larvae of *Aphodiinae*, living in faeces on the soil surface, should be classified into epigeal species. The larvae of the subfamilies *Valginae*, *Trichiinae*, and *Cetoniinae*, living on decaying wood, cannot be classified to any of the habitat layers. The occurrence of scarabaeids in a particular biocoenotic layer is firstly related to the possibility of finding food in it. For example, an increase in the proportion of the species the young stages of which live in soil in Warsaw as compared with Mazovia, results from the fact that phytophagous species predominate under urban conditions (Tab. 4). Adult beetles of this family are very mobile and they move freely from one plant layer to another, they can also bury themselves in litter or soil.

Tab. 4. Proportions of groups dwelling in different kind of substratum in larval scarabaeids of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Group dwelling in	Mazovia		Warsaw									
			Suburbs		Urban green areas							
	Total				Parks		Housing estates		Town centre			
			N	%							N	%
Soil	29	33.0	24	35.3	8	47.1	7	46.7	3	60.0	3	50.0
Faeces	50	56.8	36	52.9	7	41.2	6	40.0	2	40.0	2	33.3
Decaying wood	9	10.2	8	11.8	2	11.8	2	13.3	—	—	1	16.7

FOOD HABITS

The beetles of the family *Scarabaeidae* are phytophages, coprophages, and (few) saprophages. Some coprophages can additionally live on carrion of vertebrate animals or on decaying plant remains. Adult phytophages feed on leaves, flowers, or fruit. Their larvae are rhizophages or feed on decaying wood. In addition, many phytophages as well as representatives of the subfamilies *Coprinae* and *Geotrupinae* lick the sap of injured trees [51].

In natural biotopes of Mazovia, the phytophagous species accounted for one-fourth of all the species recorded there (Tab. 5). If they are sufficiently tolerant of various factors of the transformed urban habitat, they can readily colonize urban green areas. An additional facilitation here is that they are not closely associated with particular species of host plants. For this reason the proportion of phytophages increased from 25% in Mazovia to 41.2% in urban green areas. Instead, many coprophages cannot find suitable food in the town, and for this reason they cannot occur in this habitat. Coprophages predominated in Mazovia (64.8%), while in the urban green areas their proportion dropped (52.9%). Also within urban green areas the proportion of coprophagous species decreased with urban pressure. It was 46.7% in parks, 40% in lawns of housing estates, and 33.3% in the centre

Tab. 5. Proportions of trophic groups in scarabaeids of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Group	Mazovia		Warsaw									
			Suburbs		Urban green areas							
	Total				Parks		Housing estates		Town centre			
N	%	N	%	N	%	N	%	N	%	N	%	
Coprophages	57	64.8	46	67.6	9	52.9	7	46.7	2	40.0	2	33.3
Saprophages	9	10.2	5	7.4	1	5.9	1	6.6	1	20.0	—	—
Phytophages	22	25.0	17	25.0	7	41.2	7	46.7	2	40.0	4	66.7

of the town. Among 9 saprophagous species occurring in Mazovia and accounting there for 10.2% of the total fauna, only one species, *Rhyssmus germanus*, was found in urban areas — in parks and lawns of housing estates.

The successful establishment of a coprophagous species in urban areas depends on the degree of its food specialization (Tab. 6). Among coprophages occurring in Mazovia, 7 species have a narrow food spectrum. These are species living on faeces of deers, cows, or horses. In non-urban biotopes they accounted for 12.3%, while in the town they did not occur at all. The coprophagous scarabaeids of Mazovia are dominated by the species living on faeces of herbivorous mammals (45.6%). Among them, only *Onthophagus nuchicornis* and *Aphodius granarius* were found in the town. From the group of species feeding on faeces of herbivorous mammals and others (omnivorous and predatory), which comprises 15.8% of the scarabaeids in non-urban habitats, only one species, *Aphodius scrofa*, was recorded from Warsaw, in green areas of housing estates.

In contrast to these three groups, the coprophages, the diet of which is not restricted to faeces (they can also live on dead animals, plants, and on

Tab. 6. Proportions of groups with different degree of food specialization in coprophagous scarabaeids of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Source of faeces	Mazovia		Warsaw									
			Suburbs		Urban green areas							
	Total				Parks		Housing estates		Town centre			
N	%	N	%	N	%	N	%	N	%	N	%	
Single family of herbivorous mammals	7	12.3	4	18.7	—	—	—	—	—	—	—	—
Various herbivorous mammals	26	45.6	22	47.8	2	22.2	2	28.6	—	—	—	—
Various mammals	9	15.8	7	15.2	1	11.1	—	—	1	50.0	—	—
Mammals and other sources	15	26.3	15	32.6	6	66.7	5	71.4	1	50.0	2	100.0

fungi), tend to increase their proportion in urban areas as compared with Mazovia. In non-urban areas they accounted for 26.3% of the total scarabaeid fauna, while in the urban green areas for 66.7% in the centre of the town only this group of coprophages occurred (Tab. 6).

To sum up, the species with broad diet can easily change the substrate used as food, which favours them in colonizing urban habitats.

CONCLUSIONS

Mazovia is inhabited by 88 scarabaeid species, this being about 60% of the scarabaeid fauna in Poland. Most of them have also been recorded from suburban areas of Warsaw. However, in urban habitats such as parks, green areas of housing estates, and town centre, the number of scarabaeid species dropped to 17, this being merely 19.3% of the scarabaeid fauna in Mazovia.

The simplification of the species composition was accompanied by changes in the proportions of various zoogeographical and ecological elements. The scarabaeids of urban green areas consisted of cosmopolitan, Holarctic, Palaearctic, Euro-Siberian, south-Euro-Siberian, and European elements. All of them were represented in parks, while the areas subjected to the heaviest urban pressure were inhabited only to Holarctic, Palaearctic, and south-Euro-Siberian species. These three elements also predominated the scarabaeids of all urban green areas; they were richest in species in non-urban habitats as well.

A large range is usually combined with a high ecological tolerance of a species. The percentage of such species (eurytopic and polytopic) is very high in Warsaw. South-Euro-Siberian species have a smaller geographical range but they are thermophilous. They accounted for 21.1% of the scarabaeids of urban green areas, which lets us suppose that they found rather suitable habitat conditions in the town.

The species colonizing urban green areas originate mostly in open habitats and they are xerophilous, or tolerant of both low and high humidity. These are mainly phytophagous species, but not associated with specified plant species; their larvae develop in soil which protects them to some extent from pollution. Among coprophages, only the species which can also switch their diet to saprophagous one, occur in larger amounts in urban green areas.

Habitat conditions in the town differ so much from those in non-urban habitats that even some eurytopic species are unable to live there (in Mazovia there are 10 eurytopic species while only 5 in the urban green areas). This is probably related to pollution with chemicals, characteristic of urban habitats. The only species of the family *Scarabaeidae* reaching high numbers in Warsaw, *Rhizotrogus solstitialis*, is extremely tolerant of soil pollution. Also *Hoplia graminicola* and *Serica brunnea* are frequently met.

Such processes associated with urbanization as changes in climate and plant cover, as well as high concentrations of toxic chemicals in the air and soil, account for the fact that urban green areas can be inhabited only by few species, highly tolerant of environmental effects or specifically adapted to these peculiar conditions.

NEW STANDS OF RARER AND LOCAL SPECIES

Four species of scarabaeids, classified in Table 7 as occurring in Mazovia, have no literature records from this region. In the collection of the Institute of Zoology PAS there are specimens of these species, originating from the following localities:

Rhizotrogus ruficornis (Fabr.).

Skolimów, 29 May, 1937 (ex coll. Sz. Tenenbaum).

Hoplia graminicola (Fabr.).

Czarna Struga, 29 May, 1920, 4 July, 1927; Grodzisk Maz., 9 June, 1924, 25 June, 1933; Chojnów, 4 June, 1932; Komorów, 20 May, 1934; Wilanów, 13 July, 1937; Dembe Wielkie (ex coll. Sz. Tenenbaum); Warsaw-Saska Kępa, 16 June, 1923; Gliniak (near Mińsk Mazowiecki), 29 June, 1923; Dęblin, 10 July, 1925 (ex coll. H. Ciszewicz).

Hoplia philanthus (Füessly).

Dęblin, June, 1910; Bielany (ex coll. Sz. Tenenbaum); Dęblin, 21 June, 1925 (ex coll. H. Ciszewicz).

Gnorimus octopunctatus (Fabr.).

Otwock, 8 June, 1889 (ex coll. Sz. Tenenbaum).

Most of the species occurring in urban green areas of Warsaw have been recorded during the studies conducted in 1974—1977. The following of these species were found in Warsaw for the first time:

Onthophagus coenobita (Herbst).

Park of Culture, 11—30 May, 1977; grassy slope of the Vistula escarpment. Other specimens recently captured or present in the collection of the Institute of Zoology PAS, originate from non-urban habitats or from suburbs.

Trichonotulus scrofa (Fabr.).

Wierzbno, 6—20 May, 1975; lawn in the housing estate.

Valgus hemipterus (L.).

Rakowiec, April, 1977; boundary of the housing estate and allotments, in a decaying branch of a plum tree, leg. E. Nowakowski.

Potosia metallica (Herbst.).

Praga park, 15 May, 1975. In addition, in the collection of the Institute of Zoology PAS there is one specimen labelled: Warsaw, 12 September, 1908 (ex coll. Sz. Tenenbaum).

Hoplia graminicola (Fabr.).

The species considered as "sparse and local", occurring "late in the springs on sandy stands near water" [53], during the study of 1974—1977 many specimens were captured by means of Barber's pitfall traps in the following sites:

Parks: Saxon Garden, 16—30 July, 1974 (1 specimen), 7—21 June, 1975 (10 specimens), 2—16 July, 1976 (1 specimen), 13—27 June, 1977 (17 specimens); Łazienki, 9—23 July, 1974 (1 specimen), 5—19 June, 1975 (59 specimens), 1—15 June, 1976 (4 specimens), 11—25 June, 1977 (120 specimens); park at Gdańska street — slope covered with shrubs, 8—23 June, 1977 (6 specimens); AWF, Bielany, a lawn, 12—27 April, 1977 (2 specimens), 14—28 June, 1977 (120 specimens).

Suburbs: Arkadia, escarpment slope covered with shrubs and trees, adjoining large wasteland and allotments, 7—23 June, 1977 (16 specimens); Bielany, a carr, 14—28 June, 1977 (2 specimens); SGGW, Ursynów, a lawn, 6—18 July, 1974 (1 specimen), 9—23 June, 1975 (17 specimens); Białołęka, birch wood, 3—17 June, 1977 (1 specimen).

Representatives of this species were also found beyond the boundaries of Warsaw: Radziejowice, lawn in a rural park, 13—27 May, 1977 (3 specimens); 1—16 June, 1977 (76 specimens); Łomna, a lawn, 8—28 July, 1976 (1 specimen); Kampinos Forest, mixed forest, 8—27 July, 1976 (3 specimens).

Most of these stands are open areas with single trees or shrubs. *Hoplia graminicola* is most abundant in habitats of this type, though single specimens can be found in more wooded areas and even in forests. Almost all stands were located near small water bodies (at a distance from about 10 to several ten metres). The only exception here was the lawn of AWF (Bielany), very dry, without water bodies.

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

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(Continued on p. 161).

Tab. 7. Check list of *Scarabaeidae* species occurring in Warsaw and Mazovia¹

No.	○ — literature data ● — proved literature data + — unpublished data ? — doubtful information	Species	Mazovia	Warsaw				
				suburban areas	parks	green areas in housing estates	town centre	other sampling areas
1		2	3	4	5	6	7	8
		<i>Scarabaeidae laparosticti</i> :						
1		<i>Oniticellus fulvus</i> (Goeze)	●	+	-	-	-	-
2		<i>Copris lunaris</i> (L.)	●	+	-	-	-	-
3		<i>Caccobius schreberi</i> (L.)	●	+	-	-	-	-
4		<i>Onthophagus taurus</i> (Schreb.)	●	+	-	-	-	-
5		<i>Onthophagus ovatus</i> (L.)	●	○	-	-	-	-
6		<i>Onthophagus joannae</i> Golj.	-	●	-	-	-	-
—		<i>Onthophagus furcatus</i> (Fabr.)	?	?	-	-	-	-
7		<i>Onthophagus gibbulus</i> (Pall.)	●	+	-	-	-	-
8		<i>Onthophagus coenobita</i> (Hbst)	●	+	+	-	-	-
9		<i>Onthophagus fracticornis</i> (Preyss.)	●	+	-	-	-	-
10		<i>Onthophagus similis</i> (Scr.)	●	○	-	-	-	-
11		<i>Onthophagus nuchicornis</i> (L.)	●	+	+	-	-	-
12		<i>Onthophagus vacca</i> (L.)	●	●	-	-	-	-
—		<i>Codocera ferruginea</i> Eschsch.	?	-	-	-	-	-
—		<i>Ochodaeus chrysomeloides</i> (Schr.)	?	-	-	-	-	-
13		<i>Geotrupes (Geotrupes) mutator</i> Marsh.	●	●	-	-	-	-
14		<i>Geotrupes (Geotrupes) stercorarius</i> (L.)	●	+	-	-	-	-
15		<i>Geotrupes (Geotrupes) spiniger</i> Marsh.	●	+	-	+	-	-
16		<i>Geotrupes (Anoplotrupes) stercorosus</i> (Scr.)	●	●	-	-	-	-
17		<i>Geotrupes (Trypocopris) vernalis</i> (L.)	●	-	-	-	-	-
18		<i>Odontaeus armiger</i> (Scop.)	●	●	-	-	-	+
—		<i>Bolbelasmus unicornis</i> (Schr.)	-	?	-	-	-	-
19		<i>Aegialia (Rhysothorax) rufa</i> (Fabr.)	○	-	-	-	-	-
20		<i>Aegialia (Psammoporos) sabuleti</i> (Panz.)	●	-	-	-	-	-
21		<i>Oxyomus silvestris</i> (Scop.)	●	+	+	-	+	-
22		<i>Aphodius (Coloboaterus) subterraneus</i> (L.)	●	+	-	-	-	-
23		<i>Aphodius (Coloboaterus) erraticus</i> (L.)	●	●	-	-	-	-
24		<i>Aphodius (Teuchestes) fossor</i> (L.)	●	●	-	-	-	-
25		<i>Aphodius (Teuchestes) haemorrhoidalis</i> (L.)	●	+	-	-	-	-
26		<i>Aphodius (Birus) satellitius</i> (Hbst)	○	●	-	-	-	-
27		<i>Aphodius (Plagiogonus) arenarius</i> (Oliv.)	●	-	-	-	-	-
28		<i>Aphodius (Limarus) zenkeri</i> Germ.	●	-	-	-	-	-
29		<i>Aphodius (Limarus) maculatus</i> Sturm	○	-	-	-	-	-
30		<i>Aphodius (Acrossus) bimaculatus</i> (Laxm.)	○	●	-	-	-	-
31		<i>Aphodius (Acrossus) rufipes</i> (L.)	●	+	-	-	-	-
32		<i>Aphodius (Acrossus) luridus</i> (Fabr.)	●	●	-	-	-	-
33		<i>Aphodius (Acrossus) depressus</i> (Kügel.)	●	-	-	-	-	+
34		<i>Aphodius (Trichonotulus) scrofa</i> Fabr.	●	+	-	+	-	-

¹ The species recorded from Mazovia include also those considered in the literature as occurring throughout Poland, but the location of which is not specified.

1	2	3	4	5	6	7	8
35	<i>Aphodius (Volinus) sticticus</i> (Panz.)	●	●	-	-	-	-
36	<i>Aphodius (Volinus) distinctus</i> (Müll.)	●	+	+	-	○	-
37	<i>Aphodius Volinus melanostictus</i> W. Schm.	●	○	-	-	-	-
38	<i>Aphodius (Volinus) tessulatus</i> (Payk.)	○	○	-	-	-	-
39	<i>Aphodius (Volinus) pictus</i> Sturm	○	-	-	-	-	-
40	<i>Aphodius (Nimbus) contaminatus</i> (Hbst)	●	○	-	-	-	○
41	<i>Aphodius (Melinopterus) prodromus</i> Brahm	●	+	+	-	-	-
42	<i>Aphodius (Melinopterus) sphacelatus</i> (Panz.)	●	●	-	-	-	-
43	<i>Aphodius (Melinopterus) sabulicola</i> Thoms.	●	●	-	-	-	-
—	<i>Aphodius (Melinopterus) circumcinctus</i> W. Schmidt	?	-	-	-	-	-
44	<i>Aphodius (Melinopterus) consputus</i> Creutz.	●	●	-	-	●	-
45	<i>Aphodius (Melinopterus) reyi</i> Reitt.	●	-	-	-	-	-
46	<i>Aphodius (Esymus) merdarius</i> (Fabr.)	●	+	+	-	-	-
—	<i>Aphodius (Amidorus) tomentosus</i> (Müll.)	?	-	-	-	-	-
47	<i>Aphodius (Amidorus) thermicola</i> Sturm	○	-	-	-	-	-
48	<i>Aphodius (Orodalus) pusillus</i> (Hbst)	○	+	-	-	-	-
49	<i>Aphodius (Orodalus) coenosus</i> (Panz.)	●	○	-	-	-	-
50	<i>Aphodius (Orodalus) paracoenosus</i> Balth. et Hrub.	●	-	-	-	-	-
51	<i>Aphodius (Orodalus) quadriguttatus</i> (Hbst)	●	+	-	-	-	-
—	<i>Aphodius (Orodalus) quadrimaculatus</i> (L.)	?	-	-	-	-	-
52	<i>Aphodius (Calamosternus) granarius</i> (L.)	●	+	+	-	-	-
53	<i>Aphodius (Nialus) varians</i> Duft.	●	●	-	-	-	-
54	<i>Aphodius (Nialus) plagiatus</i> (L.)	●	●	-	-	-	-
55	<i>Aphodius (Nialus) niger</i> (Panz.)	○	-	-	-	-	-
56	<i>Aphodius (Nialus) lividus</i> (Oliv.)	●	○	+	-	-	-
57	<i>Aphodius (Aphodius) fimetarius</i> (L.)	●	+	-	-	-	-
58	<i>Aphodius (Aphodius) foetens</i> (Fabr.)	●	+	-	-	-	-
59	<i>Aphodius (Aphodius) foetidus</i> (Hbst)	●	-	-	-	-	-
60	<i>Aphodius (Bodilus) immundus</i> Creutz.	●	●	-	-	-	-
61	<i>Aphodius (Bodilus) sordidus</i> (Fabr.)	●	●	-	-	-	-
62	<i>Aphodius (Bodilus) lugens</i> Creutz.	○	-	-	-	-	-
63	<i>Aphodius (Bodilus) rufus</i> (Moll)	●	●	-	-	-	-
64	<i>Aphodius (Bodilus) ictericus</i> (Laich.)	●	-	-	-	-	+
65	<i>Aphodius (Agrilinus) nemoralis</i> Er.	○	-	-	-	-	-
66	<i>Aphodius (Agrilinus) ater</i> (De Geer)	●	+	-	-	-	-
67	<i>Aphodius (Agrilinus) putridus</i> (Hbst)	●	●	-	-	-	-
68	<i>Aphodius (Agrilinus) borealis</i> Gyll.	●	-	-	-	-	-
69	<i>Heptaulacus villosus</i> (Gyll.)	●	-	-	-	-	-
70	<i>Heptaulacus testudinarius</i> (Fabr.)	●	+	-	-	-	-
71	<i>Heptaulacus sus</i> (Hbst)	●	●	-	-	-	-
72	<i>Psammobius sulcicollis</i> (Ill.)	○	+	-	-	-	-
73	<i>Rhyssemus germanus</i> (L.)	+	+	+	+	-	-
74	<i>Diasticus vulneratus</i> (Sturm)	○	-	-	-	-	-
	<i>Ssarabaeidae pleurosticti:</i>						
75	<i>Serica brunnea</i>	●	●	+	+	+	-
76	<i>Maladera holosericea</i> (Scop.)	+	●	+	-	+	-
77	<i>Homalopia ruricola</i> (Fabr.)	●	+	-	-	-	-
78	<i>Anisoplia segetum</i> (Hbst)	●	-	-	-	-	-
79	<i>Anomala dubia</i> (Scop.)	●	●	-	-	-	-

1	2	3	4	5	6	7	8
80	<i>Phyllopertha horticola</i> (L.)	●	+	●	-	-	-
81	<i>Rhizotrogus (Amphimallon) solstitialis</i> (L.)	●	+	+	+	+	-
82	<i>Rhizotrogus (Amphimallon) ruficornis</i> (Fabr.)	+	-	-	-	-	-
83	<i>Polyphylla fullo</i> (L.)	●	-	-	-	-	+
84	<i>Melolontha melolontha</i> (L.)	●	+	-	-	-	-
85	<i>Melolontha hippocastani</i> (Fabr.)	●	-	-	-	-	-
86	<i>Hoplia graminicola</i> (Fabr.)	+	+	+	-	-	-
87	<i>Hoplia philanthus</i> (Fuessly)	+	+	-	-	-	-
88	<i>Oryctes nasicornis</i> (L.)	●	+	+	-	+	-
89	<i>Valgus hemipterus</i> (L.)	●	+	-	-	-	+
90	<i>Gnorimus octopunctatus</i> (Fabr.)	+	-	-	-	-	-
91	<i>Osmoderma eremita</i> (Scop.)	●	●	-	-	-	-
92	<i>Epicometis hirta</i> (Poda)	●	+	-	-	-	-
93	<i>Cetonia aurata</i> (L.)	●	+	-	-	-	-
94	<i>Potosia (Liocola) lugubris</i> (Hbst)	●	+	-	-	-	-
95	<i>Potosia (Potosia) metallica</i> (Hbst)	●	-	+	-	-	+
96	<i>Potosia (Cetonischema) aeruginosa</i> (Drury)	●	○	-	-	-	+

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ŻUKOWATE (COLEOPTERA, SCARABAEIDAE) WARSZAWY I MAZOWSZA

STRESZCZENIE

W wyniku badań prowadzonych na terenie Warszawy i Mazowsza w latach 1974—1977, oraz na podstawie danych wcześniejszych (zbiory Instytutu Zoologii PAN, dane bibliograficzne) uzyskano materiał pozwalający na porównanie fauny *Scarabaeidae* terenów niezurbanizowanych Mazowsza i aglomeracji warszawskiej. Fauna żukowatych w mieście, będąca pochodną fauny Mazowsza, jest jednak znacznie od niej uboższa. Spośród 88 gatunków występujących na Nizinie Mazowieckiej, na terenach zielonych miasta stwierdzono tylko 17 gatunków, tzn. 19,3% żukowatych Mazowsza. Reprezentują one elementy zoogeograficzne: kosmopolityczny, holarktyczny, palearktyczny, eurosyberyjski, południowoeurosyberyjski i europejski. Podobnie jak na Mazowszu, ale zdecydowanie wyraźniej, w mieście dominują elementy holarktyczne, palearktyczne i południowoeurosyberyjskie. Na najsilniej zurbanizowanych terenach (osiedla i centrum miasta) utrzymują się wyłącznie gatunki o tych trzech zasięgach. Do miasta nie wkraczają gatunki submedyteraneńskie i subpontyjskie, które choć nielicznie, są jednak na Mazowszu reprezentowane.

Najliczniejszą grupę, zarówno na terenach pozamiejskich jak i w Warszawie stanowią gatunki związane z suchymi środowiskami otwartymi. Ich udział procentowy w ogólnej liczbie gatunków żukowatych występujących w Warszawie wzrasta w porównaniu z Mazowszem. W środowisku miejskim znaczny jest też udział gatunków odznaczających się dużą plastycznością ekologiczną (mogących zasiedlać zarówno tereny leśne jak i otwarte, mało wrażliwych na zmiany wilgotności) fitofagów i koprofagów o bardzo urozmaiconej diecie. Ich udział procentowy jest mniej więcej dwa razy wyższy w Warszawie niż na terenach niezurbanizowanych. Gatunkami najliczniej i najpowszechniej występującymi w zieleni miejskiej są: *Rhizotrogus solstitialis*, *Hoplia graminicola* i *Serica brunnea*.

НАВОЗНИКИ И ХРУЩИ (COLEOPTERA, SCARABAEIDAE) ВАРШАВЫ И МАЗОВИИ

РЕЗЮМЕ

В зелёных насаждениях Варшавы (в парках, жилых районах и в центре города) нашли 17 видов *Scarabaeidae*. Это лишь 19,3% фауны этих жуков, населяющей Мазовию. В специфических условиях городской среды могут существовать только виды с широкой экологической пластичностью (главным образом эвритопные и политопные), убиквисты или преферирующие открытые и сухие территории. С точки зрения питания это копрофаги или фитофаги, могущие временно переходить на сапрофагию. В городской зелени доминируют виды широко распространенные (голарктические и палеарктические) или с несколько более ограниченным ареалом, но теплолюбивые южно-евро-сибирские.