

Nests and nest-sites of the House Sparrow *Passer domesticus* (LINNAEUS, 1758) in urban, suburban and rural environments

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Abstract. Nesting of *Passer domesticus* in the urban (879 nests), suburban (162 nests) and rural (191 nests) environments in Central Poland is discussed. Out of the 19 types of nest-sites distinguished, 18 were noted in towns, 11 in suburban areas and 12 in the country. The mean height of nest-sites above the ground was, respectively, 7.3, 3.9, and 5.8 m. The size of nests was determined by the spatial conditions of the places in which they were situated: the largest nests were found in towns, the smallest in suburbs and those of medium size in the country. While the nest size is generally marked by great variation, the dimensions of the nest cup show the smallest fluctuations. The amounts of building materials used range within very wide limits and so does their weight (from 15.3 to 616.2 g). A great variety of materials, dependent on the environment, was also observed.

Key words: *Aves*, *Passer domesticus*, nest, environment.

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I. INTRODUCTION

The House Sparrow is widely regarded as one of the few bird species which are almost perfectly adapted to the ways of life in the urbanized environment. This opinion was probably based on observations of the quite amazing plasticity of the behaviour of this species, the adaption of its breeding biology to the existing environmental conditions or its ability to adapt various nest-sites. However, there are still a great many unknown facts, connected if not with other problems at least with this last one. Although the literature on the nests and nesting of this species is copious, yet the problem of the differentiation of the House Sparrow nests according to environmental conditions has rarely been treated as a subject of a detailed study. It was discussed in part, among other authors, by KULCZYCKI and MAZUR-GIERASIŃSKA (1968), IORDACHE (1970) and HEIJ (1986) but their comparatively scanty material (respectively, 271, 223 and 144 nests) they as a rule

confined themselves to description of the nests from particular environments or to their merely mechanical comparison.

The purpose of this study is to present a survey of a variety of the House Sparrow's nest-sites in the urban, suburban and rural environments, to discuss the differences and similarities between the nests built by the Sparrow in the environments distinguished, with special attention given to the situation and height of their sites, to their shape and dimensions, the materials of which nests were built and, lastly, to show the House Sparrow's adaptive faculty in the breeding season.

II. MATERIAL AND METHOD

Descriptions of 1232 nests of House Sparrows were collected in 1982-1985. The investigation covered three environments: urban (towns: Bydgoszcz 53°07'N, 18°03'E and Toruń 53°02'N, 18°36'E), suburban (Łęgowo and Piaski - the north-easternmost and north-westernmost districts of Bydgoszcz) and rural (villages: Białe Błota - 53°06'N, 17°55'E, Ostaszewo - 53°41'N, 17°37'E, Sicienko - 53°18'N, 14°57'E and Ugoda - 53°18'N, 17°45'E)

The criteria for distinguishing the urban environment from the remaining ones was adopted after STRAWIŃSKI (1963) and TOMIAŁOJC (1970) and included the compactness and structure of settlement, the structure of vegetation, the size and density of human population and the intensity of pedestrian and vehicular traffic.

Each nest was described individually and its site, site height, shape and dimensions as well as materials of which it was built were taken into consideration. Such a description of completely constructed nests was made in breeding season. After the season some of the nests were gathered and their building material was submitted to a close analysis. A detailed description of the methods of taking the nest measurements has been given in another paper (INDYKIEWICZ 1990).

The degree of utilization of nest-sites was calculated from the formula:

$$\frac{N.n. \times 100}{N.n-s. + N.n.} (\%)$$

where N.n. is the number of nests and N.n-s. denotes the number of nest-sites which were not used.

The sites unused by Sparrows compared with those already occupied (naturally within the same category of nest-sites) were always at the same height above the ground and characterized by the same spatial conditions (= measurements) and the identical orientation towards the points of the compass. They were therefore "similar" nest-sites, but lying at a certain distance from each other horizontally. Such places can be exemplified by identical letters of the same neon sign, the pipe-clips of parallel gutter-spouts situated at the same height, etc. The analysis of the degree of nest-site utilization does not include hollows under roof-tiles, the insides of gutters, and Virginia creepers.

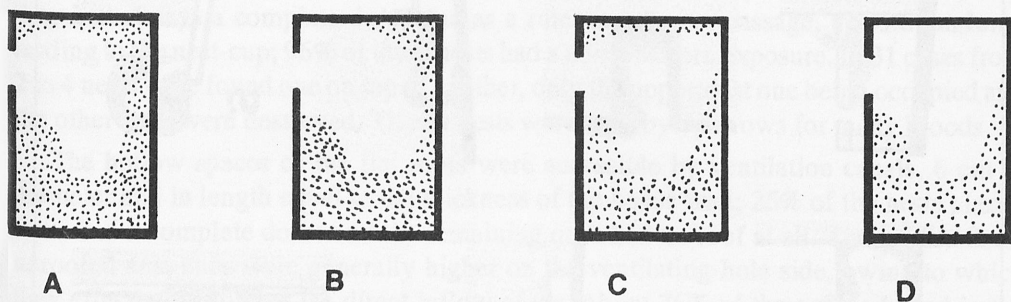


Fig. 1. Types of nests of the House Sparrow placed in tree-holes, recesses, etc. with a complete dome (A), semidome (B), canopy (C) and roofless (D).

Three kinds of roofing were distinguished in House Sparrows' nests (dome, semidome and canopy) according to the degree of its formation and the type of connection with the nest cup (Fig. 1). The dome was joined to the nest cup by all its four side walls, giving 100% protection to it. The semidome sheltered the nest cup up to 60% of its area and was attached to it by two side walls (one of them was always opposite the entrance). Lastly, the canopy protected 90-100% of the nest area and was not attached to it at all.

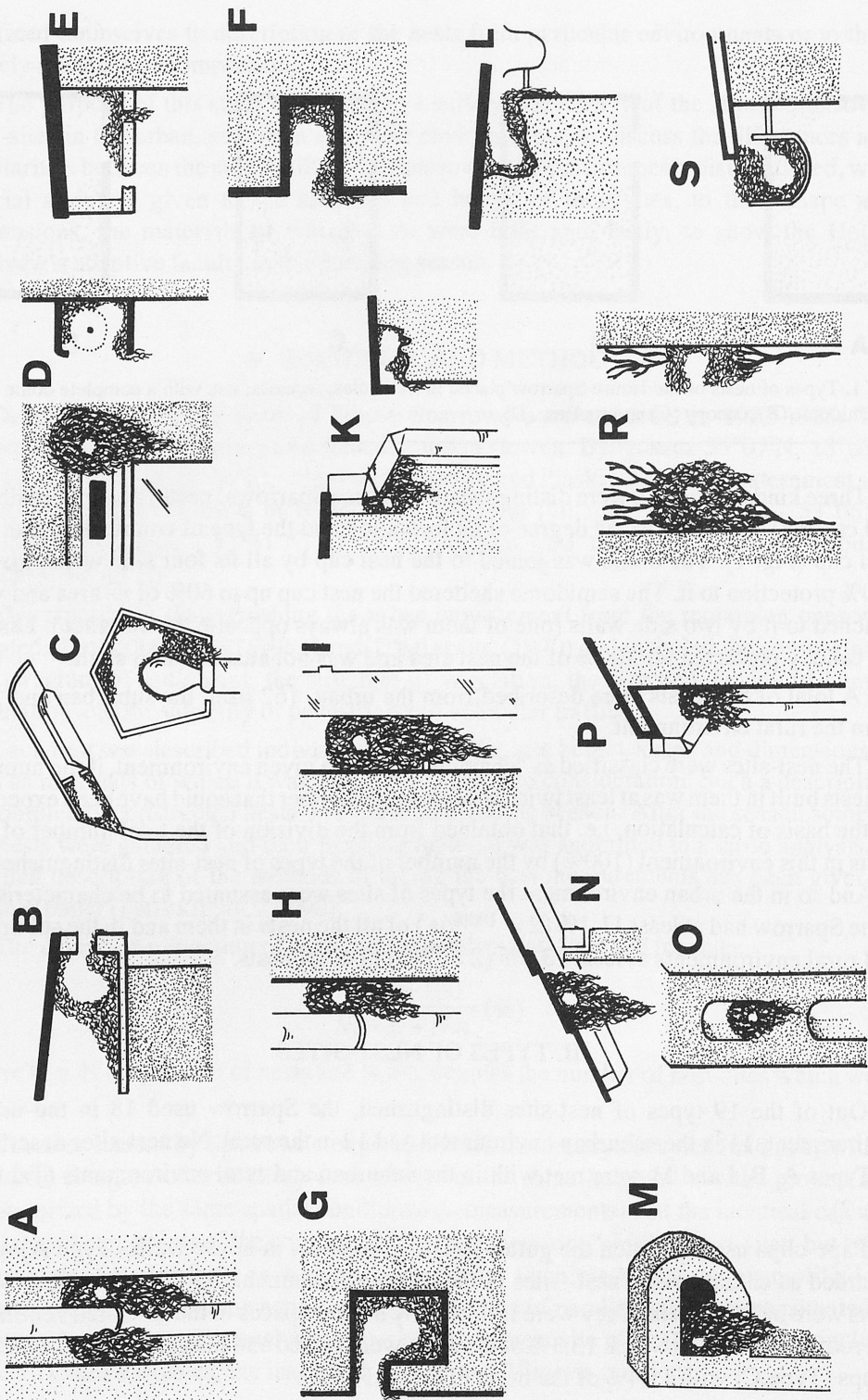
A total of 879 nests were described from the urban, 162 from the suburban and 191 from the rural environment.

The nest-sites were classified as "characteristic" in a given environment, if the number of nests built in them was at least twice as high as the number that could have been expected on the basis of calculation, i.e. that obtained from the division of the total number of the nests in this environment (100%) by the number of the types of nest-sites distinguished in it. And so in the urban environment the types of sites were assumed to be characteristic, if the Sparrow had at least 11.1% ($2 \times 100\%/18$) of all the nests in them and in the suburban and rural environments at least 13.3% ($2 \times 100\%/15$) of all nests.

III. TYPES OF NEST-SITES

Out of the 19 types of nest-sites distinguished, the Sparrow used 18 in the urban environment, 11 in the suburban environment and 12 in the rural. No nest-sites described as Types A, B, I and M were met with in the suburban and rural environments (Table I, Fig. 2).

Pape-clips used to fasten the gutter-spouts in recesses in house walls (Type A) were regarded as characteristic nest-sites in the urban environment; 33.0% of the Sparrow's nests were built on them. They were followed by hollow spaces in the so-called ventilated flat roofs (Type B), in which 13.3% of the nests were placed and the glass casings of street lamps (Type C) with 11.4% of the nests (Table I, Fig. 2).



The nests built on the clips of gutter-spouts were characterized by the widest range of nesting heights above the ground, namely, from 2.5 to 32.2 m (\bar{x} = 16.2 m, SD = 7.7); they had always a complete dome and as a rule an entrance passage, up to 8 cm long, leading to the nest-cup; 96% of these nests had a north-eastern exposure. In 31 cases from 2 to 4 nests were found one on top of another, only the uppermost one being occupied and the other ones were destroyed. These nests were used by Sparrows for many broods.

The hollow spaces of the flat roofs were accessible by ventilation canals, 6 cm in diameter and in length equal to the thickness of the house wall; 25% of the nests placed there had a complete dome and the remaining ones had no roof at all. The side walls of unroofed nest-cups were generally higher on the ventilating-hole side, owing to which they effectively stopped the direct inflow of air. About 76% of the nests situated in the hollow spaces of flat roofs were on the southern and eastern sides of houses. They occurred at a height from 3.25 to 12.25 m (\bar{x} = 4.4 m, SD = 0.5) and many of them several birds for several broods.

Eighty-one nests were found in park lamp casings with open-work side walls, 11 in lamp casing with openings in their bottoms and 8 in the casing of street mercury-vapour lamps. The nests built in the first two types of casings mentioned above were marked by their relatively great dimensions and considerable weight. They were placed at a height of 4.25-6.5 m (\bar{x} = 4.4 m, SD = 0.5) and frequently were used by birds for several broods.

In the suburban environment the Sparrow preferred recesses between the wall and the roof of houses (Type K - 48.2%) and hollows in a wooden closed cornice (Type E - 25.3% of nests) (Table I, Fig. 2). In the first of these sites the birds formed a kind of colony and the nests placed in them had a scant lining of the nest-cup and, generally, lacked entrance passages. Niches in the wooden closed cornices of houses were also occupied in a colonial way, often for several broods. The nests placed there had no domes nor entrance passages. Starlings and less frequently Jackdaws competed with Sparrows for such sites.

In the rural environment the Sparrow, more often than not, built its nests on the pipe-clips fastening gutter-spouts directly to house walls (Type H - 25.1%) and in recesses between the wall and the roof of houses (Type K - 20.9%) (Table I, Fig. 2). The nests constructed on the pipe-clips fastened to walls but not in recesses had always a complete dome and entrance passage. They were always single nests.

It should be emphasized that the nests at sites regarded as characteristic averaged about 59% of all the nests of the given environment. The highest number of nests built at sites considered to be characteristic was noted in the suburban environment, where they formed

Fig. 2. Types of nest-sites of the House Sparrow: A - clips of gutter-spout placed in a wall recess, B - hollows in the flat roof (the so-called ventilated roof), C - glass casings of the street lamps, D - sunshades (awnings) in front of shopwindows, E - wooden closed cornice, F - recess in the house wall, G - tree-hole-like holes in the house wall, H - clips of gutter-spout placed immediately on the house wall, I - space behind a neon sign, K - recess between the wall and the roof of a house, L - recess under gutter, M - inside of neon sign, N - under a roof tile, O - reinforced concrete pylons of electric traction lines, P - gutter-spout elbow connection, R - Virginia creeper, S - inside of gutter.

Table I

Types of nest-sites of the House Sparrow (symbols correspond to Fig.2).

Symbol	Nest-site	Environnement						Total (n)
		Urban		Suburban		Rural		
		n	%	n	%	n	%	
A	clips of gutter-spout placed in a wall recess	290	33.0	—	—	—	—	290
B	hollows in the flat roof (the so-called ventilated roof)	117	13.3	—	—	—	—	117
C	glass casings of street lamps	100	11.4	7	4.3	20	10.5	127
D	sunshades (awnings) in front of shop-windows	91	10.4	—	—	—	—	91
E	wooden closed cornice	68	7.7	41	25.3	6	3.1	115
F	recess in the house wall	43	4.9	3	1.9	8	4.2	54
G	tree-hole-like holes in the house wall	43	4.9	2	1.2	4	2.1	49
H	clips of gutter-spout placed immediately on the house wall	34	3.9	8	4.9	48	25.1	90
I	space behind a neon sign	23	2.6	—	—	—	—	23
K	recess between the wall and the roof of a house	20	2.3	78	48.2	40	20.9	138
L	recess under gutter	12	1.4	—	—	16	8.4	28
M	inside of neon sign	8	0.9	—	—	—	—	8
N	under a roof tile	8	0.9	10	6.2	20	10.5	38
O	reinforced concrete pylons of electric traction lines	4	0.4	—	—	4	2.1	8
P	gutter-spout elbow connection	4	0.4	2	1.2	5	2.6	11
R	Virginia creeper	2	0.2	—	—	—	—	2
S	inside of gutter	1	0.1	1	0.6	—	—	2
T	adapted nests of other bird species*	11	1.3	8	4.9	12	6.3	31
U	niches inside houses	—	—	2	1.2	8	4.2	10
Total		879	100.0	162	100.0	191	100.0	1232

*nine nests of the Sparrow were found in two nests of *Ciconia ciconia* and the remaining 22 were adapted nests of *Delichon urbica*.

73.5% of all the nests in it, whereas in the urban environment they made 57.7% and in the rural environment only 46.8%.

Most types of nest-sites observed in a given environment were represented by very few nests of Sparrows each. And so, for instance, in the rural environment the Sparrow placed scarcely 2.1-4.6% of its nests in as many as 6 out of the 12 types of nest-sites found in it,

whereas in the suburban environment there were 0.6-4.9% of nests in 8 out of the 11 types of nest-sites distinguished in it and in the urban environment 0.1 - 4.9% of nests in no less than 11 out of the 18 types of nest-sites.

Many types of nest-sites (e.g. B, C, D, F, K, L, M and I) were used by colonies of Sparrow and many a time for several broods at that (e.g. B and D).

IV. DEGREE OF UTILIZATION OF NEST-SITES IN THE URBAN ENVIRONMENT

An attempt was made to determine the influence of the factors specified below upon the degree of utilization of the potential nest-sites by the House Sparrow. They are as follows: a) the sort of building material of the niche in which a nest could have been placed (i.e. metal, bricks, wood); b) the orientation of the nest towards the points of the compass; c) height above the ground and d) spatial conditions in the niche.

The largest number of nests were noted behind gutter-spouts placed in the recesses of house walls (Type A); nevertheless, these sites were utilized only in 66.1%, and so they come in sixth regarding the degree of utilization. The highest degree of utilization (100%) was observed in the sites in hollow spaces in wooden closed cornices (Type E). The recesses in house walls (Type F) were utilized in 82.7%, in which they were followed by the casings of street lamps (Type C - 81.3%), the insides of neon signs (Type M - 80.8%) and the sites behind gutter-spouts immediately on house walls (Type H - 77.7%) (INDYKIEWICZ 1990: Fig. 4).

Out of the 768 nests of House Sparrows described from the urbanized environment, 323 nests (42.0%) were placed on house walls facing the north and north-east. However it should be emphasized that this was chiefly influenced by the fact that 90% of the gutter-spouts of houses were on the walls with that exposure. 168 nests or 21.9%, occurred in sites with an eastern exposure and a similar number of nests (155) were in sites facing the south. The fewest nests, i.e. 122, were placed on the western sides of houses.

Although the most sites in which Sparrows placed their nests had a northern exposure, the degree of their utilization was hardly 62.5%. A higher degree of utilization, equal to 66.5%, was noted at the sites with eastern exposures, whereas the sites with southern and western exposures were utilized, respectively, in 50.7 and 40.6% (INDYKIEWICZ 1990: Fig. 5).

V. HEIGHT OF NESTING

The degree of the mosaic nature and differentiation of houses in respect of height in particular environments has a direct influence both on the number of the types of nests-sites suitable for the House Sparrow's nests and on their height above the ground. The Sparrow's nests observed were built at a height from 2.0 to 32.2 m. The mean height was

Table II

Nesting heights of the House Sparrow

Environment	No. of nests	Nesting heights (m)			
		\bar{x}	max.	min.	SD
Rural	191	5.8	12.05	2.50	2.6
Suburban	162	3.9	7.40	2.95	1.6
Urban	686	7.3	32.20	2.05	2.9
Total	1221	5.7	32.20	2.05	2.5

The mean nesting heights obtained from the three environments show statistically significant differences ($P < 0.001$), indicated by means of Student's t-test.

5.7 m ($n = 1221$, $SD = 2.5$) and ranged, according to environment, from 3.9 m (suburban environment) through 5.8 m (rural environment) to 7.3 m (urban environment) (Table II).

The greatest mean height of nesting was found in the urban environment. It may seem a surprising fact that there is a relatively great difference between the mean heights of nesting in the suburban and the rural environment. However, it is so because the heights of houses in the suburban environment (mostly villas) varied, reaching a maximum of 8 m, whereas in the rural environment the maximum height of buildings approximated to 15 m (e.g. church). The fact that the mean height of nesting in the suburban environment is 1.9 m lower than that in the villages is only natural if we keep in mind that about 74% of nests in the former environment (Types E and K) were placed in hollows in the wooden closed cornices and in recesses between the walls and the roof of houses (at a max. height of 8 m). The higher above the ground, the smaller were the numbers of nests in all these environments (Fig. 3).

The most commonly inhabited was the height zone between 3.0 and 4.99 m above the ground, where there were altogether 44.4% ($n = 542$) of all nests. In the particular environment the situation presented itself as follows: 39.6% of all the nests in the urban environment, 72.2% in the suburban environment and 41.4% in the rural environment. The great number of nests found at a height from 12.0 to 12.99 m in the urban environment was connected with the fact that most ventilated flat roofs of houses (type B) occurred within that range of heights; as many 13.3% of all the nests of this environment were placed in them.

In the urban environment 80.9% of Sparrow's nests were built within the height range from 0 to 15 m and in consequence in analyzing the degree of utilization of nest-sites I concentrated on this very range. It appeared that there was a certain convergence of the number of nests found at those heights and the utilization of the potential nest-sites. The most nests of Sparrows (29%) were placed between 4.0 and 4.99 m above the ground. Both this range and that of 3.0-3.99 m were characterized by the greatest utilization of the potential nest-sites (respectively, 85.1 and 84.8%) (INDYKIEWICZ 1990: Fig. 6).

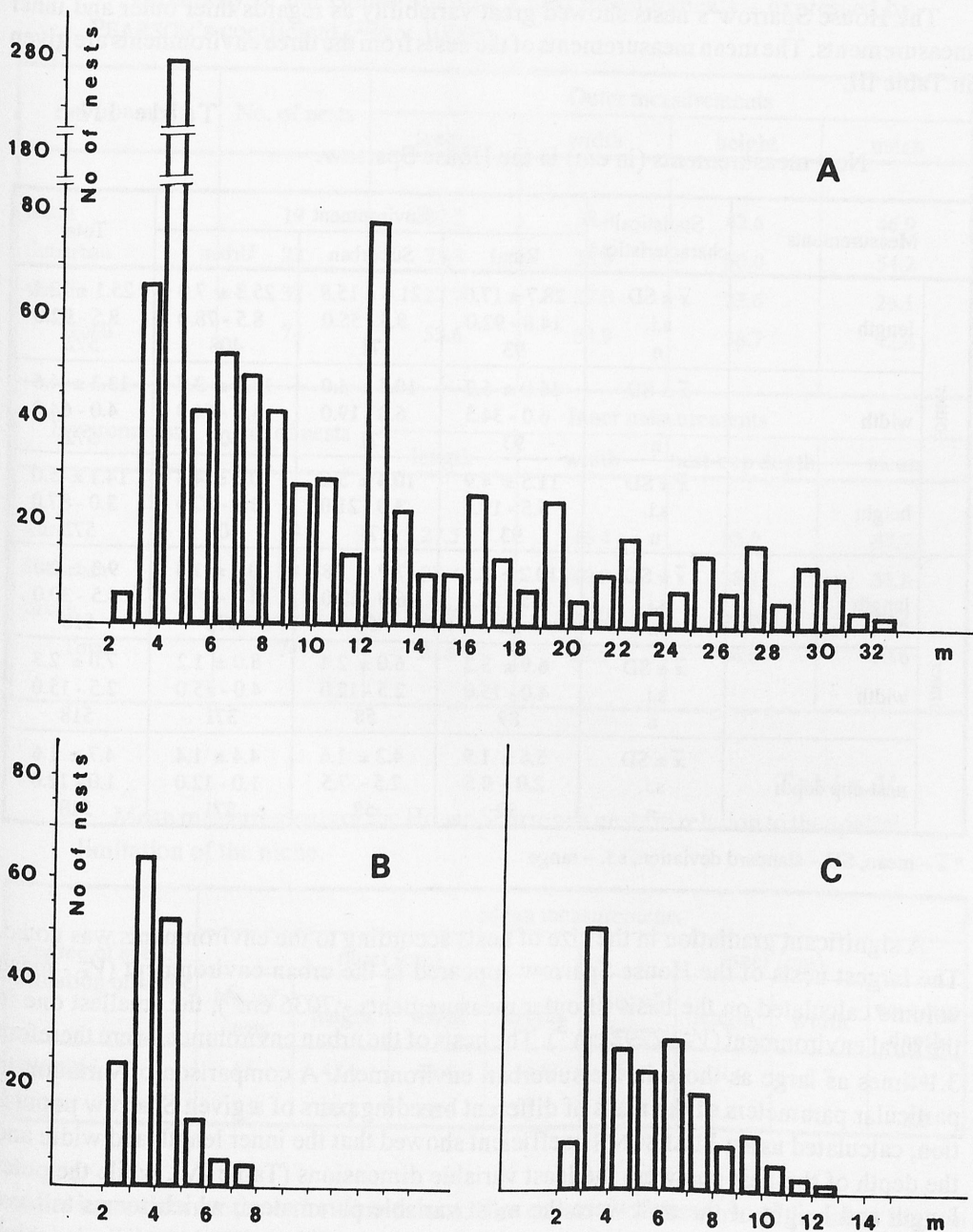


Fig. 3. Nesting heights of the House Sparrow in particular environments: A - urban, B - suburban, C - rural.

VI. NEST SIZE

The House Sparrow's nests showed great variability as regards thier outer and inner measurements. The mean measurements of the nests from the three environments are given in Table III.

Table III

Nest measurements (in cm) in the House Sparrow.

Measurements		Statistical characteristics*	Environment			Total
			Rural	Suburban	Urban	
outer	length	$\bar{x} \pm SD$ s.i. n	28.7 \pm 17.0 14.8 - 92.0 93	21.4 \pm 15.8 8.5 - 55.0 71	25.3 \pm 7.0 8.5 - 78.0 408	25.1 \pm 13.2 8.5 - 92.0 572
	width	$\bar{x} \pm SD$ s.i. n	16.0 \pm 6.2 6.0 - 34.5 93	10.3 \pm 4.0 6.0 - 19.0 71	13.7 \pm 3.7 4.0 - 64.0 408	13.3 \pm 4.6 4.0 - 64.0 572
	height	$\bar{x} \pm SD$ s.i. n	11.5 \pm 4.9 5.5 - 19.5 93	10.4 \pm 5.2 3.0 - 21.0 71	20.3 \pm 4.8 3.0 - 87.0 408	14.1 \pm 5.0 3.0 - 87.0 572
inner	length	$\bar{x} \pm SD$ s.i. n	10.2 \pm 2.8 6.5 - 18.5 89	7.7 \pm 1.8 6.0 - 12.0 58	10.1 \pm 1.4 4.5 - 30.0 371	9.3 \pm 2.0 4.5 - 30.0 518
	width	$\bar{x} \pm SD$ s.i. n	6.9 \pm 3.2 4.0 - 15.0 89	6.0 \pm 2.4 2.5 - 12.0 58	8.0 \pm 1.2 4.0 - 15.0 371	7.0 \pm 2.3 2.5 - 15.0 518
	nest-cup depth	$\bar{x} \pm SD$ s.i. n	5.6 \pm 1.9 2.0 - 9.5 89	4.2 \pm 1.6 2.5 - 7.5 58	4.4 \pm 1.4 1.0 - 12.0 371	4.7 \pm 1.6 1.0 - 12.0 518

* \bar{x} - mean, SD - standard deviation, s.i. - range

A significant gradiation in the size of nests according to the environments was noted. The largest nests of the House Sparrow appeared in the urban environment ($V_{\bar{x}}$ - mean volume calculated on the basis of outer measurements - 7036 cm³), the smallest one in the rural environment ($V_{\bar{x}}$ - 2292 cm³). The nests of the urban environment were therefore 3.1 times as large as those in the suburban environment. A comparison of variation in particular parameters of the nests of different breeding pairs of a given Sparrow population, calculated using PEARSON'S coefficient showed that the inner length and width and the depth of the-nest cup were the least variable dimensions (Table IV), while the outer length and height of the nest were the most variable parameters, which seems to have resulted from the fact that the birds always endeavoured to fill up the whole niche in which the nest lay with building material.

An analysis of the measurements of Sparrows' nests built in the urban environment indicated that the spatial conditions provided by a niche had a considerably smaller effect

Table IV
 Variability of the House Sparrow's nest measurements – expressed by
 PEARSON's coefficient ($\frac{SD}{\bar{x}} \times 100\%$).

Environment	No. of nests	Outer measurements			
		length	width	height	mean
Rural	19	39.2	38.8	42.6	46.9
Suburban	23	73.8	38.8	50.0	54.2
Urban	32	27.7	27.0	23.6	26.1
Total	74	53.6	34.9	38.7	42.4

Environment	No. of nests	Inner measurements			
		length	width	nest-cup depth	mean
Rural	19	27.5	46.4	33.9	37.7
Suburban	23	23.4	40.0	38.1	33.8
Urban	32	13.9	15.0	31.8	20.2
Total	74	21.6	33.8	34.6	30.6

Table V
 Mean measurements of the House Sparrow's nests in relation to the spatial
 limitation of the niche.

Degree of spatial limitation of niche	Mean measurements							
	outer (cm)				inner (cm)			
	No. of nests	length	width	height	No. of nests	length	width	nest-cup depth
unlimited	55	42.6	37.8	14.8	51	10.4	8.7	4.4
limited	94	26.4	12.0	13.1	88	8.4	7.3	3.9

on the inner than on the outer dimensions. The capacity of the cups of the nests built in spacious niches (e.g. Types A and B) was scarcely about 40% greater than that of the nests built in remarkably limited spaces (Types D, F, G, and M), whereas the volume of the whole nest was about 5.8 times as large (Table V). As a result, the nests built in spacious niches were characterized by considerably thicker side walls and a longer entrance passage (INDYKIEWICZ 1990).

The most nests placed at spatially unlimited sites (Types A, B, E and P) were observed in the urban environment (57.2% of the nests), fewer in the suburban environment (25.3% of the nests), while in the rural environment they formed hardly 3.1%. On the other hand, in strongly limited places (Types D, M, N and O) the Sparrow built 12.6% of the its nests in the urban and rural environments and 6.2% in the suburban environment. The remaining 30.2% of the nests in the urban environment, 68.5% in the suburban environment and 84.3% in the rural environment were built in somewhat limited places (e.g. Types F and G).

The nests of the urban environment showed the lowest mean variation of all parameters. It was lower than the variation found in the nests in the rural and suburban environments, where it was about 1.9 times as high in the case of outer measurements and about 1.7 times as high as regards the inner measurements.

VII. NEST BUILDING MATERIAL

A. The Use of Particular Building Materials

For building their nests Sparrows used a broad range of materials, which, in general, can be divided into materials of natural origin (derived from plants and animals) and man-made materials.

Down and covert feathers, grass inflorescences, stalks and roots of plants, bark and bast, threads, string, pieces of paper and wool (Tables VI and VII) are acknowledged as characteristic materials, that is, such as appear in at least 60% of the nests.

Significant environmental differences were found in the use of particular groups of nest building materials. And so, for instance, in the nests in the urban and suburban environments the vegetable and animal material averaged about 95 and 97% of all the materials identified, whereas in the rural environment those sorts of materials made only 41% and the remaining 59% were man-made materials.

In the urban environment Sparrows used all the 17 sorts of man-made materials distinguished for nest building, while in the rural and suburban environments only 10 sorts of these materials (about 59%) were applied. In the urban environment the relatively highly isothermal materials such as paper, cotton wool, wadding and fragments of fabric were much more commonly used than in the rural and suburban environments (SKOWRON & KERN 1980). These materials were found in 73% of the nests in the urban environment, hardly 30% of the nests in the rural environment and 26% of the nests in the suburban environment.

Some significant environmental differences were also observed as regards animal materials, which in particular refers to down and covert feathers. The frequency of their use for building nests (especially their cups) reached 100% of the nests in the rural environment and about 70% in the suburban environment. However, the essential point of the difference lies in the number of feathers used by the birds to build their nests. For instance, the mean number of feathers found in the nests in the rural environment (\bar{x} = about 396 feathers) and in the suburban environment (\bar{x} = about 476 feathers) was

Table VI
Numbers of the House Sparrow's nests with particular kinds of building materials.

Material	Environment						Total (572 nests)	
	Rural (93 nests)		Suburban (71 nests)		Urban (408 nests)			
	n	%	n	%	n	%	n	%
feathers (coverts)	93	100.0	56	78.9	384	94.1	533	93.2
feathers (down)	93	100.0	43	60.6	264	64.7	400	69.9
animal hair	34	36.6	7	9.9	96	23.5	137	24.0
horsehair	29	31.2	—	—	8	2.0	37	6.5
grass inflorescences	82	88.2	28	39.4	408	100.0	518	90.6
stalks and roots	88	94.6	18	25.4	388	95.1	494	86.4
bark and bask	73	78.5	57	80.3	296	72.5	426	74.5
twigs	69	74.2	43	60.6	232	56.9	345	60.3
leaves of trees and shrubs	78	83.9	7	9.9	248	60.8	333	58.2
sticks	15	16.1	—	—	16	3.9	31	5.4
moss	10	10.8	8	11.3	8	2.0	26	4.5
threads	44	47.3	57	80.3	370	90.7	471	82.3
string	73	78.5	28	39.4	360	88.2	465	81.3
paper	29	31.2	28	39.4	360	88.2	417	72.9
wool	49	52.7	28	39.4	328	80.4	405	70.8
jute	25	26.9	28	39.4	296	72.5	349	61.0
wadding	24	25.8	21	29.6	280	68.6	325	56.8
fragments of fabric	34	36.6	14	19.7	248	60.8	296	51.7
cotton wool	5	5.4	—	—	272	66.7	277	48.4
cotton	78	83.9	36	50.7	152	37.2	266	46.5
cigarette tissue	—	—	28	39.4	176	43.1	204	35.7
cigarette filter	—	—	21	29.6	136	33.3	157	27.4
nylon fibre	34	36.6	—	—	80	19.6	114	19.9
foil	—	—	—	—	96	23.5	96	16.8
decorative ribbon	—	—	—	—	64	15.7	64	11.2
insulation tape	—	—	—	—	16	3.9	16	2.8
wire	—	—	—	—	16	3.9	16	2.8
earth	88	94.6	64	90.1	384	94.1	536	93.7

Table VII

Number of pieces of particular kinds of materials used by the House Sparrow to build one nest (\bar{x} – mean, max. – maximum values are given).

Material	Environment						Total (572 nests)	
	Rural (93 nests)		Suburban (71 nests)		Urban (408 nests)			
	\bar{x}	max.	\bar{x}	max.	\bar{x}	max.	\bar{x}	max.
feathers (coverts)	306.1	1434	469.0	3407	37.7	145	287.6	3407
feathers (down)	36.2	161	7.4	360	5.5	44	49.1	360
animal hair	6.3	48	0.1	1	1.7	20	2.7	48
horsehair	1.1	9	–	–	0.7	10	0.6	10
stalks and roots	1602.0	6182	687.3	3159	2019.1	7902	1436.1	7902
grass inflorescences	30.1	115	2.0	9	19.8	53	17.3	115
twigs	4.0	19	4.2	21	10.8	65	6.3	65
leaves of trees and shrubs	5.0	15	0.1	1	3.0	26	2.7	26
bark and bask	6.2	19	1.4	6	5.2	17	4.3	19
sticks	0.1	1	–	–	0.0	1	0.0	1
moss	0.1	1	0.1	1	0.0	1	0.0	1
threads	2.6	12	6.7	34	68.5	442	25.9	442
jute	9.6	44	1.7	12	4.2	11	5.2	44
cotton	5.6	37	0.8	3	13.2	33	6.5	37
paper	0.1	2	2.3	13	10.9	35	4.4	35
string	2.9	10	0.4	2	13.7	25	5.7	25
wool	1.6	13	0.8	4	3.7	21	2.0	21
cigarette tissue	0.0	1	0.7	5	2.2	19	1.0	19
cotton wool	0.1	1	–	–	2.3	12	0.8	12
decorative ribbon	–	–	–	–	0.5	11	0.2	11
fragments of fabric	0.5	4	0.3	2	1.6	9	0.8	9
wadding	0.6	6	0.4	2	0.5	3	0.5	6
nylon fibre	0.8	5	–	–	0.1	1	0.3	5
cigarette filter	–	–	0.6	3	0.2	2	0.3	3
wire	–	–	–	–	0.1	2	0.0	2
foil	–	–	–	–	0.1	1	0.0	1
insulation tape	–	–	–	–	0.0	1	0.0	1

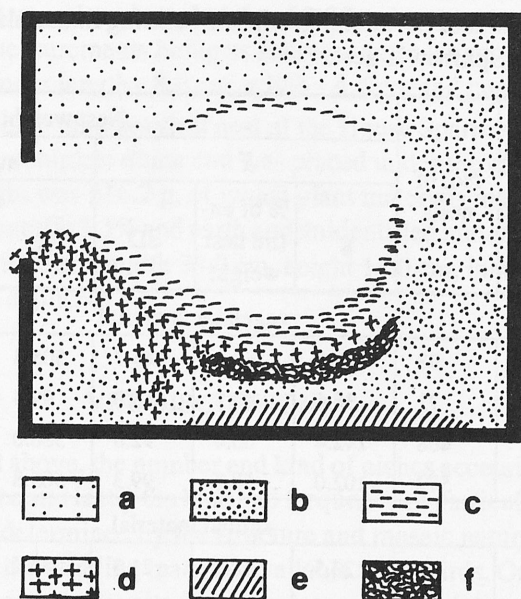


Fig. 4. Example of structure of the House Sparrow nest (INDYKIEWICZ 1990 – modified). Materials used to build the nest: a – stalks, b – stalks mixed with roots, c – animal material (feathers and hair), d – man-made materials, e – earth, f – unidentified.

about 9-11 times as high as the number of feathers encountered in the nests in the urban environment (\bar{x} = about 43 feathers).

Environmental differences were also seen in the frequency of vegetable materials used for nest building, especially stalks and roots of grasses (used chiefly to build nest walls and roofs) (Fig. 4). These materials were used in about 95% of the nests in both rural and urban environments and in hardly about 25% of the nests in the suburban environment.

B. Nest Weight

The great differentiation of the nest size and the diversity of nest materials resulted in a broad range of total nest weights. The mean weight of the Sparrow's nests was 158.7 g and they ranged from 15.3 to 616.2 g ($n = 572$, $SD = 115.0$). The highest mean weight, equal to 228.5 g ($n = 408$, $SD = 101.9$) was found for the nests in the urban environment. The lightest nests in this environment weighed 31.7 g and the heaviest ones 449.3 g. The mean nest weight in the rural environment was 169.6 g ($n = 93$, $SD = 166.7$) with a range from 24.1 to 616.2 g, whereas the nests in the suburban environment showed the lowest mean weight of 78.1 g ($n = 71$, $SD = 76.5$), ranging from 15.3 to 287.2 g.

The frequency of the use of particular sorts of materials by the Sparrow for nest building (Table VI) corresponded closely with their percentage contributions to the total nest weight. And so the vegetable materials averaged about 59% of the nest weight, the animal materials 17.9%, the man-made materials 13.44% and the earth brought to the nests with plants 16.1% (Table VIII). The remaining material, 3.3%, was unidentified, e.g. rotten

Table VIII

Proportion of particular groups of building materials in the entire mass of the House Sparrow's nest.

Environment	No. of nests	Nest weight (g)						
		\bar{x}			max.		min.	
		g	% of en- tire nest weight	SD	g	% of en- tire nest weight	g	% of en- tire nest weight
vegetable material								
rural	93	125.1	60.8	145.7	505.8	94.8	8.3	28.8
suburban	71	38.6	49.3	56.0	99.4	73.6	6.7	32.1
urban	408	142.4	65.4	92.6	380.0	93.1	28.0	26.5
total	572	102.0	58.3	99.3	505.8	94.8	6.7	26.5
animal material								
rural	93	23.5	18.7	21.3	89.2	61.7	0.7	0.6
suburban	71	21.3	24.5	32.9	96.8	100.0	0.3	0.2
urban	408	7.7	3.5	6.1	46.3	38.0	0.3	0.2
total	572	17.5	15.6	20.2	96.8	100.0	0.3	0.2
man-made material								
rural	93	3.3	2.5	5.8	8.3	14.0	0.0	0.0
suburban	71	1.6	2.0	6.4	5.5	9.1	0.3	0.5
urban	408	35.3	16.2	27.8	98.0	48.7	0.0	0.0
total	572	13.4	6.9	13.3	98.0	48.7	0.0	0.0
earth								
rural	93	17.7	15.8	16.9	57.0	45.4	1.5	0.9
suburban	71	16.6	24.2	12.1	38.5	38.6	5.9	16.2
urban	408	14.0	7.0	11.6	76.4	33.4	0.8	0.2
total	572	16.1	15.7	13.5	76.4	45.4	0.8	0.2

pieces of plants and man-made stuffs in consequence of the action of faeces. The relatively high proportion of unidentified materials (about 8%) in the total nest weight, noted in the urban environment, may indicate the frequent use of the same nest for several broods.

The common use of man-made materials by the Sparrow in the urban environment found its reflection in the proportion of this material in the total nest weight. It averaged about 16% of the nest weight and was 7.3 times as heavy as the material of this kind recorded from the other environments.

A nest built whole of feathers was found in the suburban environment. The birds used 3407 feathers to build it. It was placed at a height of 2.95 m in a tree-hole-like niche in a house wall (Type G), its measurements being as follows: outer length - 55.0 cm, width - 7.5 cm, height - 21.0 cm, inner length - 8.0 cm, width - 4.5 cm and cup depth - 3.5 cm.

The biggest and at the same time heaviest nest of the House Sparrow was found in the rural environment. It had a complete dome and was placed under the eaves of a house, at a height of 7.7 m. Its weight was 616.2 g, of which plant materials made 82.1%, animal material 11.1%, man-made stuffs 3.3% and earth and unidentified materials the remaining 3.5%. Its outer length was 91.0 cm, width 28.0 cm, height 14.0 cm, inner length 10.5 cm, width 8.0 cm and nest-cup depth 6.5 cm.

VIII. DISCUSSION

As has been pointed out above, the number and kind of niches accessible to Sparrows, their nesting height, nest size and lastly the kind and frequency of particular nest materials were directly or indirectly determined by the structure and mosaic nature of buildings in the given environment and the building material available to the birds. On the other hand, as regards the choice of an actual nest-site in the environment, the following reciprocally complementing factors are decisive: the situation of the niche, material of which it is built, nesting height, exposure of the nest-site, spatial conditions of the niche and food basis (INDYKIEWICZ 1990). It may be stated in general that the House Sparrow preferred very spacious niches 3-5 m above the ground, with wooden walls and exposed to the east.

The upper nesting limit I found to be at a height of 32.2 m (Table II) and so exceeding the limit reported by POPOW (1962), BARLOY (1966), KULCZYCKI & MAZUR-GIERASIŃSKA (1968) and IORDACHE (1970) by about 20 m, seems to have been due mainly to the fact that the present study included also town areas built over by modern large-panel buildings of more than ten storeys. The minimum nesting height of 2 m observed in the present study was besides given only by ŁACKI (1962). SUMMERS-SMITH (1963, 1980) described Sparrows' nests placed still lower. One of them was situated in a gorse bush, at a height of a few inches, and another underground (in a coalmine gallery). And yet the ranges of nesting heights most commonly occupied by this species, 3-4 m according to KULCZYCKI and MAZUR-GIERASIŃSKA (1968), 5-6 m acc. to IORDACHE (1970) and 3-7 m acc. to SUMMERS-SMITH (1963), resemble the present findings. It seems that the Sparrows preferred heights between 3 and 5 m for three reasons. One of them may be adaptation caused by the attempts of hole dwellers to evade the pressure of birds of prey (NILSSON 1975, 1983, 1984). This may also be due to a tendency for the Sparrow to forage most frequently in proximity to the nest (BARNARD 1980, DAWSON 1972, SUMMERS-SMITH 1963) so as not to lose sight of it or to go beyond the range of audibility of the chicks in it; then, in case of direct danger the bird is able to react immediately (SECKER 1975). DYRCZ (1982) observed similar behaviour in *Turdus grayi*. On the other hand, the Sparrow may place its nests at considerable heights, especially in an urbanized environment, for the lack of lower-lying places fit for nesting and the simultaneous increase in the density of the population, which NILSSON (1984) pointed out for other hole dwellers.

The density of occurrence of the Sparrow in the territory of Poland ranged from 0.5 to 81.9 breeding pairs per 10 ha (GÓRSKI & GÓRSKA 1979, JAKUBIEC & BLUJ 1977 and others). This problem can also be considered in the aspect of the expenditure of energy made by a breeding pair if only in the period of feeding their young: the lower is the nest situated, the more energy and time needed for getting food for the chicks is saved, as indicated indirectly by DOLNIK's (1987) data.

One of the interesting adaptations of the Sparrow is its utilization of street lamps and neon signs for nesting (SUMMERS-SMITH 1963, HYLÁ 1971, HEER 1973, NANKINOV 1984, INDYKIEWICZ 1990). It may be supposed that the choice of such places is of advantage to this bird. Actually, the lighted nest-site provides much more favourable thermal conditions for surviving cool nights and for faster and more successful rearing the young. NANKINOV (1984) suggest simply that such conditions create a good chance for *Passer montanus* to have a brood or two more in a breeding season. Moreover, a nest situated in such places has a very small entrance opening and so it is virtually inaccessible to a predator larger than the Sparrow itself. An additional advantage of these places is their situation at a height of 4-5 m and then within the range most preferred by this species. I shall venture the statement that the great attractiveness of these nest-sites and others like them may be one of many reasons for which Sparrows increasingly rarely build their detached nests in trees and Virginia creepers (Table IX). It seems however the main cause was the strong pressure of nest predators (*Pica pica*, *Corvus corone*) in the season of nest building and the first brood (i.e. March-April), when the nest placed amidst the branches of a tree has no protection (in the northern zone of the temperate climate it is the beginning

Table IX

The situation of the House Sparrow's nests in the territory of Poland in 1963-66 and 1982-85 (expressed as percentages of the nest-sites observed in the given environment).

Situation of nest	Environment					
	Rural		Suburban		Urban	
	1963-66 ¹	1982-85 ²	1963-66	1982-85	1963-66	1982-85
-houses	68.7 ³	77.1	64.9	89.5	68.4	84.1
in them: - roofs	47.1	13.8	32.4	31.5	8.7	21.9
- walls	21.6	35.6	24.3	51.3	19.4	24.8
- gutters	0.0	27.7	8.2	6.7	40.3	37.4
-vegetation	21.6	0.0	33.1	0.0	30.3	0.2
in it: - trees	19.6	0.0	0.0	0.0	0.0	0.0
-creepers on walls (e.g. Virginian creeper)	2.0	0.0	33.1	0.0	30.3	0.2
-neon signs and street lamps	9.7	22.5	2.0	10.5	1.3	15.7

^{1,2}Data obtained from works by KULCZYCKI and MAZUR-GIERASIŃSKA (1968) and INDYKIEWICZ (1990).

³Nests in particular types of sites as percentages of the total of nests found by either author.

of vegetation season). This is confirmed by POPOV's (1962) reports; he observed Sparrows occupying various recesses of houses for the first brood and constructing their nests in trees for the second brood in Moscow. NICE (1937), NOLAN (1978) and TOMEK (1980) also found a relationship between the nesting sites of *Melospiza melodia*, *Dendroica discolor* and *Prunella modularis* and the developmental state of the foliage of trees. Furthermore, the building of a nest in open site often requires a higher expenditure of energy of the breeding pair than the building of nests in protected places. Hence, the utilization of artificially protected places by Sparrows is probably about twice as frequent as that of unprotected ones (INDYKIEWICZ 1990).

The House Sparrow much oftener used protected places (e.g. spaces of flat roofs, niches behind gutter-spouts in recesses in a house, electric bulb casings of street lamps and neon signs) for nest colonies than unprotected places. According to COLLIAS and COLLIAS (1984), this proves that gregarious nesting of the passerines is a kind of protection against predators (the success of rearing the young in trees is 1.6 times smaller than that observed in protected places - ESCOBAR & GIL-DELGADO 1984) and not, as CHAPIN (1954), CROOK (1962), CROOK and BUTTERFIELD (1968) and LACK (1968) state, that the only cause of the formation of colonies is one source of food common to all.

Striking is also the Sparrow's ability of adapting the niches that differ exceedingly from each other in size. For instance, when the only available places are those of very limited spaces, the Sparrow confines itself to very scanty lining (Section VIIA and INDYKIEWICZ 1990). In COLLIAS & COLLIAS's (1964) opinion this behaviour evidences that this species acquired the greatest skill in adapting existing cavities. In adapting very spacious niches, the Sparrow is observed to fill them up completely with building material, with an entrance passage leading to the nest cup (NOVOTNY 1970, INDYKIEWICZ 1990). Such a procedure allows the Sparrow to compete successfully with *Sialia sialis* (ZELENY 1978).

The extreme plasticity of the Sparrow is also evidenced by a broad range of materials used by it to build a nest. It handles any available material in an easy manner, using e.g. paper and foil as substitutes for feathers (Sec. VII and PITTS 1979). Its great plasticity has also been pointed out by SENGUPTA (1981) in his report on the use of green leaves of the tree species *Azadirachta indica* by the House Sparrow in Calcutta.

Naturally, the above-mentioned examples do not exhaust the whole range of behaviours that point to the adaptive plasticity of the species. Suffice it to mention, if nothing else, the reports on the adaptation of nests of as many as 14 avian species by the Sparrow for its breeding sites (SUMMERS-SMITH 1963, CATUEANU & THEISS 1965, IORDACHE 1970, NANKINOV 1984 and many others), the use of such places as a balcony flower-box to build its nest in it (KULCZYCKI & MAZUR-GIERASIŃSKA 1968), an aeroplane left to be repaired (BRIDGMAN 1962), rock cracks (SCHMIDT 1966, SUDHAUS 1967 and others) or on the placement of a nest between the conductors of an electric traction line (BARLOY 1966).

Variation found in the Sparrow's nests in particular environments may evidence that a faculty for fast adapting to definite environmental conditions is more important to an individual population than lasting and directed selection; in the case of this species that faculty seems to be unlimited (LOWTHER 1977).

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