able shelters determines the occurrence or absence of field mice in an urban green space. The number of shelters may also be assumed to determine population numbers. The large number of shelters rich luxuriant vegetation and in the surface layer of the soil, and the very rare visits to the area by dog's and humans, justify the assumption that the cemetery area is among the most abundant in numbers of *A. agrarius* in Warsaw.

Acknowledgements: The author wishes to thank Dr. R. Andrzejewski, Dr. J. Babinska-Werka and Dr. J. Gliwicz for their assistance in these studies and their helpful comments on the text of this paper.

REFERENCES

Andrzejewski R. & Wrocławek H., Mass occurence of *Apodemus agrarius* (Pallas, 1771) and yariations in the number of associated *Muridae*. Acta theriol., *5*, 13: 173—184. Andrzejewski R., Babińska-Werka J., Gliwicz J. & Goszczyński J., 1978: Synurbization processes in population of *Apodemus agrarius*. I Characteristics of population in urbanization gradient. Acta theriol., *23*, 20: 341—358. Babińska-Werka J., Gliwicz J. & Goszczyński J., 1979: Synurbization processes in a population of *Apodemus agrarius*. II. Habitats of the striped field mouse in a town. Acta theriol., 24: 405—415. Chudoba S., Humiński S. & Wójcik J., 1961: Drobne ssaki okolic Wrocławia. Prz. zool., *5*: 363—374. Goszczyński J., 1977: Connections between predatory birds and mammals and their prey. Acta theriol., *22*, 30: *399—430*. Petersen C. G. J., 1896: The yearly immigration of young plaice into the Limfjord from the German Sea. Rept. of Danish Biol. for 1895, *6*: 1—77. Ryszkowski L., 1970: Estimates of consumption of rodent populations in different pine ecosystems. [In: Petrusewicz K. & Ryszkowski L. (eds), »Energy flow through small mammal populations«]. Państw. Wyd. Nauk.: 281—289. Warszawa. Ryszkowski L., Goszczyński J. & Truszkowski J., 1973: Trophic relationships of the common vole in cultivated fields. Acta theriol., *18*, 7: 125—165. Sumiński S. M., 1922: Fauna Warszawy. Ziemia, 7, 12: 328—335.

Accepted, March 15, 1979.

Penetration of Mammals Over Urban Green Spaces in Warsaw

Penetracja terenów zieleni miejskiej Warszawy przez ssaki

Jacek GOSZCZYŃSKI

Goszczyński J., 1979: Penetration of mammals over urban green spaces in Warsaw. Acta theriol., 24, 31: 419—423 [With 2 Tables & 1 Fig.].

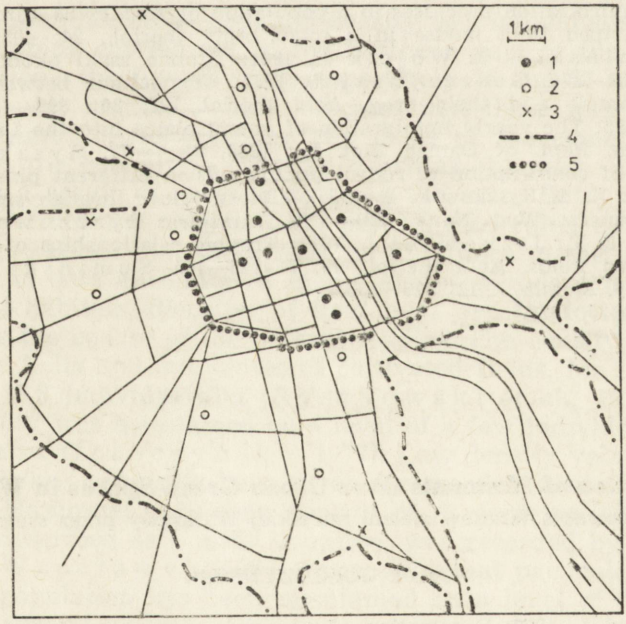
The method of counting tracks in the snow was used to examine the composition and numerical relations of the group of mammals in three urban zones in Warsaw, and also in control areas. A threefold decrease in number of species was found from the city boundaries towards its centre. The number of green agreas in which mammals occur decreases with increasing urbanization of the area and this also applies to penetration of mammals. Only a small number of species (squirrels, stone martens and partly also rabbits) increase their numbers in a town. Domesticated mammals (cats and dogs) greatly dominate in urban green spaces.

[Agricultural Univ., Dept. Game Management, Rakowiecka 26/39, 02-528 Warszawa].

Mammals, unlike birds, have rarely been studied in the habitats of green areas in Warsaw. Exceptions to this are the studies by Wałecki (1881) and Sumiński (1922), and also the study by Andrzejewski *et al.* (1978) discussing changes in the rodent populations due to urbanization. In the present note, in addition to listing mammal species, the quantitative deformation of theriofauna with increasing urbanization has been described. Domesticated predatory mammals — dogs and cats — which have hitherto been overlooked, have included in the studies.

STUDY AREA AND METHODS

The method applied in this study consisted in carrying out winter assessing walks, during which the number of tracks of different species per unit of route were recorded. A necessary condition for application of this method is a fresh snow cover (from 1—3 days after snow fall). In the centre of the city such assessments can usually only be made on the first day after snow has fallen, owing to the considerable traffic over the area by humans and dogs, trampling the snow cover and later making it impossible to identify the mammal species by their tracks.



1 — areas in the city centre zone, 2 — areas in the peripheral zone, 3 — boundary areas, 4 — city limits, 5 — limits of the city centre zone.

The studies were carried out in different green areas in Warsaw (in parks, cemeteries, squares, waste land etc.). The green areas were divided according to the type and density of buildings into three urban zones. Estimates from 4 study stations (including wooded land and cultivated fields), situated at distances from 1—20 km from the city boundaries, were used as the control. The boundaries between dense housing and scattered buildings, or the boundaries between dense housing and open areas, were taken as city limits, instead the official administrative ones. Areas adjacent to these boundaries formed the boundary zone. The peripheral zone included areas lying within city limits but outside its central part,

and the central zone — areas lying in the central part of the city. The number of areas covered by studies and allocated to boundary, peripheral and central zones were respectively: 5, 10 and 9 (Fig. 1).

Division of green areas into different urban zones, from boundary zone to city centre, reflects the gradient of increasing urbanization. Studies were carried out in the above-mentioned zones from 1976—1978. The combined length of assessing walks for control zones was approximately 67 km, for the boundary zone 44 km, for the peripheral zone 62 km, and 11 km for the central zone. In addition, during the winter of 1977/1978, single assessments were made along both banks of the Vistula within the city limits. The combined length of these assessing walks was 11 km. Distinction was made between different sectors of the river banks as corresponding to city zones.

RESULTS AND DISCUSSION

The absence of many species of wild mammals is a characteristic feature of the central zone, only squirrels and small rodents occurring there. Biotic community of the peripheral zone is enriched by presence

Table 1

Penetration of urban green spaces by mammals (number of tracks per 1 km of assessing walk per day ± SD). The percentage of habitats in the given zone in which the species was found to occur has been given in brackets. Average values apply to habitats in which the given species occurs.

Species	City centre zone	Peripheral zone	Boundary zone	Control
Canis familiaris	241.1 ± 112.5 (100)	126.5 ± 69.7 (60)	50.0 ± 37.6 (80)	16.3 ± 9.9 (100)
Felis catus	5.2 ± 2.9 (22.2)	5.6 ± 7.8 (90)	1.0 ± 0.4 (100)	0.9 ± 0.5 (75)
Mustela nivalis		0.5 ± 0.3 (20)	0.3 ± 0.3 (60)	0.3 ± 0.2 (75)
Martes foina + *M. martes*		1.6 ± 0.8 (30)	0.7 ± 0.5 (60)	0.7 ± 0.4 (75)
Vulpes vulpes			2.0 (20)	2.2 ± 0.4 (100)
Muridae + *Microtidae*	2.7 (11.1)	1.3 ± 1.6 (60)	1.1 ± 0.6 (80)	1.1 ± 0.4 (100)
Sciurus vulgaris	2.4 ± 1.6 (44.4)	4.3 ± 2.2 (70)	2.2 ± 1.0 (40)	0.7 ± 0.4 (75)
Oryctolagus cuniculus		2.0 ± 1.8 (40)	30.0 ± 25.6 (80)	11.5 ± 15.7 (100)
Lepus europaeus		1.1 ± 0.7 (30)	7.9 ± 5.7 (40)	23.0 ± 6.7 (100)
Capreolus capreolus			10.5 (20)	13.4±10.7 (100)
Sus scrofa			1.5 (20)	2.4 ± 0.9 (50)

of hares, wild rabbits, weasels and martens, while all the species recorded in the control areas are encountered in the boundary zone (Table 1).

Among the species examined foxes, roe-deer and wild boar distinctly avoid the city, and were found to be present in only one habitat in the boundary zone. A gradual decrease, towards the city centre, of number

of habitats occupied and intensity of penetration was observed for hares (intensity of habitat penetration in the peripheral zone by this species is significantly lower; $0.01>p>0.001$) than in the control areas.

The gradient of number of occupied habitats, decreasing towards the city centre, is also characteristic of martens, weasels and small rodents (Table 1). But intensity of penetration by these species is higher in the peripheral habitats than in the control ones. A similarly decreasing gradient of number of occupied habitats is typical for wild rabbits, but there are habitats in the city with a very high index of area penetration intensity, differing greatly from the averages for this zone. The squirrel finds favourable living conditions in the city (Table 1), the habitats in which this rodent appears being as a rule more intensively penetrated than the control areas (*e.g.* the difference between the peripheral and control zones is significant; $0.01>p>0.001$), which points to their greater numbers in the city. The gradient of distinctly increased penetration of the area towards the city centre is typical of domesticated Carnivora: dogs and cats, although cats visit green areas less often in the city centre zone than in the peripheral zone (Table 1).

The Vistula river bank areas must be treated separately (Table 2). The variety of the fauna in these areas is partly due to rich and dense plant cover of vegetation, providing shelter for mammals, and also due to the absence of artificial barriers between the areas. The river bank sectors corresponding to the different city zones are usually richer in

Table 2

Penetration of banks of the River Vistula by mammals within city limits (number of tracks per 1 km of assessing walk per day).

Species	City centre sector	Peripheral sector	Boundary sector
Canis familiaris	54	21.2	11.6
Felis catus	0	0	0.7
Mustela nivalis	2.3	4.8	3.8
Martes foina	0	0.3	1.9
Vulpes vulpes	0	0.8	4.5
Oryctolagus cuniculus	0	4.8	7.0
Lepus europaeus	2.1	4.7	24.7
Muridae + *Microtidae*	4.2	1.5	1.3

mammal species (the type of vegetation accounts for the absence of squirrels there), and are more intensively penetrated by mammals than urban zones. The river bank sector corresponding to the city centre zone, for instance, is intensively penetrated by small rodents and weasels (Table 2), and hares also occur there. The sector lying within the peripheral zone is also penetrated by foxes. The banks of the Vistula not faced with concrete thus form a natural channel penetrated by wild species of mammals within city limits.

Since not all the green areas coming within each of the zones were examined, the list of species found may prove to be incomplete. Despite

this reservation, the data collected point to gradual degradation of the mammal community with increasing urbanization. This process may be traced not only from the spatial aspect (from the city limits to the centre): it can also be discerned by comparing historical material. Earlier studies (Wałecki, 1881; Sumiński, 1922) and reports (Pielowski, 1957; Pawłowski, 1963) point to far richer and more numerous theriofauna of Warsaw. It would appear that the basic cause of such degradation is the progressive isolation of green areas from suburban habitats and the Vistula river banks, and internal divisions of green areas into smaller units. An important limiting factor, particularly in relation to small migrating mammals, consists in the dogs and cats dominating in the city.

Among the few mammals which fit in well with urban conditions is the squirrel, which occurs in greater numbers in the city then in the control areas, and also the stone marten. The latter species has, however, more stringent habitat requirements and occurs only in old parks and cemeteries. It is a characteristic fact that only the stone marten occurs within city limits, while the both: stone and pine marten can be encountered in the control areas. The field mouse is also known to be a synurbic species (Andrzejewski *et al.*, 1978), the domination of which increases in the rodent community with increasing urbanization.

Acknowledgements: The author would like to express his gratitude to Dr R. Andrzejewski for his valued comments on the text of this paper.

REFERENCES

Andrzejewski R., Babińska-Weerka J., Gliwicz J. & Goszczyński J., 1978: Synurbization processes in population of *Apodemus agrarius*. I. Characteristics of population in an urbanization gradient. Acta theriol., *23*, 20: 341—358. Pawłowski W., 1963: Awifauna Parku Skaryszewskiego w Warszawie. Prz. zool., 7, 3: 273—284. Pielowski Z., 1957: Ptaki w parku Łazienkowskim w Warszawie. Chrońmy Przyr. ojcz., *13*, 1: 34—41. Sumiński S. M., 1922: Fauna Warszawy. Ziemia, 7, 12: 328—335. Wałecki A., 1881: Fauna zwierząt ssących Warszawy i jej stosunek do fauny całego kraju. Pam. fizjograf., *1*: 226—291.

Accepted, March 15, 1979.

Praca wykonana w Inst. Kształtowania Środowiska, w ramach problemu PR-5 i częściowo MR.II.6.