INSTITUTE OF ECOLOGY-POLISH ACADEMY OF SCIENCES

EKOLOGIA POLSKA

Vol. XVIII Warszawa 1970 No. 14

Department of agroecology, Turew

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BREEDING COMMUNITIES OF BIRDS IN MID-FIELD AFFORESTED AREAS

(Ekol. Pol. 18: 307–350). In mid-field afforested areas 44 bird species were found to nest. 18 of these species appeared to be typical to this habitat, representing 60–90% of the total number of birds of a community. Although in small afforested areas fewer species nest than in the large ones, the total population density there is higher. Species that feed in fields are more abundant in small afforested areas than in large ones. Their breeding territories are small. Only a slight relationship is seen between the size of an afforested area and the population density of those species which feed in it. The breeding territories of this group of birds are large, spreading along the afforested areas.

Contents

INTRODUCTION

The purpose of present study is to ascertain the species composition of communities of birds nesting in mid-field afforested areas, the origin of the species in the community and the density and distribution of the birds. A trial is made to elucidate the relationship between these phenomena and the kind, size and structure of the afforested areas.

Mid-field afforestations fall into clumps, shelterbelts, alleys and rows of trees or shrubs found in the open country. In our conditions, mid-field afforestations are artificial like other areas with man-planted trees near houses or riverside, and also orchards, parks, forests. They differ considerably in surface area, location and management. Their equivalents under natural conditions are landscape elements associated with the forest-steppe zone and even with the steppe or shrub-desert zone (Berg 1962).

To establish the composition of the bird community of a midd-field afforested area the common practice is to take into account all those species which build nests in the particular area; similarly, in the calculation of the density of breeding pairs only those pairs are considered whose nests have been found within the given afforested area. These is a different approach to this problem, in which all the bird species and individuals found in an area are included into the community of that area. Both these methods have their disadvantages. The former will exclude from a community a number of species and pairs which in spite of having their nests outside the afforested area could not occur in an area with no trees at all. If the latter method is applied birds found in a given afforested area only occasionally will be regarded to belong to the community characteristic of that area. For this reason, in the research were described bird species which were found to have their nests in afforested areas, as well as those which do not build their nests in afforested areas, but need them to maintain their breeding territories. Although their dependence on afforested land, as regards food, appears to be considerable, those bird species which only visit afforested areas to feed, have not been included into the mid-field afforestation communities, because their occurrence there is accounted for by the presence of forests in the neighbourhood, where they nest. As the connection of the birds with the biotope is the strongest during the breeding season, this study is restricted to that period alone. The study does not include accipiters, owls or gallinaceous birds, because the method of material collecting, which was used, did not insure adequate results concerning these groups. *Cuculus canorus* L. was also left out.

Many papers have so far been published dealing with mid-field afforestation avian fauna. Most of them are based on researches carried out in East European regions, i.e. under conditions of steppe, forest-steppe or semi-desert zones, which differ from the conditions prevailing in our country. Most of the papers are concerned with the qualitative composition of the avian fauna, with the distribution of birds within a biotope or the significance of birds for agriculture. There are considerably fewer papers describing the abundance and density of birds (Volčaneckij 1952, Micheev 1953, Budničenko 1960b, 1961). An extensive round-up of the results of all the research work carried out so far by the Soviet scientists has been written by Budničenko (1965).

Although fewer investigations have hitherto been carried out in Central Europe, most of the reports contain data concerning the numbers of birds. Among the papers to be noted are those by: Tischler (1948), Mildenberger (1950), Czarnecki (1956), Foksowicz and Sokołowski (1956), Riabinin (1957a), Turček (1958), Schmidt (1964), Seibert (1967). Notes on some bird species nesting in mid-field afforested areas can also be found in papers concerned with other topics (e.g. Sokołowski 1962).

In mid-field afforestations, as in other cultivation landscape-elements, the fauna consists primarily of species of local origin (Dementeev and Spangenberg 1949, Gladkov 1958, 1960, Strawiński 1965), therefore species associated with mid-field afforestations will vary with the geographical zones. Population density (Budničenko 1965) and habitat preference (Gladkov 1949, Voinstvenskij 1960) also vary with geographical zones. It follows that conclusions based on evidence supplied by a research carried out in one are do not apply to other areas. Studies on mid-field afforestation avian fauna must, therefore, by continued, especially in Poland where few studies have hitherto been carried out in this field.

STUDY AREA

The research was carried out in the years 1964–1966 in areas near Turew, Kościan district, with a lowland, typically agricultural landscape. The forests found there form small patches, each of several dozen hectares in surface, occupying about 13% of the area. There are also a number of manorial parks, and a great variety of mid-field afforestations. These are remnants of the afforestations established there during the first part of 19th century.

Regular observation was carried out in selected mid-field afforested areas (Fig. 1). In addition, bird fauna of the neighbouring areas was observed.

In selecting the afforested areas for study two criteria were considered: firstly, they had to be of comparatively uniform structure and size, and, secondly, they should represent a range from large afforested areas with a complex structure to small ones with a simple structure.

The following types of afforestation were selected: clumps, shelterbelts, alleys, tree-rows with hedge, hedge-rows and shrubbelts.

As clumps and shelterbelts showed a considerable variation of surface

Description of the mid-field afforestated areas under research

Tab. I

Kind of afforestation	Symbol	Size (area in ha or breadth in m)	Tree-layer	Shrub-layer	Nest-boxes	Distance from dwellings (m)
Large clumps	C1	2.1 ha	+	++	+	500
	C2	2.0 ha	+	–	–	300
	C3	2.0 ha	+	+++	–	300
	C4	1.7 ha	+	+	–	300
Medium-sized clumps	C5	1.2 ha	+	+++	–	700
Small clumps	C6	0.6 ha	+	+++	–	1000
	C7	0.5 ha	+	–	–	300
Very small clumps	C8	0.4 ha	+	+++	–	500
Broad shelterbelts	B1	on an average 50 m (26–87 m)	+	–	–	200
	B2	37 m	+	+++	+	500
Medium-broad shelterbelts	B3	on an average 28 m (18–37 m)	+	++	+	200
	B4/1	on an average 25 m (20–33 m)	+	–	–	200
	B4/2	23 m	+	–	+	1000
	B5	20 m	+	+++	+	500
Narrow shelterbelts	B6	on an average 15 m (10–20 m)	+	–	+	100
	B7	12 m	+	–	+	500
Very narrow shelterbelts	B8	6.5 m	+	–	–	800
Alleys	A1	9 m	+	–	–	400
	A2	9 m	+	–	–	200
Tree-rows with hedges	R1	10 m	+	+++	–	200
	R2	ca 7.5 m	+	+++	–	300
	R3	9 m	+	+++	–	1200
Hedgerows	H	13 m	–	+++	–	400
Shrubbelts	S	9 m	–	++	–	400

+ present, – absent. Shrub-layer: + thin, ++ medium-thick, +++ thick.

whereas the relationship between bird distribution and the herb-layer was not studied. The shrub-layer was described from the point of view of its structure and thickness of growth.

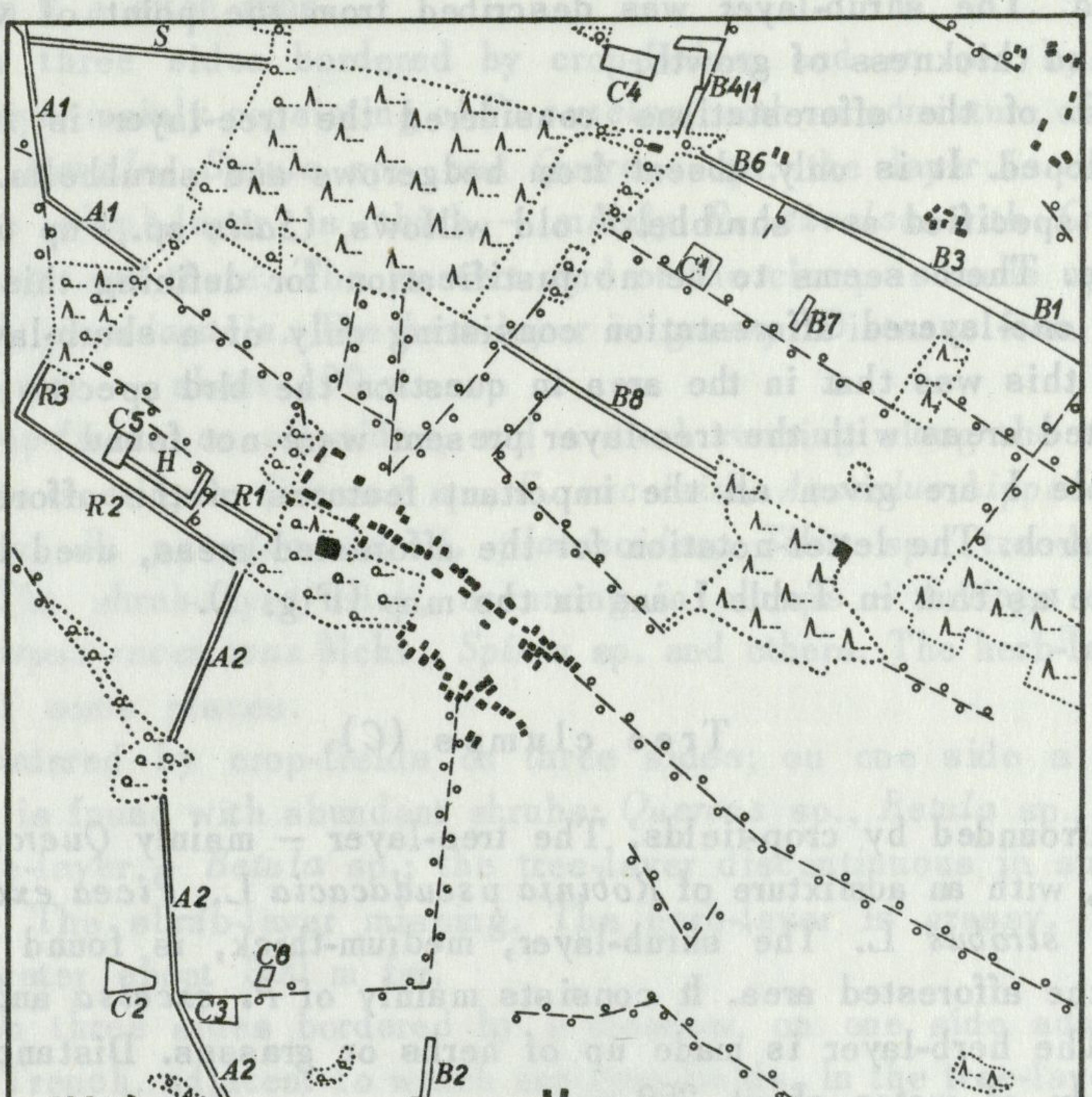

Fig. 1. Map of study area

1 — forests, large mid-field afforestations, *2* — mid-field afforestations, *3* — mid-field afforestations under research, *4* — built-up area. Letter notation same as in Tab.I

area, they were specified according to the following rules: large tree-clumps were defined to be afforested areas of 1.5–2.0 ha; medium-sized — about 1 ha; small — about 0.5 ha; very small — below 0.5 ha. Broad shelterbelts were defined as being above 30 m in average breadth; medium-broad — from 20 to 30 m; narrow — 10 to 20 m; very narrow — below 10 m.

In addition, the afforestations under study differed in size of plant layers. Three layers were distinguished: a tree-layer, shrub-layer (in the text a synonymous term "undergrowth" is used) and a herb-layer. In later considerations, however, only the tree and shrub layers were taken into account, whereas the relationship between bird distribution and the herb-layer was not studied. The shrub-layer was described from the point of view of its structure and thickness of growth.

In most of the afforestations considered the tree-layer is found to be well developed. It is only absent from hedgerows and shrubbelts. In one of the areas, specified as "shrubbelt" old willows, (*Salix* sp.,) up to 7 m tall, were found. There seems to be no justification for defining this afforested area as a one-layered afforestation consisting only of a shrub-layer but the reason for this was that in the area in question the bird species peculiar to all afforested areas with the tree-layer present were not found.

In Table I are given all the important features of the afforested areas under research. The letter-notation for the afforested areas, used in the text, is the same as that in Table I and in the map (Fig. 1).

Tree clumps (*C*)

C1. Surrounded by crop-fields. The tree-layer – mainly *Quercus* sp. and *Betula* sp., with an admixture of *Robinia pseudacacia* L., *Picea excelsa* Link. and *Pinus strobus* L. The shrub-layer, medium-thick, is found over about a half of the afforested area. It consists mainly of *P. excelsa* and *Sambucus nigra* L. The herb-layer is made up of herbs or grasses. Distance from the nearest body of water about 250 m.

C2. On two sides bordered by crop-fields, on one – by a meadow and on one – by a tract of waste-land. The tree-layer mainly *Betula* sp. in very bad condition, *R. pseudacacia*, single specimens of *Pinus silvestris* L. and *Picea excelsa*; loose layer structure. The shrub-layer – single specimens of *Crategus* sp. A grassy herb layer. About 50 m from the nearest body of water. The area is intersected by a field-road.

C3. On one side bordered by the Wyskocki Trench followed by meadows, on one by an asphalt road lined by *Acer platanoides* L., and on the remaining two sides – by crop-fields. The tree-layer – mainly *Alnus glutinosa* Gaertn., *R. pseudacacia*, single *Populus tremula* L., *Salix* sp. and *Quercus* sp.; tree-stand structure continuously thick, good condition. The shrub-layer very thick – *S. nigra*, *Evonymus* sp., *Rhamnus catharctica* L., *A. platanoides*, *Crategus* sp., *Rubus* sp. and others. Abundant *Humulus lupulus* L. Exuberant, herbaceous herb-layer.

C4. On three sides bordered by crop-fields and on one by a meadow about 100 m broad, followed by a sizeable tract of woodland, over ten hectares in surface area. The tree-layer – *R. pseudacacia* and *Fraxinus excelsior* L.; the tree-stand of loose structure and bad condition. The shrub-layer single bushes of *S. nigra*, *Crategus* sp. and *Prunus padus* L.; near the clump margin occasional *Prunus spinosa* L. are found. The herb-layer grassy or herbaceous.

Within the afforested area two seasonal bodies of water are found; about 100 m from it a ditch runs.

C5. On three sides bordered by crop-fields, and on one by a meadow. The tree-layer mainly consisting of *P. excelsa*, with an admixture of *R. pseudacacia*, *P. tremula*, *Betula* sp., and *Quercus* sp.; the layer is continuously thick. The shrub-layer is thick – mainly *P. excelsa* with *Crategus* sp., *S. nigra* here and there. The western end of the clump is made up of a loose stand of *R. pseudacacia*. The herb-layer is grassy. Distance from the nearest body of water – about 100 m.

C6. Crop-fields on all sides, and a ditch running along the edge on one side. In the tree-layer: *Quercus* sp., *F. excelsior*, *Aesculus hippocastanum* L., *P. excelsa*, *R. pseudacacia*, *A. platanoides*, *Tilia* sp.; tree-layer discontinuous. The shrub-layer thick, occurring in clumps – *Syringa vulgaris* L., *Symphoricarpus racemosus* Mchx., *Spirea* sp. and others. The herb-layer grassy, missing at some places.

C7. Bordered by crop-fields on three sides; on one side a young pine-plantation is found with abundant shrubs: *Quercus* sp., *Betula* sp., *P. tremula*. In the tree-layer – *Betula* sp.; the tree-layer discontinuous in structure, bad condition. The shrub-layer missing. The herb-layer is grassy. The nearest body of water about 300 m far.

C8. On three sides bordered by a meadow, on one side adhering to the Wyskocki Trench, adjacent to which are crop-fields. In the tree-layer: *A. glutinosa*, *Salix* sp., *Betula* sp.; the layer is continuous and thick throughout its length. The shrub-layer – *Rhamnus frangula L.*, *A. glutinosa*, *S. nigra*, *Crategus* sp., *Rubus* sp., *H. lupulus*. The herb-layer consists of herbs alone or grasses.

Shelterbelts (*B*)

B1, *B3*, *B6*. With crop-fields around, except for a 700-metre section of the southern edge where a nursery is found. A field road runs along the afforested area. In its north-western part the area is intersected by a ditch; another ditch is found running, at a distance of about 200 m, along the southern margin. Considering its variable breadth and structure of vegetation the afforested area was subdivided into three section each of which will be dealt with separately. Section 1 (*B6*), 700 m long: the tree-layer – mainly *R. pseudacacia* with *Quercus* sp., *F. excelsior* and *Ulmus campestris* L. here and there; moderate density. The shrub-layer is missing; the herb-layer consists of grasses. Section 2 (*B3*), also 700 m long: the tree-layer *Betula* sp., *Quercus* sp., *R. pseudacacia*, *F. excelsior*, *P. tremula*, with single trees of other species; medium-dense. The shrub-layer thin, consisting of clumps – *P. tremula*, *Crategus* sp., *R. pseudacacia*, *Sorbus aucuparia* L. and others. The herb-layer – herbs or grasses. Section 3 (*B1*), 400 m long: the tree-layer

– *Larix europaea* DC, *Quercus* sp., *R. pseudacacia*, *Betula* sp.; medium density. The shrub-layer – single shrubs: *P. tremula*, *R. pseudacacia*, *Crategus* sp. The herb-layer made up of grass or missing.

B2, *B4/2*, *B5*. The first section, 275 m long, lies in the neighbourhood of meadows, the remainder of the area bordering on crop-fields. A field road runs along all the parts of the afforested area. About 200 m from the northern edge of the area the Wyskocki Trench runs, and on its southern side a small pond is found. Another small pond is situated in the centre of the afforested area; across the northern portion of the area a ditch runs. The area was divided into three parts, each of them will be discussed separately. Section 1 (*B2*), 275 m long: the tree-layer – *A. glutinosa*, *R. pseudacacia*, *Quercus* sp.; the layer is thick. The shrub-layer, also thick, consists of: *S. nigra*, *Rh. cathartica*, *Rh. frangula*, *Crategus* sp., *H. lupulus*. The herb-layer is exuberant, herbaceous. The second section (*B5*), 800 m long: the tree-layer – *R. pseudacacia* with sporadic specimens of *Quercus* sp. and *L. europaea*; moderate density. The shrub-layer, thick, especially in its part extending to the east of the road that runs through the centre of the afforested area: *S. nigra*, *R. pseudacacia*. The herb-layer herbaceous and grassy. The third section (*B4/2*), 600 m long: the tree-layer – *R. pseudacacia*, single *Quercus* sp. The shrub-layer – single shrubs of *S. nigra* and *Crategus* sp. The herb-layer grassy.

B4/1. 500 m in length. Bordered by crop-fields, and on one side, over a stretch of 200 m, by a meadow. In the tree-layer *R. pseudacacia* with ocassional *Quercus* sp.; in the north-western part of the area also *Betula* sp., *U. campestris* and *Populus* sp. In the shrub-layer – single shrubs of *Crategus* sp., and *Rosa* sp. The herb-layer grassy. The distance to the nearest body of water 100 m.

B7. Surrounded by crop-fields. In the tree-layer – *R. pseudacacia*. The shrub-layer missing. The herb-layer grassy. The distance to the nearest body of water 250 m.

B8. 1000 m long. A ditch intersects the afforested area at one third of its length. Crop-fields extend on either side. In the tree-layer – *R. pseudacacia*. The shrub layer missing. The herb-layer grassy.

Alleys (*A*)

A1. This is an alley, 1200 m long, running along an asphalt road. On either side of the alley crop-fields are found. The tree-layer – *Tilia* sp., *U. campestris*, *A. platanoides*, *F. excelsior*, all in bad condition; spacing between trees 12 m. A ditch runs across the alley in its northern part.

A2. The area considered is an alley along an asphalt road. Its length is 1800 m. In the tree-layer – *A. platanoides*; bad condition. Spacing of trees 11 m. The Wyskocki Trench runs across the alley in its southern part; in the northern part, the distance from the nearest body of water is about 150 m.

Tree-rows with hedges (*R*)

R1. 200 m in length, with meadows on either side. In the tree-layer – single *P. tremula* and *F. excelsior*, about 10 m tall. The shrub-layer is made up of a compact thick hedgerow, 10 m broad and 5 m high, consisting of *Crategus* sp., *Rh. cathartica*, *Cornus* sp., *P. tremula* and others. A ditch runs across the tree-row.

R2. Roadside tree-rows, 1100 m long. The tree-layer – to the south, in the area considered single *Quercus* sp. and *U. campestris* or lines of *A. platqnoides*, and in the central part on the western side of the road single *Quercus* sp., 150-year old, are found. The last stretch, 200 m long, extending to the north, is planted with *A. platanoides*; the trees, about 20 m tall, are in a line, with 6-metre spacing; the condition of the trees is bad. The shrub-layer – on the eastern side of the road a hedgerow of *Crategus* sp., 5 m high and 7.5 m in breadth, is found. There are a few bodies of water, some 200 m from the area under study. The area is bordered by crop-fields, and, over a stretch of 200 m, with a meadow.

R3. Roadside tree-rows, 200 m in length, with crop-fields on either side. In the tree-layer, up to 23 m high – *Quercus* sp., *Populus* sp., *P. tremula*, *U. campestris*, *P. silvestris*, *Betula* sp. *Salix* sp.; the shrub-layer – a hedgerow of *Crategus* sp. with *Rosa* sp., *S. nigra*, *Rh. cathartica*. 150 m from the nearest body of water.

Hedgerows (*H*)

H: a hedgerow of *Crategus* sp., 475 m long, bordering on crop-fields and a meadow. The shrub-layer – a thick, 6 m tall hedge of *Crategus* sp. with scattered shrubs of *S. nigra*, *P. tremula*, *Cornus* sp., *Rh. cathartica*, *Rosa* sp. and *Salix* sp., and exuberant herbaceous vegetation along its edges.

Shrubbelts (*S*)

S. Two shrubbelts, 4.5 m broad and 1100 m long, on either side of a field road were selected for observation. On both sides the belts border on arable land. In the shrub-layer – single specimens of old pollard willow (*Salix* sp.), 7 m tall, *Crategus* sp., *F. excelsior*, *Pirus communis* L., *Malus* sp., *S. nigra*, *Tilia* sp., *P. tremula*, *Lycium vulgare* Dun., *A. platanoides*, *U. campestris*, *Betula* sp., *Prunus spinosa*, *Rubus* sp., *Rosa* sp. In gaps in the shrub-layer exuberant herbs and grasses are found. The nearest body of water is 150 m far from the shrubbelt considered.

MATERIAL AND METHODS

Techniques of material collecting in field. Numeric data was obtained by using a modified mapping method (Enemar 1959, Naumov 1963). All birds encountered in the field (seen or heard) were recorded on a 1:5000 scale sketch-map of the area under survey. The species, and where possible, also the sex of the birds was identified. Movements of individual birds were represented by lines connecting the points which represented the successive locations at which they were found. All nests as well as young birds just out-of-nest were marked on the map. From the sets of points representing the locations at which a given male or a pair of birds was found the boundaries of the breeding territories were determined. For a number of species the distance between the singing points of two different males, located near the border-line separating two territories, was sometimes very small. In such situations the boundary was established only when the two males were observed singing simultaneusly, or when they were seen fighting.

Field observation was carried out from 20th April until the first days of July. This period is the breeding season for all the bird species nesting in the area studied; most pairs complete their breeding activity during this period. Additional or second broods, which sometimes continued until the end of August, were not taken into account; broods repeated during the observation time were also neglected.

The observation timing during the day was 4 to 10 A.M., and 4 P.M. until dusk. Afternoon observation was planned on account of those species which sing much more rarely in the morning (e.g. *Turdidae*). However, it later appeared that the time immediately before dusk was very convenient also for recording other species, since they were singing then more intensely, and it was, therefore, easier to notice them. The reason for this probably lies in the fact that most of the species inhabiting mid-field afforestations feed in fields and feeding obviously is more intense in the morning than late in the afternoon. Another important factor may also be the winds, as will be pointed out later in the paper.

In the field, the observer moved slowly at equal speed, stopping for short periods for a better observation of birds and recording their movements. The duration of one census depended on the size of the afforested area studied.

Field observation was continued regardless of cloudiness or temperature, except during rainy days or days with strong winds. Even a moderate wind makes the observation of birds among trees difficult because due to the rustling of the leaves bird sounds cannot be heard. It is perhaps for this reason that observations carried out late in the afternoon, when the wind abates, always give good results.

The specification of the width of the census strip, so important in other habitats (Rogačeva 1963), is of no significance as far as mid-field afforested areas are concerned, because in this case the whole area is covered by the research.

Density assessment. When the number of censuses is small, the data obtained is likely to be weighted with a considerable error, because, firstly, those singing males which have not their own territories and are only temporarily occurring in the given area will be considered to be settled there, and secondly, not all occupied territories will be recorded. To avoid this the census should be repeated many times; some authors suggest it should be repeated 4 to 10 times (Kendeigh 1944, Danilov 1956, Enemar 1959).

It seems that the number of censuses may be reduced considerably if the number of occupied territories is established not only from the number of singing males encountered. In the research here described a territory was considered to be occupied when at least 3 times a singing male had been found in it, or when at least once a singing male was heard and at least once a pair of birds was encountered. Other proofs recognized included the presence of a nest with eggs or nestlings in it, or the presence of young birds, which although they had left the nest were too young to have arrived from a different territory. As a result, in a number of areas, after the 5th or 6th census already, the record included only the known pairs or the known males.

Another source of error in density assessment is the afforested area under research being short, due to which only part of a given territory is found, while the remainder of the territory lies within an unknown section, or in a wooded area nearby. This type of error will vary from one bird species to another: the density of species whose territory covers a short stretch can be assessed more accurately than that of birds with expanded territories. To avoid this error the length of the stretch of afforested area that is to be studied should be many times greater than the mean length of the territory of the given bird species; if it is 10 times as great as the length of the territory, there still is 10% probability of overestimating the density. It is difficult to avoid this error, because very often there is no afforested area long enough for that.

Material. The observation was continued along the same routes in the field. Table II shows the censuses made on each route in the years 1964–1966. During the 3-year period a total of 1959 bird pairs was recorded in the afforested areas under study.

Method of studying the material. As the variations in numbers, from year to year, of the most abundant species were small, and the permanency of

Number of censuses made in particular years

Tab. II

Afforestations	Number of censuses		
	1964	1965	1966
B2, B4/1, B5	13	8	11
C2, C3, C8	9	9	8
C5, H	9	6	7
C1, B3, B6, B7	9	9	10
C4, B4/2	8	6	6
B8	—	7	9
A1	—	9	6
A2	—	7	6
S	—	8	7
R	—	6	7
B1	—	—	10
C6	—	—	7
C7	—	—	11

occurrence of the species was rather great, it was possible to combine the data collected during the entire study period and consider them jointly as if the study area were twice or three times its actual size. The values thus obtained were more suitable for statistical calculations. Data relating to those afforested areas which were only studied in 1966 (*C7*, *C6*, *B1*) were used exclusively for the assessment of the total density of the bird community.

Bird population density is usually specified as a number of individuals per unit surface. However, in cases where the calculation of surface area is difficult, e.g. in studies on forest margin avian fauna, various authors (Turček 1948–1951, Seibert 1967) specify it in numbers of birds per unit length of area. This simplification is no doubt convenient in certain types of mid-field afforestations. This procedure has not, however, been used in the present study since the values obtained by it cannot be compared with quantities denoting density per unit surface, so in this paper density is expressed in terms of the number of occupied territories per a hectare of afforested area. While the calculation of the tree-clump area was not difficult, certain assumptions had to be made to calculate the area of the other types of afforestation. The area of an afforestation was assumed to be the area with trees or shrubs on it. Accordingly, the area of a road running through the middle of a shelterbelt is not included into the surface of the afforestation. This principle could not be applied for the calculation of the surface of alleys. In this case the width accepted was the distance between the outer sides of the trunks of trees growing on either side of the road.

Comparisons of the communities found in the different afforested areas were made by means of the indices: Sörensen's index of specific similarity

(QS), and Renkonen's index of similarity of dominance (Re) (Kontkanen 1957, Łuczak 1963) calculated by the formula:

$$QS = \frac{200_c}{a+b}$$

where c — the number of species common to two biotopes; a — the number of species in biotope I; b — number of species in biotope II. The Re index is calculated from the sum of the lower values of dominance of those species which are common to the two biotopes. In the calculation of the Re index bird pairs nesting in nest-boxes were neglected. Nest-boxes were hung only in some of the afforested areas. Nests of *Sturnus vulgaris* L., *Passer montanus* (L.) were often found in them, and sometimes also nests of *Passer domesticus* (L.). The presence and the abundance of the first two species depend solely on the availability of suitable places for nest-building, and are not associated with a particular kind of afforestation, its size or structure. It was, therefore, to be expected that the hanging of nest-boxes would considerably affect the dominance relationship but the changes thus caused would not reflect variations of the character of the afforestation itself.

ORIGIN OF THE SPECIES FOUND IN THE STUDY AREA

Only four of the forty-four bird species found in the mid-field afforestations can occur in an open ground with no trees or shrubs on it; these are: *Emberiza calandra* L., *Motacilla flava* (L.), *Acrocephalus palustris* (Bechst.) and *Saxicola rubetra* (L.) (Schiermann 1943, Mildenberger 1950). They are species, no doubt penetrating into the afforestations from the nearby fields.

Two of the species found in the afforestations may be called "deurbanized": *Passer domesticus* and *Serinus canaria* (L.). These are species penetrating into afforestations from the urbanized areas. The former species usually occurs near houses, the latter appears to have recently increased its distribution by occupying first of all urbanized areas where it is common (Strawiński 1963a).

Emberiza hortulana L. deserves special discussion. In Eastern Europe the species is found in various biotopes, nesting at the edge of forests, in mid-field afforestations (Budničenko 1965), in shrub-steppe (Spangenberg 1949) and even on the slopes of ravines where there is no shrub vegetation (Gladkov 1949). It shows quite a different distribution in the biotopes of Central Europe where it avoids forest periphery, large mid-field tree clumps (Mildenberger 1950, Czarnecki 1956, Seibert 1967), towns (Strawiński 1963a) and open ground devoid of woody vegetation. In the area covered by the present study it was found to occur in all those afforestations in which the tree-layer was present. For this reason *E. hortulana* may be considered to be characteristic of the mid-field afforestations of this latitude.

The distribution of the remaining 37 species is associated with the presence of shrubs and trees. Assuming that originally they were forest species, we may, considering their relationship with this biotope and with the open biotopes, divide them into three groups (Gladkov 1950, Volčaneckij 1950):

Typically forest-species, living deep in the forest in preference to forest periphery, but not avoiding the latter; in the forest they find all they need. This group includes: *Garullus glandarius* (L.), *Oriolus oriolus* (L.), *Pyrrhula pyrrhula* (L.), *Turdus philomelos* Brehm, *Erithacus rubecula* (L.), *Phoenicurus phoenicurus* (L.), *Phylloscopus collybita* Vieill, *Phylloscopus trochilus* L., *Sylvia atricapilla* (L.), *Sitta europaea* (L.), *Certhia brachydactyla* Brehm, *Parus major* L., *Parus caeruleus* L., *Parus palustris* L., *Jynx torquilla* L., *Dendrocopos major* (L.).

Forest-periphery species, occurring deep in the forest as well as on its periphery, but preferring the latter; their feeding ground also is open areas close to the forest, though the presence of these is not necessary for them. The group includes: *Corvus cornix* L., *Sturnus vulgaris* L., *Fringilla coelebs* L., *Turdus merula* L., *Luscinia megarhynchos* Brehm, *Sylvia borin* (Bodd.), *Hippolais icterina* (Vieill), *Lanius excubitor* L., *Columba palumbus* L., *Streptopelia turtur* (L.).

Forest-margin species. They occur only at the edge of the forest. It is necessary for them to have open areas close to the forest, in which they find most of their food. They are: *Carduelis carduelis* (L.), *Chloris chloris* (L.), *Emberiza citrinella* L., *Passer montanus* (L.), *Muscicapa striata* (Pall.), *Anthus trivialis* (L.), *Sylvia curruca* (L.), *Sylvia nisoria* (Bechst.), *Sylvia communis* Lath., *Lanius collurio* L., *Upupa epops* L.

The number of species in the communities of the mid-field afforestations varies, depending on the size and structure of the afforestation. The total number of species decreases with the decreasing size of the afforestation. Simultaneously, the forest- and the forest-periphery species disappear altogether. The margin species also become less frequent, but at a much slower rate. In the largest afforestations only one field species is found. Their number increases up to four in smaller afforestations (Tab. III).

The variations in the community composition appear to be even more marked when instead of the number of species the percentage of birds representing the different groups distinguished are considered. As the size of the afforested area decreases, the percentage of the forest-species birds drops from 20% (as estimated for the largest size of afforestation) to 0%, and the percentage of birds of the forest-periphery species drops from about 40%

Number of species of different origin, forming communities in mid-field afforestations

Tab. III

Bird species \ Afforestations	Clumps	Shelterbelts broad	Shelterbelts of medium breadth	Shelterbelts very narrow	Alleys	Hedge-rows	Shrub-belts	Total
Forest species	15	9	9	3	4	–	–	16
Forest-periphery species	10	6	5	1	3	2	1	10
Forest-margin species	11	9	9	5	6	6	6	11
Deurbanized species	2	1	2	1	1	–	–	2
Characteristic species	1	1	1	1	1	–	–	1
Field species	1	1	3	4	3	2	3	4
Total	40	27	29	15	18	10	10	44

Percentage of the group distinguished in relation to the total number of birds of the communities

Tab. IV

Bird species \ Afforestations	Clumps	Shelterbelts broad	Shelterbelts of medium breadth	Shelterbelts very narrow	Alleys	Hedge-rows	Shrub-belts
Forest species	21.0	9.5	10.0	8.0	8.0	0.0	0.0
Forest-periphery species	37.5	46.0	42.0	18.0	33.0	14.0	2.0
Forest-margin species	35.0	35.0	32.0	29.0	30.0	70.0	77.0
Deurbanized species	1.5	3.0	2.0	1.9	1.0	0.0	0.0
Characteristic species	1.5	3.5	8.0	18.0	14.0	0.0	0.0
Field species	3.5	3.0	6.0	25.0	14.0	16.0	21.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

to 2%. At the same time an increase of the percentage of birds of the margin species is seen, from 35% to about 80%, of the field-species – from 4% to about 20%, and of the mid-field afforestation characteristic species – from 2% to 14–18% (Tab. IV). In general, the main bulk of birds in the mid-field afforestations consists of forest-periphery and forest-margin species, these two groups together representing 61–85% of the total number of birds in each of the afforestations studied.

SPECIES COMPOSITION OF THE COMMUNITY

The number of species in the community. In the mid-field afforestations covered by the present study 44 bird species were found. As has already been mentioned, the largest numbers of species are found in the bird communities of the tree clumps (Tab. III); the number of species then decreases gradually with the transition from the largest to the smallest size of afforested area, and from the most complex structure of afforestation to the simple one, in extreme cases consisting of one layer.

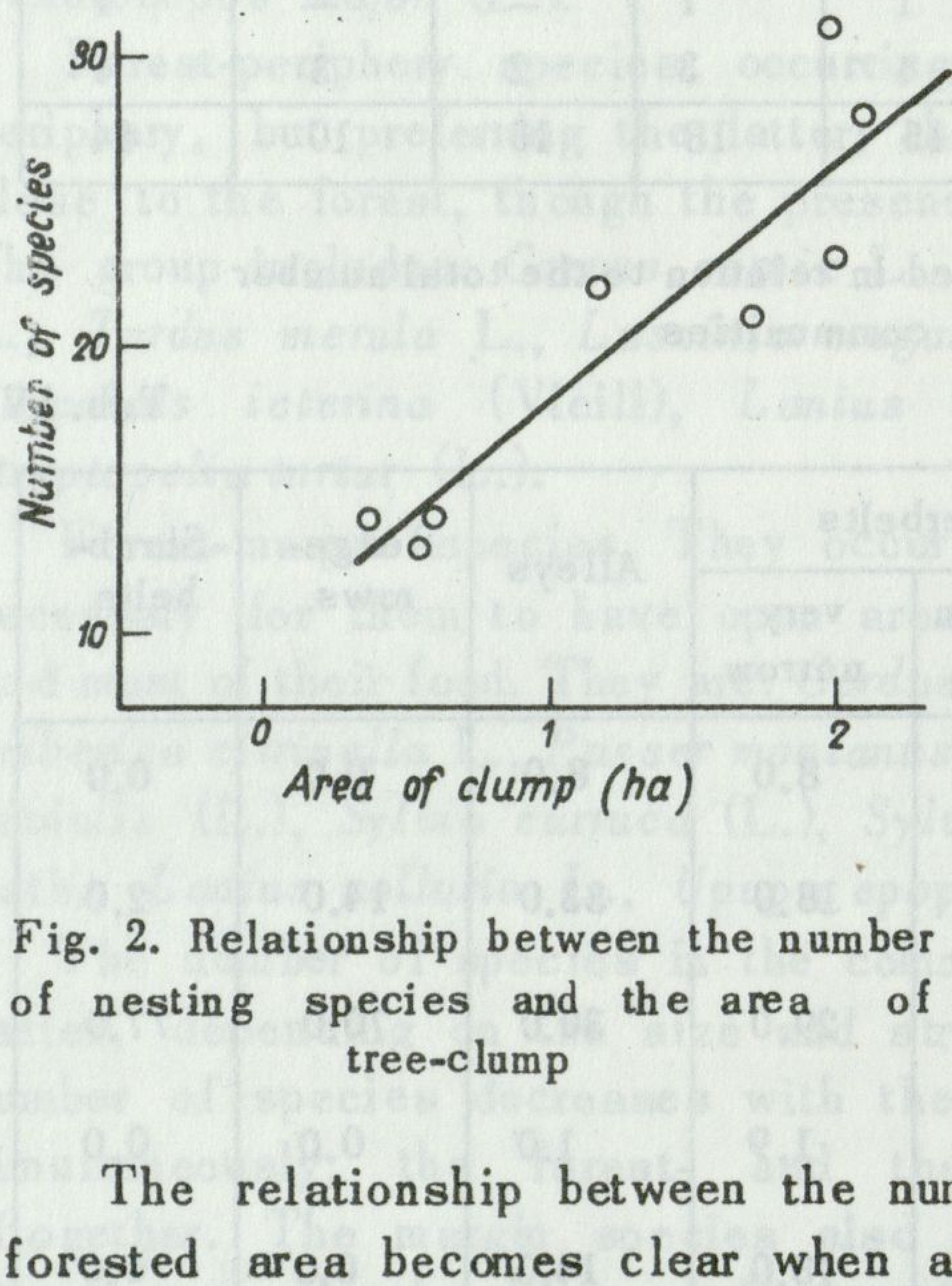

Fig. 2. Relationship between the number of nesting species and the area of tree-clump

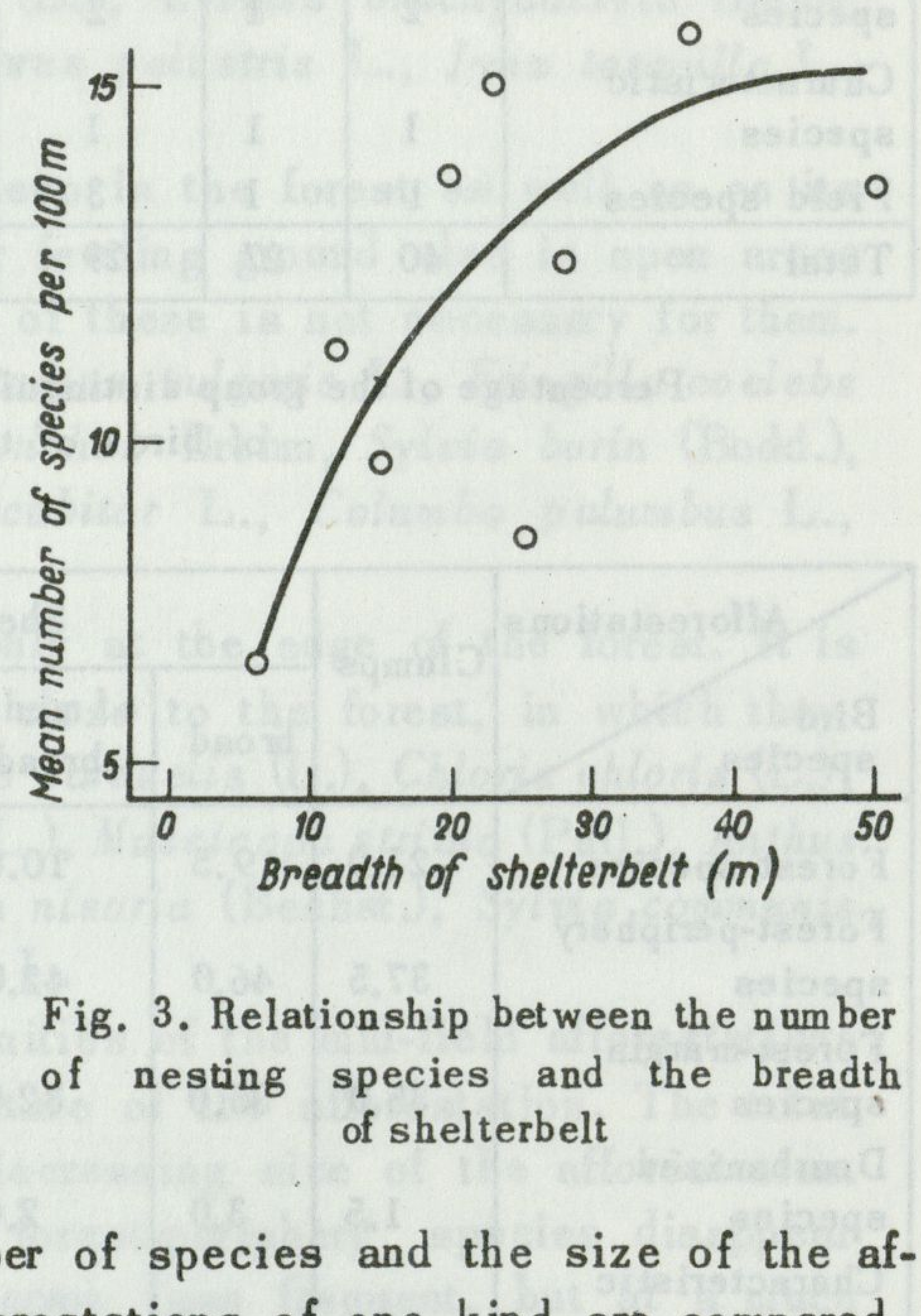

Fig. 3. Relationship between the number of nesting species and the breadth of shelterbelt

The relationship between the number of species and the size of the afforested area becomes clear when afforestations of one kind are compared. In clump-afforestations the number of species grows with the growth in size of the afforested area (Fig. 2), in shelterbelts – with the growth in breadth of the belts (Fig. 3). However, the effect of the size of the afforestation is modified by the degree of development of their structure: in both the shelterbelts and clumps the number of species increases with the development of the shrub-layer.

As the size of the afforested area decreases and its structure becomes simpler the number of bird species occurring in it decreases, mainly due

Number of pairs per one ha of species typical of mid-field afforestations

Tab. V

Afforestations / Species	Clumps						Shelterbelts						Alleys	Tree rows with hedges	Hedges	Shrub-belts
	C3	*C5*	*C1*	*C4*	*C2*	*C8*	*B2*	*B3*	*B5*	*B4*	*B6*	*B8*	*A*	*R*	*H*	*S*
Chloris chloris	1.17	1.42	0.47	0.38	0.66	2.70	1.30	0.49	1.17	0.63	1.05	2.30	1.11	3.12	3.33	2.52
Emberiza citrinella	2.35	1.70	1.43	1.55	1.32	2.70	2.60	2.65	2.74	2.80	3.50	3.07	2.03	4.68	5.00	5.55
E. calandra		0.56	0.15	0.19	1.32	1.80	1.62	0.49	1.56	1.39	1.75	3.84	2.96	2.34	1.66	3.53
Passer montanus	0.16		1.59		1.48		5.22	3.15	2.74	0.89	4.56	3.07	3.70			1.01
Hippolais icterina	2.18	0.85	0.63	0.97	0.33	2.70	1.96	0.33	2.15	0.89				2.34	1.66	
Sylvia communis	0.33	0.85	0.63		0.16	1.80	1.62	0.66	1.56	1.14	1.05	2.30	1.29	1.95	4.44	5.05
Lanius colluria	0.67		0.15	0.58	0.66	1.80	0.98		0.39	0.76				1.56	1.66	2.02
Per cent of total density	33.6						30.7		28.2			37.0	30.0	47.4	74.1	88.4

Number of pairs per one ha of species typical of mid-field afforestations, found in afforestations with the tree-layer present

Tab. VI

Species \ Afforestations	Clumps						Shelterbelts						Alleys	Tree-rows with hedges
	C3	*C5*	*C1*	*C4*	*C2*	*C8*	*B2*	*B3*	*B5*	*B4*	*B6*	*B8*	*A.*	*R*
Fringilla coelebs	2.69	2.56	2.87	1.75	1.81	2.70	2.94	2.98	5.09	4.19	5.26	6.92	8.14	5.46
Emberiza hortulana	0.33		0.63	0.58	0.16		0.65	1.82	3.92	2.41	2.80	6.92	5.18	3.12
Carduelis carduelis	0.50		0.47	0.58	0.49		0.98	0.49	0.98	0.63	0.70		1.85	0.78
Oriolus oriolus	0.50	0.85	0.47	0.58	0.49	0.90	0.65	0.49	0.58	0.76	0.70		0.37	0.78
Parus major	0.50	0.85	0.47	0.58	0.49	1.80	0.98	0.49	0.78	0.63	0.70	0.76	0.55	1.56
P. caeruleus	0.50	0.28	0.47	0.58	0.16	2.70	0.65	0.49	0.78	0.76	0.70	0.76	1.48	1.95
P. palustris	0.16	0.28			0.49	0.90	0.32	0.16	0.19	0.12	0.70			0.39
Sturnus vulgaris	0.67	0.85	12.44		0.49		16.00	7.62	15.29	5.72	9.12		3.88	
Muscicapa striata	0.33		0.63	0.38	0.33		0.98	0.82	1.37	0.89	1.40	0.76	0.92	
Certhia brachydactyla	0.50		0.47	0.19	0.49		0.98	0.49	0.78	0.76	1.40	1.53	0.55	
Columba palumbus	0.50	0.56	0.31	0.19	0.49			0.33	0.58		1.05		0.18	
Per cent of total density	42.5						56.6		30.5			44.8	62.6	41.6

to the disappearance of those species whose occurrence is associated with large areas covered by tree growth. In small groups of trees there is a different group of bird species which have moved there from the nearby open spaces. Apart from the above two groups there is a number of species whose occurrence is not affected by the size of the area covered by woody plants. Those species are found in all, or almost all kinds of afforestations. They may, therefore, be regarded as typical to the mid-field afforested areas.

Species typical to mid-field afforested areas. Two groups may be distinguished. One of the groups includes species which may be found in all kinds of afforestations (Tab. V). The absence of some of these species from a number of the afforested areas considered results from the fact that the particular afforestations lack certain structure elements required by the species. *Passer montanus* does not occur in those afforestations where there are no holes in tree trunks. *Hippolais icterina* and *Lanius collurio* are only found in those small afforestations in which there is a well developed shrub-layer. The absence of *Emberiza calandra* from area *C3*, and of *Hippolais icterina* from shrubbelts is rather difficult to explain. In the first case the reason probably is that the species concerned, being a field species, is rare in large and thick tree-clumps.

The second group consists of species occurring in wooded areas with the tree-layer present (Tab. VI). As with the former group, certain irregularities of distribution can be observed. The irregularities most probably are connected with some elements of structure of the afforestations.

In general, typical species represent some 60% up to about 90% of the total number of birds in the community. It should be noted that the community reveals a particularly strong heterogeneity. It consists of 5 forest-species, 4 forest-periphery species, 7 forest-margin species, 1 field species, and 1 species characteristic of mid-field afforestations. In afforestations of larger size, some of these species, essentially indifferent to the size of afforestation, usually occur at the edge.

Species sporadically occurring in all, or almost all, kinds of afforestations (Tab. VII). Three of these (*Turdus merula*, *Sylvia nisoria*, *Sylvia curruca*) are species usually found in afforestations with a thick, well-developed shrub-layer. Two of them are deurbanized species, at least one of which (*Passer domesticus*) is found in the neighbourhood of man. The rare occurrence of *Upupa epops* may be connected with the generally small size of the population of this species in the area considered. Similarly to the former group, in larger afforestations some of the species representing this group choose the periphery of the afforestation in preference to its centre.

Species disappearing with the decreasing size of the afforestation (Tab. VIII). The group consists mainly of forest species, 11 in number. Besides these, there are 5 forest-periphery species, and one forest-margin species,

Tab. VII

Number of pairs per one ha of species occuring sporadically

Afforestations	Clumps						Shelterbelts						Alleys	Tree-rows with hedges	Hedge-rows	Shrub-belts
Species	*C3*	*C5*	*C1*	*C4*	*C2*	*C8*	*B2*	*B3*	*B5*	*B4*	*B6*	*B8*	*A*	*R*	*H*	*S*
Passer domesticus	0.16				0.33		0.32	1.32	0.19		1.40		0.37			
Serinus canaria			0.31	0.19	0.16				0.19		0.35	0.76				
Sylvia curruca	0.33	0.85	0.15				0.32							1.17	0.55	
S. nisoria	1.17	0.28				2.70								1.17	1.66	1.01
Turdus merula	0.84	0.85	0.47	0.58			0.98							0.78	1.66	0.50
Upupa epops	0.16									0.12				0.39		
Per cent of total density			7.7					4.1		2.6		1.9	1.0	10.2	16.1	6.9

Number of pairs per one ha of species disappearing with decreasing area of afforestation

Tab. VIII

Species \ Afforestations	Clumps						Shelterbelts				
	C3	*C5*	*C1*	*C4*	*C2*	*C8*	*B2*	*B3*	*B5*	*B4*	*B6*
Garrulus glandarius		0.56									
Phylloscopus collybita	0.50	0.85									
Erithacus rubecula	0.16										
Pyrrhula pyrrhula		0.28									
Jynx torquilla				0.19							
Lanius excubitor					0.16						
Turdus philomelos	0.50	0.85	0.47	0.58							
Luscinia megarhynchos	0.33		0.15								
Corvus cornix	0.33		0.31		0.16						
Sylvia atricapilla	0.84		0.47				0.65				
Phylloscopus trochilus								0.33	0.19		
Sylvia borin	0.84		0.47	0.58		1.80	0.65	0.49			
Sitta europaea			0.15							0.25	
Phoenicurus phoenicurus				0.38				0.33		0.38	
Dendrocopos major		0.56	0.31					0.16	0.19	0.12	
Streptopelia turtur	0.50	0.85							0.39	0.38	
Anthus trivialis	0.16	0.56	0.63	0.97	0.49	0.90	0.98	1.65	0,98	1.39	2.80
Per cent of total density		19.0				7.8		7.6		6.3	

the latter showing the most regular occurrence. This group is most abundant in large tree-clumps with at least medium-developed undergrowth, where the species belonging to it represent almost 20% of the total number of birds present. Their percentage gradually decreases as the afforestations grow smaller, and from the very narrow shelterbelts downwards they are entirely missing.

Number of pairs per one ha of penetrating species, found only in small afforestations

Tab. IX

Afforestations / Species	Shelterbelts				Alleys	Tree-rows with hedges	Hedge-rows	Shrub-belts
	B5	B4	B6	B8	A	R	H	S
Motacilla flava	0.58	0.50		3.84	1.66			0.50
Saxicola rubetra	0.19	0.12	0.35	1.53	0.55			0.50
Acrocephalus palustris				0.76			2.22	
Per cent of total density		1.5		15.6	6.0		9.3	4.8

Field species, occurring only in small groups of trees (Tab. IX), are not found in any afforestations larger than medium-broad shelterbelts. Their percentage varies from 2% to 15% of the total number of birds. It seems most likely that the environment around the afforestations exerts a strong influence on the occurrence of these birds in the afforestations.

The effect of the surrounding habitats on the occurrence of birds in mid-field afforestations. Of a number of factors that might be involved, in the material collected the effect of three was noticeable.

1. Proximity of a forest. It was found that *Garrulus glandarius*, *Pyrrhula pyrrhula* and *Jynx torquilla* nested only in tree clumps not far from the forest (100 and 200 m). *Sitta europaea* occurred only in that part of a shelterbelt which was in direct contact with the forest. It may, therefore, be concluded that in groups of trees located near the forest more bird species can be found. This agrees with the findings of Volčaneckij (1952) and Budničenko (1955) concerning Ukrainian steppes.

2. Proximity of human dwellings. This factor was only found to exert influence on the occurrence of *Passer domesticus*. This species does not nest in afforestations more than about 500 m far from dwelling places.

3. Proximity of vast open spaces. In the northern part of the area under study groups of trees form a denser network than in the remainder of the area. Most striking in that part is the occurrence of *Emberiza calandra* in very

small numbers. For instance, in a tree-clump found in this part the average density of *E. calandra* population is 0.19 pairs/ha, while in another afforestation of similar size and structure but lying in a different part of the area, the density of the population of this bird species is 1.32 pairs/ha. The species also appeared to occur in very small numbers in the shelterbelts found there. In this case the small numbers of *E. calandra* cannot be attributed to edaphic factors or moisture conditions (Sokołowski 1958), because in this respect the part considered does not clearly differ from the other parts of the area where *E. calandra* occurs in considerably larger numbers, nor can it be related to the structure or size of the afforestations. Spangenberg (1949) writes that when plantings of trees are established in former steppes, some bird species diasppear entirely, some use the plantings but move over to those parts which border on open steppe, thus avoiding fields within the system of plantings. He includes *E. calandra* in the latter group of birds. The small numbers of this species in the above-mentioned part of the area may, therefore, be explained by the hypothesis that also in the latitudes of Poland this bird species avoids areas where the groups of trees and shrubs do not border on large open spaces.

	C8	C5	C4	C2	C3	C1	B2	R	B5	B3	B4	B6	A	B8	H	S
C8																
C5	54															
C4	56	57														
C2	54	55	59													
C3	58	62	62	58												
C1	47	47	68	66	66											
B2	68	59	73	67	70	77										
R	69	60	63	56	61	56	73									
B5	55	54	63	61	58	70	72	70								
B3	46	50	65	60	55	71	64	62	77							
B4	51	48	57	63	47	68	69	66	81	73						
B6	47	49	61	63	49	64	66	64	78	82	70					
A	34	38	43	58	40	57	48	53	66	60	67	62				
B8	39	39	39	56	38	55	52	56	68	57	69	63	71			
H	52	38	33	31	40	26	48	57	34	27	34	26	19	26		
S	43	29	24	36	29	25	38	46	31	28	38	39	28	39	72	

1
2
3
4

Fig. 4. Value of Renkonen's index of similarity of dominance (*Re*)
1 – similarity 100%, *2* – similarity, 99–70%, *3* – similarity 69–60%, *4* – similarity < 60%.
Letter notation same as in Tab. I

Comparison of bird communities in mid-field afforestations. The comparison was based on the index of similarity of dominance *Re*, and the index of similarity of species composition *QS*. The values of *Re*, found for each pair of afforestations separately, appear to differ considerably, their extremes being 19% (the smallest similarity) and 82% (the greatest similarity). So large a range of variation of the index value on the one hand indicates that the birds communities of individual afforestations may differ considerably, and on the other hand that it may be possible to combine some afforestations to form small groups characterized by a high degree of similarity. After arranging the values of the index in the diagram (Fig. 4) this supposition proved to be right. The groups consist either of afforestations of similar size and structure, or afforestations of large surface area but simple structure, and afforestations small in area but of a complex structure. The groups can be arranged to form a range with the largest afforestations of best developed multi-layered structure on one end, and the smallest (narrowest) afforestations of a very simple one-layered structure (either a tree-layer or shrub-layer) on the other end. Shrubbelts and hedge-rows appear to be most different, consisting only of a shrub-layer. Not all the afforestations considered can be included into the above-described distinct groups. The cause may lie in the floristic composition or the location of the afforestations.

In details, the results of the analysis of the *QS* index are slightly different from the results of the analysis of the *Re* index; however, the final conclusions are the same.

DENSITY OF THE BIRD POPULATIONS

Variation in numbers during the consecutive years. In the years 1964–1966 a slight increase of the total number of birds belonging to the species typical of mid-field afforestations in the area under study can be seen (Tab. X). However, in this period individual species showed different tendencies as regards changes in their numbers: the numbers of some of the species remained at the same level, while the numbers of others decreased or increased. Nine species showed a stable level of abundance, four revealed a decrease of numbers, and four – an increase in numbers. It is possible that there occurs some quantitative compensation, and that factors connected with the change of habitat exert their influence, and finally, that each of the bird species probably is subject to the action of a different complex of factors.

Birds usually live permanently only in optimal biotopes, or in those which differ least from the optimal ones (Svärdson 1949, Kalela 1954, Hilden 1965). In such biotopes the population abundance is most stable (Kluyver, Tinbergen 1953, Glas 1960, Brewer 1963, Pinowski 1967). It may, therefore, be stated that in the mid-field afforestations many, or even most of the typical species find very good living conditions, and that the afforestation is for them an optimal, or very much like an optimal biotope.

Aggregate total of pairs of typical species occuring in particular years
in the same afforestations

Tab. X

Species	Years 1964	1965	1966	Tendency
Columba palumbus	8	5	6	↘
Certhia brachydactyla	10	11	11	→
Muscicapa striata	12	8	17	↗
Sturnus vulgaris	109	120	115	→
Carduelis carduelis	10	10	11	→
Oriolus oriolus	12	10	12	→
Fringilla coelebs	57	55	58	→
Emberiza hortulana	21	26	30	↗
Parus major	11	11	12	→
P. caeruleus	10	12	12	→
P. palustris	6	5	1	↘
Hippolais icterina	19	18	22	↗
Chloris chloris	15	18	20	↗
Emberiza citrinella	44	44	45	→
Sylvia communis	20	17	14	↘
Passer montanus	34	32	27	↘
Emberiza calandra	18	21	17	→
Total	416	423	430	↗

Total density of birds in tree clumps

Tab. XI

Clumps / Pairs/ha	Large C1	C2	C3	C4	Medium-sized C5	Small C6	C7	Very small C8
Without nest-boxes	15.94	13.20	21.04	12.67	18.23	22.58	24.07	27.92
With nest-boxes	28.38	–	–	–	–	–	–	–

Bird population density. Values given in Tables V–IX represent population density of individual species, and those in Tables XI–XIII – the total density in the afforestations under study. The figures in the tables represent the average number of breeding pairs (occupied territories), of one species, or of all the species occurring in the particular afforestation, per each hectare of the afforestation. The values of density of individual species, and those of the total density found in the different afforestations show a large range of variation. The maximum total density (81.66 pairs/ha) is 6.4 times as great as the corresponding minimum value (12.67 pairs/ha), whereas the

Total density of birds in shelterbelts

Tab. XII

Shelterbelts / Pairs/ha	Broad		Of medium breadth				Narrow		Very narrow
	B1	*B2*	*B3*	*B4/1*	*B4/2*	*B5*	*B6*	*B7*	*B8*
Without nest-boxes	14.21	22.87	17.08	19.68	26.41	27.84	26.31	51.66	39.23
With nest-boxes	–	44.44	28.35	–	37.53	45.55	41.40	81.66	–

Total density of birds in alleys, tree-rows with hedges, hedgerows and shrubbelts

Tab. XIII

Afforestations	Alleys	Tree-rows with hedges	Hedgerows	Shrubbelts
	A	*R*	*H*	*S*
Pairs/ha	36.95	33.59	23.88	22.22

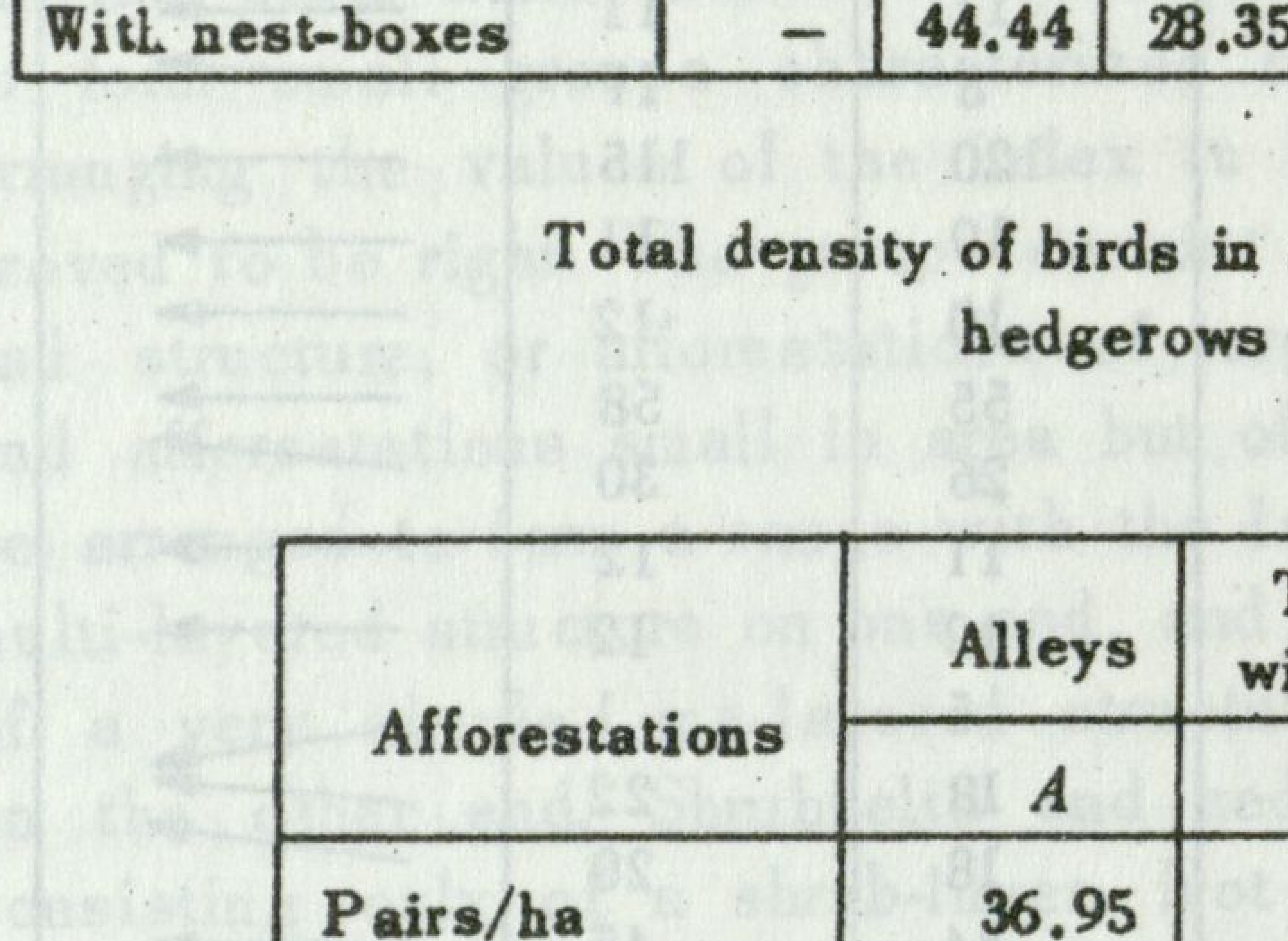

Fig. 5. Relationship between total density of nesting birds and the area of clump

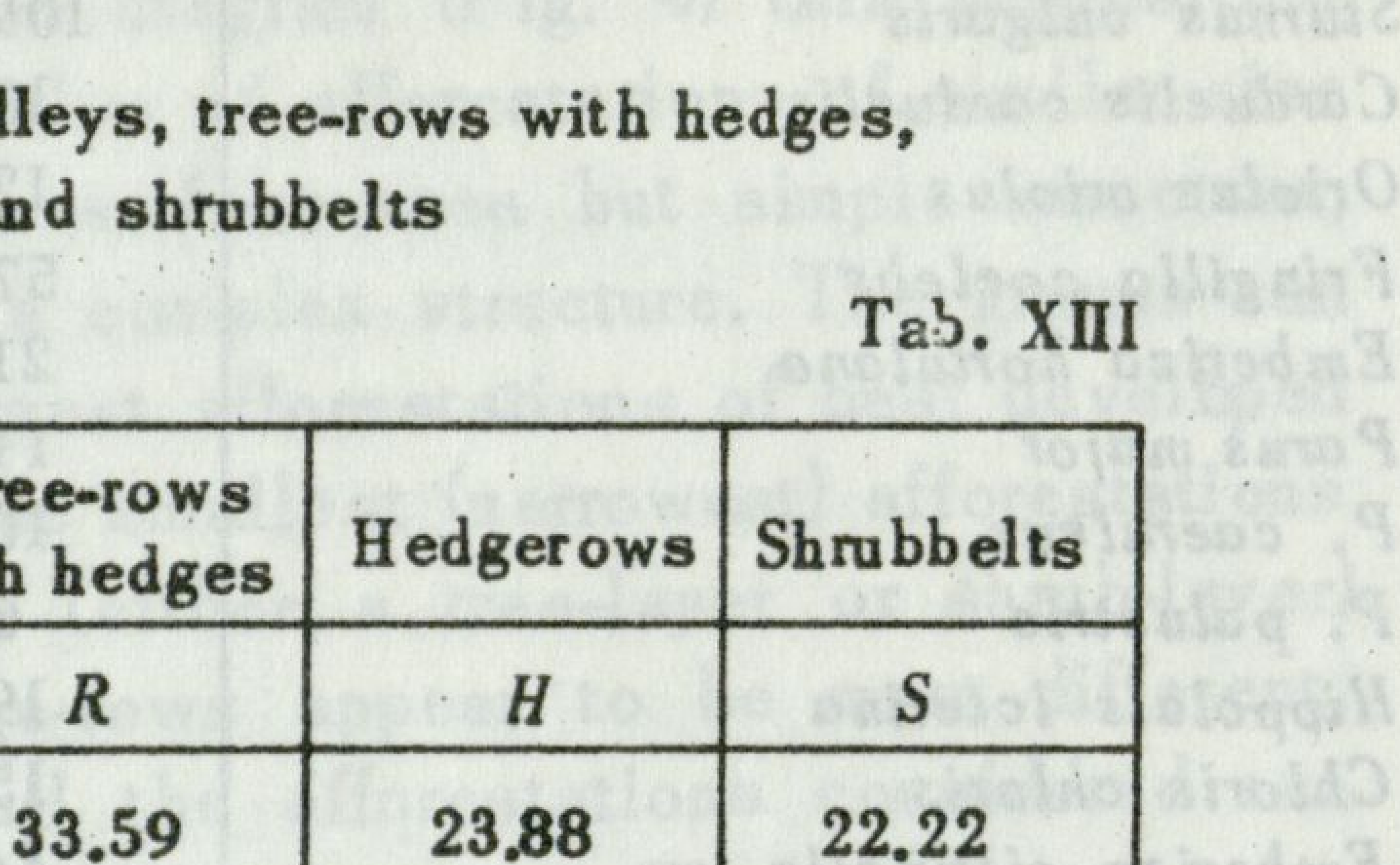

Fig. 6. Relationship between total density of nesting birds and the breadth of shelterbelt

maximum density of, for instance, *Fringilla coelebs* (8.14 pairs/ha) is 4.6 times as great as the minimum density (1.75 pairs/ha) of this species. The highest density values were recorded for the forest-periphery, and forest-margin species.

Relationship between the density and number of species present and the degree of development of the shrub-layer

Tab. XIV

Shrub-layer	Clumps		Shelterbelts	
	number of species	density pairs/ha	number of species	density pairs/ha
Missing	23	13.20	19	19.68
Thin	28	15.94	23	26.41
Thick	31	21.04	26	27.84

It is possible to almost double the bird population density by putting up nest-boxes in the trees in the afforestation (Tab. XI and XII).

The relationship between the total density and the size and structure of the afforestation. The total density of birds in mid-field afforestations show a clear relationship to the size of the afforestation; the highest density values being recorded for the smallest afforestations. This statement is illustrated by the curves which represent the relationship between the density of bird populations and the size of a tree-clump (Fig. 5), or the breadth of a shelterbelt (Fig. 6). Although the actual course of the curves is in each case slightly different, the same regularity can be seen in both cases. The relationship, mentioned earlier in this paper, between the number of species and the size of afforestation is converse – the fewest species are found in afforestations of the smallest area.

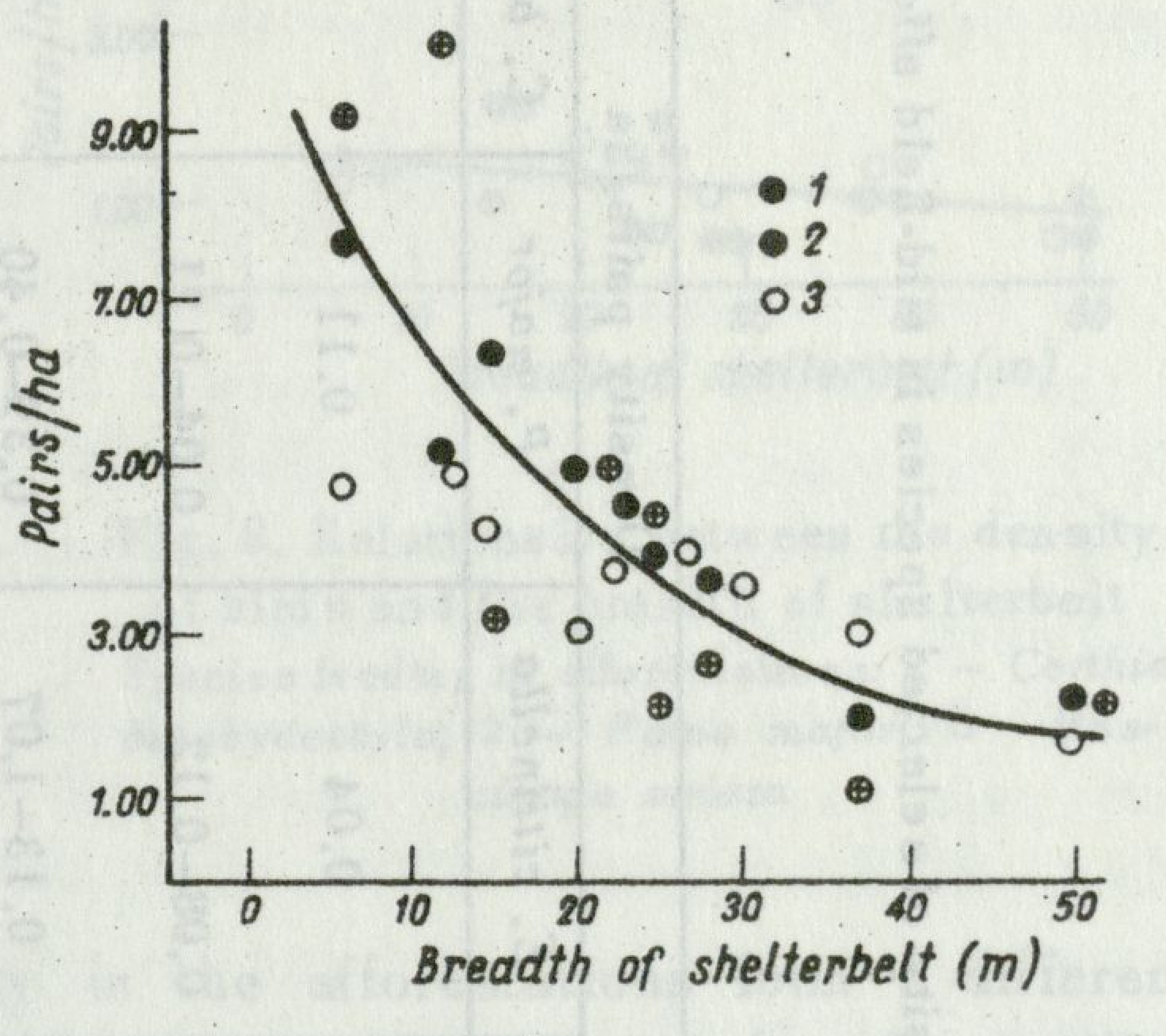

Fig. 7. Relationship between the density of birds and the breadth of shelterbelt

Species feeding in fields: *1 – Fringilla coelebs, 2 – Emberiza hortulana, 3 – Emberiza citrinella*

The effect of the size of the afforestation is modified by the effect of structure and degree of compactness of the vegetation. In both the clumps and shelterbelts with a developed shrub-layer bird population density is higher than in afforestations without any shrubs. The highest density is observed in afforestations with a well-developed, thick shrub-layer (Tab. XIV).

The influence of layer structure on density is also noticeable when afforestations of different kind are compared. In afforestations of similar

Comparison of the density of selected species in mid-field afforestations and other biotopes

Tab. XV

Biotope	Density pairs/ha					According to
	F. coelebs	*E. citrinella*	*P. major*	*C. brachydactyla*	*M. striata*	
Pine forests	0.12–0.36					Glas 1960
" "	0.48	0.04	0.11	0.08		Schiermann 1943
Mixed forests	0.72–0.81					Glas 1960
" "	0.32–1.65	0.08–0.12	0.04–0.21		0.07–0.60	Udvardy 1953
Deciduous forest	2.16					Dyrcz 1963
Steppe oak forest	2.64–2.68	0.13–1.07	0.39–0.40		0.35–1.36	Korol'kova 1963
Park	1.90	1.04	0.37	0.23	0.37	Czarnecki 1956
"	2.11		0.39	0.13	0.53	Steinbacher 1942
Mid-field afforestations						
Clumps 15 ha	1.50–2.29	0.14	0.86	0.14	1.23–1.29	Seibert 1967
" 4 ha	1.43	1.90	0.48	0.06	0.42	Czarnecki 1956
" 0.4–2 ha	1.75–2.70	1.43–2.70	0.47–1.80	0.19–0.50	0.33–0.63	author's own study
Shelterbelts	2.94–6.92	2.60–3.50	0.49–0.98	0.49–1.53	0.76–1.40	" " "
Alleys	8.14	2.03	0.55	0.55	0.92	" " "
Shrubbelts	–	5.55	–	–	–	" " "

size it will be higher in those with the tree layer alone (in very narrow shelterbelts – 39.23 pairs/ha, in alleys – 36.95 pairs/ha) than in those with the shrub-layer only (hedgerows – 23.88 pairs/ha, shrubbelts – 22.22 pairs/ha).

Relationship between the density of individual species and the size and structure of the afforestation. It has been found that as the size of the afforestation decreases, the number of bird species nesting in it grows smaller, while the total density of birds rises. The relationship between the density of individual species and the size of the afforestation varies.

A close relationship can be seen between the size of the afforestation and the density of those species which feed mainly in the fields adjacent to the afforestation (Fig. 7); in this case the origin of the species does not seem to play a significant role: the forest-periphery species (*Fringilla coelebs*), the forest-margin species (*Emberiza citrinella*) or those associated only with the mid-field afforestations (*Emberiza hortulana*) behave in a similar way. The maximum density found for the very narrow shelterbelts is 3.5–5.0 times as great as the maximum density for broad shelterbelts. In comparison to other biotopes, the density of these species in mid-field afforestations increases considerably (Tab. XV).

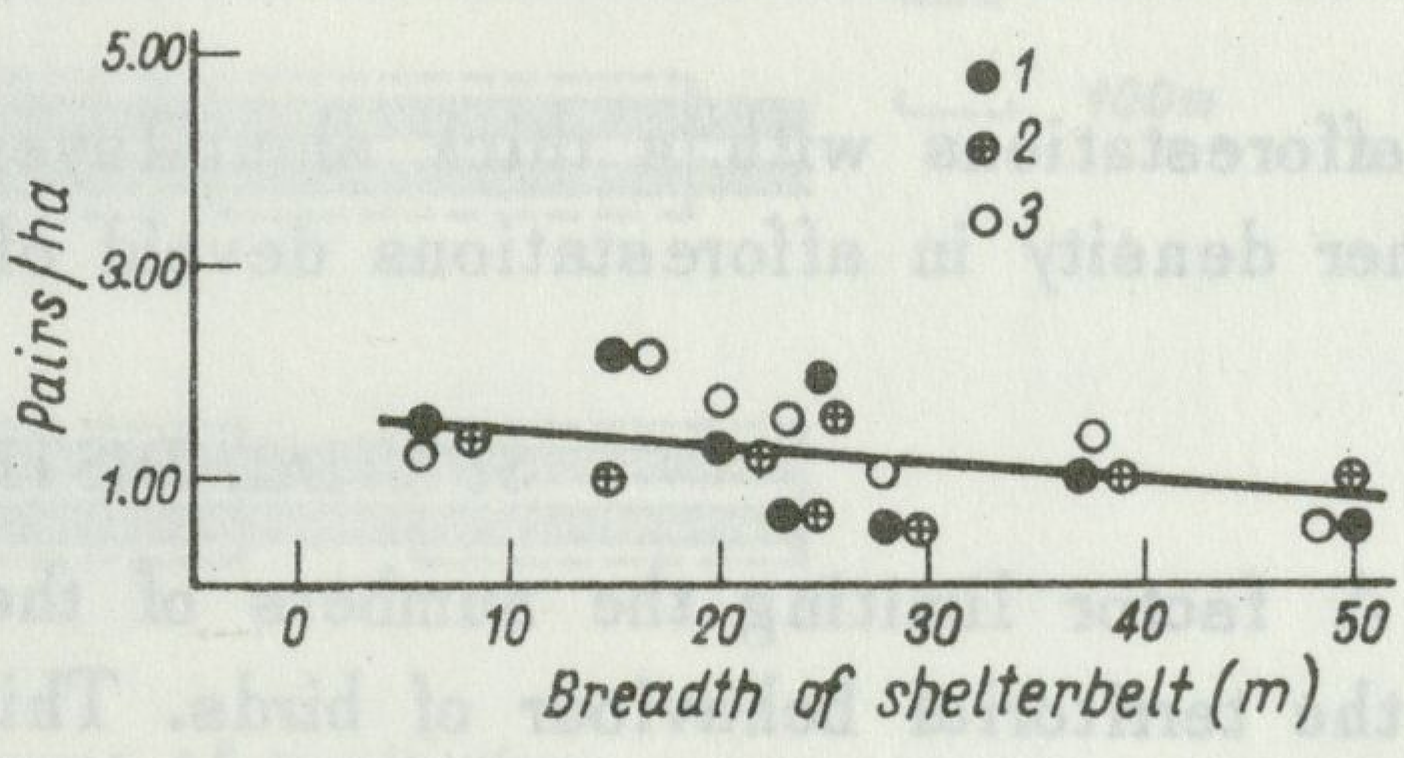

Fig. 8. Relationship between the density of birds and the breadth of shelterbelt
Species feeding in afforestations: *1 – Certhia brachydactyla*, *2 – Parus major*, *3 – Muscicapa striata*

Birds feeding entirely, or mainly in the afforestations form a different group. Their density does not depend much on the size of the afforestation (Fig. 8). The maximum density values found for the very narrow shelterbelts are only 1.5–3.0 times as large as those found for the broad shelterbelts. By contrast to the species of the former group, no increase in density, or only a slight one can be noticed here in comparison with the density values found for other biotopes (Tab. XV). As in the former group, species of different origin can be found here: forest species (*Parus major*, *Certhia brachydactyla*) and forest-margin species (*Muscicapa striata*).

In afforestations with well-developed undergrowth more bird species nest, and the total density of birds is also greater there. It may, therefore, be presumed that in this case the increase in density is the result of the presence of a larger number of species. However, in addition to this factor there is also the effect of changes in population density of individual species, related to the structure of the afforestation: most bird species occur in larger numbers

Comparison of the density of birds in afforestations with thick undergrowth and in those without undergrowth

Tab. XVI

	Species reacting to the presence of undergrowth	Density pairs/ha thick undergrowth	Density pairs/ha without undergrowth
Positively	*Fringilla coelebs*	2.69	1.81
	Hippolais icterina	2.18	0.33
	Chloris chloris	1.42	0.38
	Emberiza citrinella	2.35	1.32
	Sylvia communis	0.33	0.16
Negatively	*Anthus trivialis*	0.16	0.97
	Emberiza hortulana	0.65	1.82

in afforestations with a thick shrub-layer, but there are species which show higher density in afforestations devoid of undergrowth (Tab. XVI).

SPATIAL DISTRIBUTION

A factor limiting the numbers of the breeding part of a bird population is the territorial behaviour of birds. This view is still controversial (Lack 1967), but many authors concerned with this problem agree with it (Kalela 1954, Armstrong 1965). In a number of bird species the "buffering mechanism" was found to exist. Due to this mechanism, in biotopes optimal for the species, maximum population densities are established which persist from year to year at the same level (Kluyver and Tinbergen 1953, Glas 1960, Tompa 1964). The hypothesis of the buffering mechanism assumes that for each bird species there is the smallest possible size of territory, i.e. the lower limit of size of territory.

Micheev's (1953) interpretation of high density of birds in mid-field afforestations is based on a similar assumption that the maximum density of bird populations is determined by the size of the actively defended centre. He assumes that the part of territory occupied within the afforestation decreases at the expense of the open space where the birds feed. Malčevskij (1947b), likewise, maintains that due to the abundance of food in mid-field afforestations, and the resulting decrease of competition among bird pairs, the size of territory decreases. The problem of decrease of the size of territories in mid-field afforestations is also mentioned by Turček (1958) who thinks that "territories must vary in size and nature".

Bird territories in mid-field afforestations. Birds living in mid-field afforestations may be divided into two groups, depending on the type of territory they occupy.

One of the groups includes species whose territories are relatively small, and are aligned side by side along the afforestation. In their arrangement they to some extent resemble a string of beads (Fig. 9 – *A*, *B*). The birds defend the lateral boundaries of their territories; fighting males, and even pairs, were often seen. Species of this group feed mainly in fields adjacent to the afforestations. The typical representatives are:

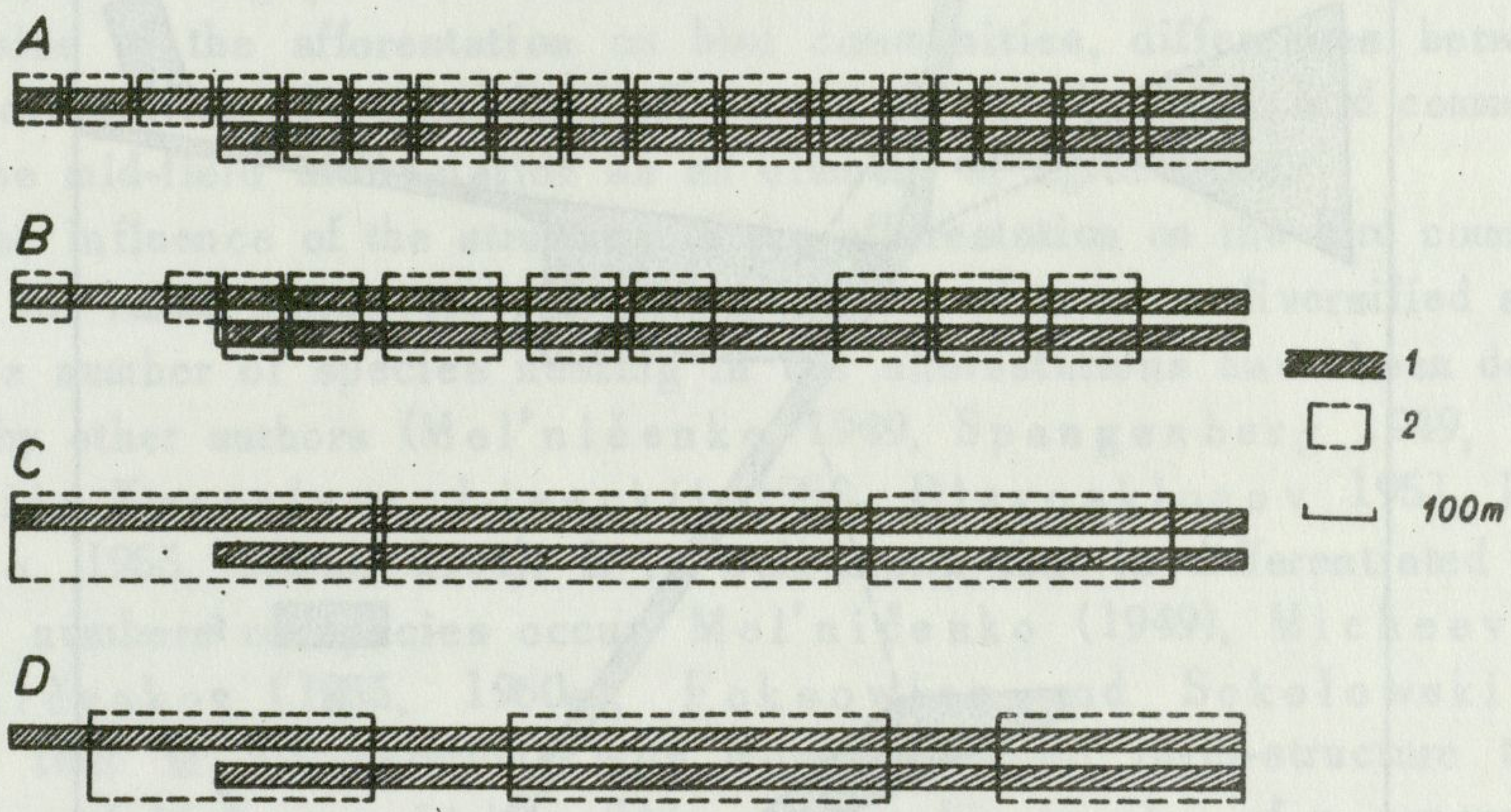

Fig. 9. Arrangement of territories
A – Fringilla coelebs, B – Emberiza citrinella, C – Parus caeruleus, D – Muscicapa striata
1 – shelterbelt, *2* – territorial boundaries

Fringilla coelebs; one territory occupies a stretch of a shelterbelt 75 up to 375 m long, most often 100 up to 150 m.

Emberiza citrinella; the length of the stretch of afforestation occupied by one territory varies from 75 to 275 m; most frequently 100 m.

E. hortulana; length of the stretch of afforestation occupied 75 to 250 m; most often 75 to 100 m. In broad afforestations it almost exclusively occupies the margins. Situations were sometimes found where two different males had their territories in the same part of the afforestation, one on one side and the other on the other side of the afforestation.

It seems that the occupied section of an afforestation is longer in the narrow than in the broad afforestations. This supposition has not, however, been proved.

The other group includes species whose large territories are extended along the afforestation (Fig. 9 – *C*, *D*). In fact it would be more precise to use the term "home range" instead of "territory", because no active defence of area against other individuals of the species could be observed. The different territories generally do not border upon one another, it is also doubtful whether a bird is able to protect such a large area against intruders. The species of this group usually penetrate afforestations and they seldom or never at all use open spaces. The typical species are: *Parus major* and *P. caeruleus* with penetration areas of from 500 to 900 m long, *Certhia brachydactyla* – sections up to 900 m long, *Muscicapa striata* – sections 400–450. *Oriolus oriolus* – 800 m.

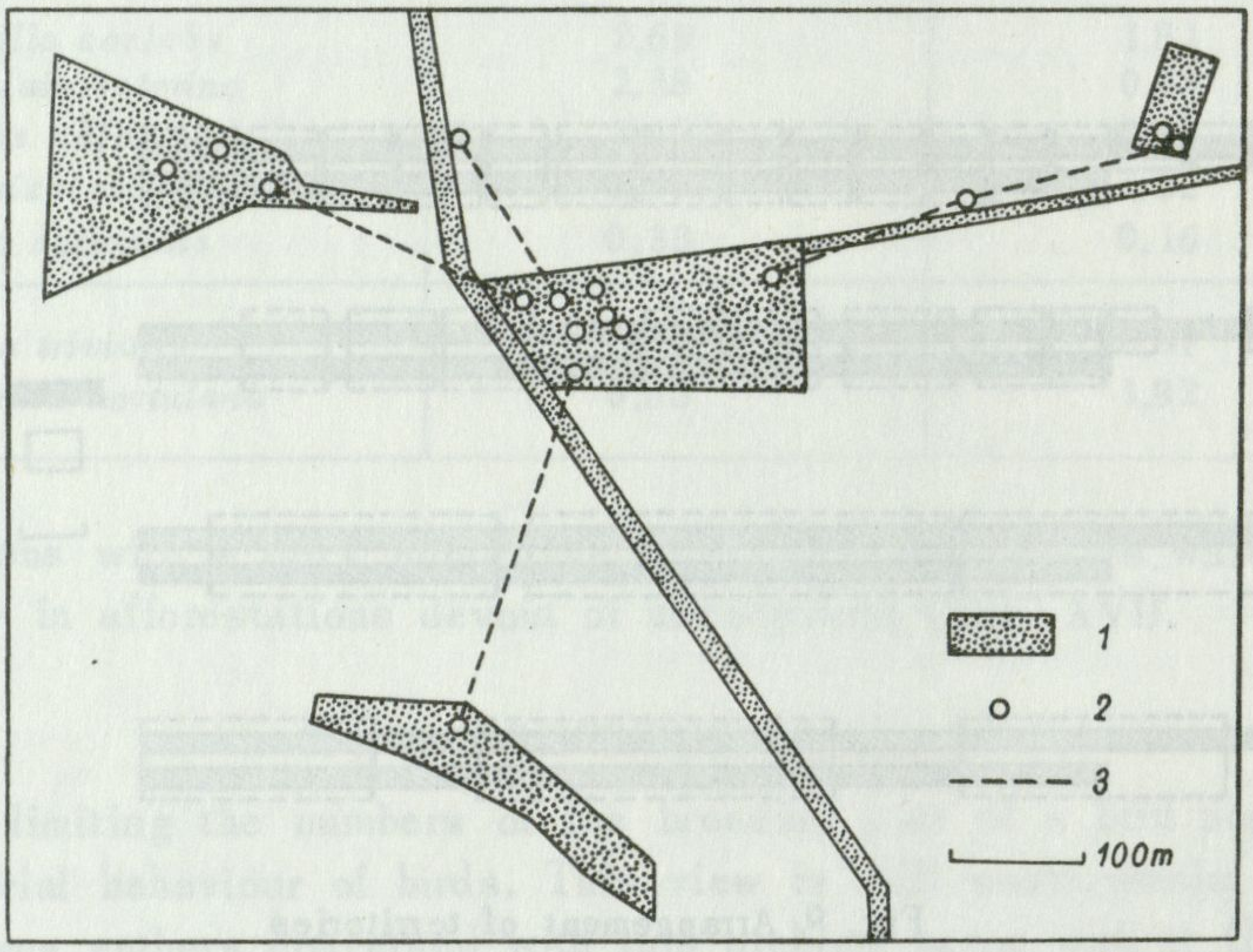

Fig. 10. Area penetrated by one pair of *Oriolus oriolus*

1 – afforestation, *2* – sites where birds were encountered, *3* – bird flights observed

If the different afforestations are not far from one another, one territory (or home range) may extend from one afforestation to another, occupying a part or the whole of it. In certain cases birds (*Oriolus oriolus*, *Chloris chloris*, *Emberiza calandra*, *Lanius collurio* and *Muscicapa striata*) penetrate two or more afforestations up to 300 m far from one another (Fig. 10). It is noteworthy that this behaviour is shown not only by the species from the fields (*Emberiza calandra*), or those living at the margin of the forest (*Chloris chloris*), but also by the forest species (*Oriolus oriolus*).

It may be stated that the birds living in the mid-field afforestations reveal an increased diurnal translocation behaviour. They migrate from the afforestations to the fields and vice versa, and it has not been established how far the birds migrate into the fields to feed. The observer very often loses sight of the birds flying to the fields before they reach the destination. Other species penetrate the afforestation itself over long distances, or fly over to other afforestations separated by open spaces. In the mid-field afforestations it is possible to see flights for food, over distances of several hundred metres, of bird species which did not nest in the afforestation, but in the forest adjacent to it. This habit was particularly frequently recorded for *Dendrocopos major*, *Garrulus glandarius*, *Turdus merula* and *Turdus philomelos*.

DISCUSSION AND SUMMARY OF RESULTS

The following problems will be discussed: the influence of the structure and size of the afforestation on bird communities, differences between the bird communities of the mid-field afforestations and the forest bird communities, and the mid-field afforestation as an element of agrocenose.

The influence of the structure of the afforestation on the bird communities does not raise controversy. Positive effects of a more diversified structure on the number of species nesting in the afforestations have been described also by other authors (Mel'ničenko 1949, Spangenberg 1949, Volčaneckij, Kapralova, Liseckij 1950, Blagosklonov 1951, Budničenko 1955, 1960a, 1961). It is well-known that in differentiated habitats larger numbers of species occur. Mel'ničenko (1949), Micheev (1953), Budničenko (1955, 1960a), Foksowicz and Sokołowski (1956) found that in afforestations with more developed layer-structure the total density of birds was higher. This relationship is also of a general nature (Wasilewski 1967), and according to Wasilewski the extent of habitat differentiation does not act directly but through the interspecific relations, as a result of a decreased competition. However, in the afforestations we can also observe direct action of habitat differentiation on the density of birds. This process may proceed in two ways: 1) increase in the number of species, 2) percentage increase of that part of the surface area of the afforestation which is suitable for the given species. If, for instance a given bird species requires a biotope with a well-developed, thick shrub-layer, its density will be higher in an afforestation in which thick shrubs cover a larger percentage of the surface area than in afforestations where thick shrubs cover a smaller percentage of area.

The role of the size of afforestation has so far received comparatively little attention. In the literature concerned, known to the author, only Volčaneckij (1950), Blagosklonov (1951) and Budničenko (1955, 1960a) stress the positive effect of the breadth of the shelterbelts on the number of species occurring in them. The same authors maintain that for their occurrence some bird species require a specified breadth of the shelterbelt. Other authors (Mal'čevskij 1949), who do not deny the role of the size of the afforestation, considering it not to be very important, emphasize the role of structure.

The relationship between the size of the afforestation and the density of the bird populations is often discussed in conjunction with the role of the shape of the afforestation. Dierschke (after Novikov 1960) thinks that with all other features being equal, density will be greater in elongate afforestations than in those of a round shape. The idea has been specified more precisely by Czarnecki (1956, 1959) who says that population density is higher in small patches, or those with a relatively high value of the edge to surface-area ratio. However, Czarnecki's papers lack numerical evidence to prove this suggestion. The same may be said of Volčaneckij's (1952) and Budničenko's (1955) statements that the total density is much higher in the narrow than in the wide shelterbelts, since these authors do not give any numerical data to prove this. One of Budničenko's more recent papers (1960b) contains numerical data indicating that in the mid-field shelterbelts of southern Ukraine density is higher in the broad than in the narrow shelterbelts. These numerical ratios he found in all afforestations, regardless of their age and degree of compactness. These findings are contradictory to Budničenko's earlier statements, as well as to the results presented in the present paper.

It has been found that as the surface area of the afforestation increases, the number of bird species living in it grows, while the total density of the birds decreases. The same relationship between these two phenomena was found by Kaczmarek (1963) who studied the soil macrofauna in the Kampinos National Park. Kaczmarek explains that the decrease of numbers, associated with the growth in the number of species, is the result of an increased interspecific competition. Possibly, this hypothesis would also apply to the situation found in mid-field afforestations, the more so that with the same size of afforestation density is higher in those afforestations which possess a more developed layer-structure, which, as has already been mentioned, is the result of a decrease of competition. The findings published by Udvardy (1957), who studied the relationship between density and the number of species in various biotopes in North America, indicate that in the interpretation of this problem some caution is required. Udvardy found entirely a different relationship; in the temperate zone forests the bird population density increases geometrically in relation to the growth of the number of species. This indicates that in the mid-field afforestations different proportions of the factors affecting the occurrence and number of birds exist than in the forest. As the area of the afforestation decreases the bird species feeding mainly in the adjacent fields grow in number, whereas those species which feed mainly or exclusively in the afforestation show no clear relationship to its size. Thus the response by a change in density to a change in the size of the afforestation depends on the way the space is utilized, which suggests that we are dealing with a change in the spatial organisation of the population, which in turn causes a decrease in the intraspecific competition.

A comparison of the forest bird communities and those living in mid-field afforestations reveals differences between them as regards their species composition, numerical ratios, density as well as distribution.

1. Species composition of the bird communities. One of the differences is the absence of field species from the forest communities; besides, field species are reluctant to settle at the margin of the forest. On the other hand, field afforestations lack some forest species. For example, in areas near Turew *Coccothraustes coccothraustes* (L.), *Parus atricapillus* L., *Troglodytes troglodytes* (L.), *Phylloscopus sibilatrix* (Bechst.), *Aegithalos caudatus* (L.), *Ficedula hypoleuca* (Pall.), *Turdus viscivorus* L., were found to nest in the forests, and to be missing from the field afforestations.

In has been found that as the afforestation grows in area, the field species gradually disappear, and new species, of the forest-, or forest-periphery-groups, steadily invade it. The largest numbers of these were found nesting in large tree clumps of about 2 ha in surface area. In a yet larger afforestation, about 4 ha, Czarnecki (1956) found all the field species missing except *Emberiza calandra*, encountered sporadically; instead, he recorded a number of further forest species such as *Parus ater* L., *Parus cristatus* L., *Coccothraustes coccothraustes*, *Aegithalos caudatus*, *Ficedula hypoleuca*, *Phylloscopus sibilatrix*, *Troglodytes troglodytes*, *Caprimulgus europaeus* L. In a park of about 10 ha in surface area the above author found two more species, i.e. *Picus viridis* L., and *Dendrocopos minor* (L.). Mildenberger (1950) writes he found *Coccothraustes coccothraustes* and *Turdus viscivorus* to nest in an afforestation of 12 ha; in an afforestation of 24 ha he found, in addition to the above two species, also *Troglodytes troglodytes*, *Dendrocopos minor*, and *Prunella modularis* (L.). In a clump afforestation, 15 ha, *Parus ater*, *Parus atricapillus*, *Troglodytes troglodytes*, *Phylloscopus sibilatrix*, *Regulus regulus* (L.), *Prunella modularis*, *Coccothraustes coccothraustes* were found to nest (Seibert 1967). Mildenberger and Seibert stated that in their investigations they did not find any of the field species, or *Emberiza hortulana* — a typical bird species of mid-field afforestations, to nest in the above mentioned afforestations. It follows, therefore, that as soon as the afforestation attains a certain size, field species will no longer nest in it, and the occurrence of forest species depends on the type rather than on the size of the woods. Thus the mid-field afforestation bird community becomes a forest community.

By their course the changes of the bird communities, associated with the growth in size, and development of structure of the mid-field afforestation, from communities most similar to field-bird communities to a typically forest community, resemble the succession of bird communities observed by a number of authors (Spangenberg 1949, Volčaneckij 1950, Volčaneckij, Medvedev 1950, Budničenko 1955, 1960a, 1961, Riabinin 1957b, Zaletaev 1960) in young afforestations, from their planting onwards. The succession leads on to communities of larger number of species; it cannot, Comparison of the density of birds in different biotopes

Tab. XVII

Biotope	Density pairs/ha	According to
Pine forests	0.50– 4.80	Novikov 1960 (modified)
Mixed forests	2.00– 9.00	" "
Deciduous forests	2.00–22.00	" "
Steppe oak forests	4.00–33.00	Novikov 1959
Parks	0.50–26.00	Novikov 1960 (modified)
Mid-field afforestations	15.00–31.00	" " "
Mid-field afforestations		
Clumps	12.67–27.92	according to the author's
Shelterbelts	14.21–51.66	own study
Shelterbelts with pairs in nest-boxes taken into account	28.26–81.66	
Alleys	36.95	
Hedgerows	23.88	
Shrubbelts	22.22	
Forests with strong bird protection and luring activities		
All species	41.30– 55.20	Pfeifer, Ruppert 1953 (after Czarnecki 1956)
Birds nesting in tree-trunk holes	32.00–252.00	Petrov 1952

however, lead to the transformation of a community, typical to mid-field afforestations, to a forest community. A change of this kind is only possible when the varying factor is the size of the afforestation.

2. Quantitative relations. A forest bird community and a mid-field afforestation community differ from one another not only by the presence or absence of certain species, but also by various numerical ratios between the species of different origin. These ratios also vary within the mid-field afforestations themselves, that is with changes in their size.

3. Density of birds in mid-field afforestations. It appears to be relatively high in comparison with other biotopes (Tab. XVII). The data gathered and elaborated by Novikov (1960) indicates that this density is much higher than that of coniferous, or mixed, and even that of most deciduous forests. Similar conclusions were drawn by Mal'čevskij (1947a), Turček (1958), Budničenko (1960a), who compared bird density in mid-field afforestations and forests of the same region. Budničenko points, however, that only those species grow in number which feed in open spaces. In natural forests, densities equal to, or even higher than the bird density of the mid-field afforestation are only found in old oak forests, and particularly in "island-like" steppe oak forests (Novikov 1959, 1960).

In forests where bird protection and luring are used bird density is higher, sometimes considerably, than in the mid-field afforestations. However, no attempt has so far been made to obtain maximum density of birds in mid-field afforestations. What is known is that the putting of nest boxes increases the number of pairs nesting in an afforestation.

4. Distribution of birds. In addition to vertical stratification, in a woodland horizontal zones may be distinguished: the centre, and the periphery. With the growth of the woodland surface area the difference in bird population between the central and the peripheral zones becomes clearer – some of the birds do not settle throughout the woods area, but only along the margin. In clumps covering an area of several hectares a distinct peripheral zone can be seen, inhabited by species which seldom, or never, occur in the central zone (Seibert 1967).

The territories of birds, and especially the territories of birds feeding in the fields, located in a mid-field afforestation show a number of differences as compared with the territories in the forest. In a shelterbelt, only two boundaries, those running across the shelterbelt, need to be protected. These boundaries usually represent a small part of the total territorial boundary length. On the remaining sides the territories are surrounded by open spaces which are a sort of "no man's land". Diesselhorst (1949), who studied the territorialism of *Emberiza citrinella* in meadows covered by clumps of shrubs, found that even if the territory consisted of a number of shrub clumps separated by open spaces, the defence of open space was not strong, or there was no open space defence at all. If a shrub clump, being the centre of the territory, was surrounded by an open meadow, the defending behaviour would grow weaker towards the meadow. By analogy, it may be presumed that this would also be true of other species living in afforested areas. Normally, a bird defending its territory will only attack singing birds or those with some other kind of display behaviour. With most of the birds living in afforested areas this behaviour is associated with woody, or shrub vegetation so individuals found out of a tree- or shrub-growth, and not singing do not evoke the attacking reaction. As territorialism is not doubt a kind of spatial organisation of the avian population (Lack 1967), in mid-field afforestations this organisation only covers a part of the area penetrated by the population, that is the part used for the breeding. The feeding ground is not comprised by the spatial organisation, it represents a no man's land. Spatial organisation is in this case replaced by hierarchy and flock organisation. This hypothesis agrees with the findings published by Pinowski (1954) that the concentration of birds in open spaces increases with the distance from the afforestation.

The hypothesis of a changing spatial structure of the population in birds living in mid-field afforestations, as a result of changes in the way of area utilization, is confirmed by the results obtained by Tompa (1964) who studied *Melospiza melodia* (Wilson) in small islands near the Canadian coast. He found that in one of the islands the population density of *Melospiza melodia* was 5–10 times as high as that found in other areas. This extremely high density was due to a specific configuration of the environment: in the central part of the island a very narrow shrub-belt is found, and the remainder of its surface is covered by grass. Defended territories, much smaller than in the other environments studied, are located only in the areas covered by shrubs, and are used for breeding. The birds feed in the same open fields, without any signs of hostility, in a way not to be seen anywhere else in this species. According to Tompa the cause of this is, in addition to the specificity of the environment, a great plasticity of the species, as well as the fact it lives in a small island where none of the species that would compete with it occurs.

The discovery in the mid-field afforestation of the same situation as that found by Tompa indicates that this situation may more often occur in nature, in all those environments where favourable conditions exist, the most important condition probably being the separation of the breeding biotope from the feeding biotope. This resembles birds nesting in colonies, in which spatial organisation of the population only exists in the breeding ground and is not extended to the feeding ground which usually lies in a different biotope.

In contrast to the mid-field afforestations, in a forest biotope the organisation covers the entire area occupied by a population. In the mid-field afforestations, the population structure appears to be changed primarily in those species which show a clear relationship between population density and the size of the afforestation.

The mid-field afforestation as an element of agrocenose. The boundary between two biotopes is often termed the ecotone, while an increase in numbers within the ecotone of the species present there, in comparison to their numbers in the surrounding biotopes, is known under the term "edge effect" (Odum 1959). According to Balogh (1958) forest margins and mid-field afforestations are "Saumbiozönosen". However, the mid-field afforestation seems not to be analogous with the forest margin. Firstly, mid-field afforestations have clear limits, while the forest margin is not spatially-delimited. Secondly, field afforestations vary in size, and in consequence their fauna shows considerable qualitative and quantitative variations — while bird communities of small afforestations are very similar to field communities, communities living in large afforestations gradually change over to forest communities. Moreover, as it increases in surface area, a mid-field afforestation begins to differentiate and become divided into a peripheral and central zones, each of these differing from the other by its fauna.

The difference between the field and the mid-field afforestation is of a qualitative, and that between the afforestation and the forest of a quantitative nature – at a certain size-level a mid-field afforestation becomes a forest. The most characteristic feature of mid-field afforestation is its size. The relationship between the fauna and the structure of the afforestation is the same as in the forest, while the relationship between the fauna and the size of the afforestation is a specific one, peculiar to the mid-field afforestation.

A forest and an open field from two distinct biocenoses, each of which can exist independently and have its own energy sources and its own routes of energy flow.

Mid-field afforestations are inhabited mostly by two-biotope species which use the afforestations and the adjacent open space in a different way – for different purposes or at different times. Many bird species use mid-field afforestations only as a breeding or resting ground, and find most of their food in the neighbouring fields or steppes (Mal'čevskij 1947a, Spangenberg 1949), they seem therefore to be more strongly associated with the open space biocenose than with the forest biocenose (Turček 1948–1951). Thus a mid-field afforestation is not a forest biotope amidst field biotopes, but an element of the biocenose of open spaces, linked to them by a number of energy-relationships.

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ZGRUPOWANIA LĘGOWE PTAKÓW W ZADRZEWIENIACH ŚRÓDPOLNYCH

Streszczenie

Celem pracy było poznanie składu gatunkowego zgrupowań ptaków gnieżdżących się w zadrzewieniach śródpolnych, pochodzenia gatunków tworzących zgrupowania, zagęszczenia i rozmieszczenia ptaków oraz próba wyjaśnienia powiązań tych zjawisk z formą, wielkością i strukturą zadrzewienia.

Do zgrupowań ptaków w zadrzewieniach wliczono te gatunki, które budują tam gniazda oraz te, które gniazd w nich nie budują, lecz wykorzystują zadrzewienie do czynności związanych z utrzymaniem terytorium lęgowego. Nie wliczono gatunków odwiedzających zadrzewienie jedynie w celach pokarmowych. W opracowaniu pominięto ptaki drapieżne dzienne, sowy, kuraki oraz kukułkę.

Badania prowadzono w latach 1964–1966 w okolicach Turwi w powiecie kościańskim. Ogólny szkic badanego terenu przedstawia figura 1, zaś ważniejsze cechy badanych zadrzewień zestawiono w tabeli I.

Dane liczbowe zbierano zmodyfikowaną metodą nanoszenia na plan, polegającą na zaznaczaniu na schematycznym planie terenu wszystkich spotkanych ptaków z oznaczeniem gatunku, a w miarę możliwości i płci oraz zaznaczaniu znalezionych gniazd i młodych, które świeżo opuściły gniazdo. Zaznaczano także przemieszczenia obserwowanych osobników. Za udokumentowane zajęcie terytorium uznano spotkanie w danym miejscu 3 razy śpiewającego samca lub raz samca i przynajmniej raz pary ptaków. Za dowód zajęcia terytorium uznano także gniazdo zawierające jaja lub pisklęta, a także pisklęta, które świeżo opuściły gniazdo.

Obserwacje terenowe prowadzone były od 20 kwietnia do pierwszych dni lipca. Liczbę taksacji odbytych w poszczególnych zadrzewieniach przedstawia tabela II.

W zadrzewieniach śródpolnych stwierdzono występowanie 44 gatunków ptaków, z czego 4 są to gatunki polne, 2 gatunki deurbanizujące się, 16 gatunków leśnych, 10 gatunków leśno-brzeżnych, 11 gatunków skraju lasu oraz jeden gatunek charakterystyczny dla zadrzewień śródpólnych – *Emberiza hortulana*. Liczba gatunków z wyżej wymienionych grup, wchodzących w skład zgrupowań zmienia się w zależności od wielkości i struktury zadrzewienia (tab. III), zmienia się również udział procentowy ptaków z tych grup (tab. IV). Główną masę ptaków w zadrzewieniach tworzą gatunki skraju lasu i leśno-brzeżne, stanowiące w sumie 61–85% całkowitej liczby ptaków.

Liczba występujących gatunków zmniejsza się wraz z przejściem od zadrzewień dużych o bardziej złożonej strukturze do zadrzewień mniejszych o strukturze prostszej. Zależność ta występuje także przy porównaniu zadrzewień tej samej formy (fig. 2 i 3).

Gatunki typowe dla zadrzewień występują bądź we wszystkich formach zadrzewień (tab. V), bądź też we wszystkich formach posiadających warstwę drzew (tab. VI). Gatunki typowe stanowią razem 60–90% ogólnej liczby ptaków tworzących zgrupowania. Oprócz grupy tej wyróżniono: grupę gatunków występujących sporadycznie (tab. VII), grupę gatunków zanikających wraz ze zmniejszaniem się wielkości zadrzewienia (tab. VIII), składającą się głównie z ptaków leśnych oraz grupę gatunków wnikających (tab. IX), składającą się z gatunków polnych.

W zebranym materiale uwidocznił się wpływ czynników otoczenia zadrzewienia na występowanie ptaków: sąsiedztwo lasu, zabudowań oraz sąsiedztwo rozległych przestrzeni otwartych.

Do porównania zgrupowań ptaków w zadrzewieniach użyto wskaźników podobieństwa dominacji (*Re*) (fig. 4) i podobieństwa składu gatunkowego (*QS*). Porównywane zgrupowania tworzą grupy, w skład których wchodzą albo zgrupowania z zadrzewień o podobnej strukturze i wielkości albo zgrupowania z zadrzewień większych o prostszej strukturze wraz ze zgrupowaniami z zadrzewień mniejszych o strukturze bardziej skomplikowanej. Wyodrębnione grupy układają się w ciąg prowadzący od zadrzewień największych do najmniejszych.

Ogólna liczebność gatunków typowych dla zadrzewień wzrasta nieco w badanych zadrzewieniach w latach 1964–1966 (tab. X), jednakże dynamika liczebności poszczególnych gatunków wykazuje w tym okresie różne tendencje: najwięcej gatunków wykazuje stałą liczebność, mniejsze grupy tendencje zwyżkowe lub zniżkowe.

Zagęszczenie poszczególnych gatunków stwierdzone w różnych zadrzewieniach podano w tabelach V–IX, zaś zagęszczenie ogólne w tabelach XI–XIII. Zagęszczenie ogólne zależy od wielkości zadrzewienia, osiągając najwyższe wartości w zadrzewieniach najmniejszych (fig. 5 i 6). Wpływ wielkości zadrzewienia jest modyfikowany przez wpływ struktury oraz stopnia zwarcia roślinności: zagęszczenie ogólne największe jest w zadrzewieniach z gęstą warstwą krzewów (tab. XIV). Zależność zagęszczenia poszczególnych gatunków od wielkości zadrzewienia jest różna. Dużą zależność wykazuje zagęszczenie ptaków żerujących na polach (fig. 7). W porównaniu z innymi biotopami zagęszczenie tych gatunków w zadrzewieniach zwiększa się znacznie (tab. XV). Zagęszczenie ptaków żerujących w zadrzewieniu wykazuje słabą zależność od jego wielkości (fig. 8). Nie obserwuje się tu również zwiększenia zagęszczenia w stosunku do zagęszczeń stwierdzonych w innych biotopach (tab. XV).

Reakcja gatunków na zwiększanie gęstości podszytu zadrzewienia jest albo pozytywna (częściej) albo negatywna (tab. XVI).

W zależności od sposobu żerowania ptaków zmienia się w zadrzewieniach wielkość ich terytoriów lęgowych. Gatunki żerujące na polach mają terytoria niewielkie, ułożone jedno obok drugiego wzdłuż zadrzewienia (fig. 9 – *A*, *B*). Bronione są tylko granice boczne takich terytoriów. Gatunki żerujące głównie w zadrzewieniu mają terytoria długie, znacznie rozciągnięte wzdłuż zadrzewienia (fig. 9 – *C*, *D*).

W przypadku, gdy zadrzewienia leżą w stosunkowo niewielkiej odległości od siebie, mogą być obejmowane całe lub ich fragmenty przez to samo terytorium (fig. 10).

Wpływ stopnia rozwoju struktury zadrzewienia na zgrupowanie zamieszkujących go ptaków ma charakter zależności ogólnej i może być traktowany jako wpływ zróżnicowania środowiska. Oddziałuje ono tu pośrednio przez zmiany nasilenia konkurencji międzygatunkowej oraz bezpośrednio drogą zmiany liczby występujących gatunków i zmiany stopnia wykorzystania zadrzewienia przez poszczególne gatunki.

Odmienny jest wpływ wielkości zadrzewienia śródpolnego na liczbę gatunków i na zagęszczenie, wzajemne ich powiązanie jest więc diametralnie różne od spotykanego w lasach. Zachodzące wraz ze zmianami wielkości zadrzewienia zmiany zagęszczenia ptaków żerujących na polach, łączące się ze zmianą struktury przestrzennej populacji, sugerują, że wielkość zadrzewienia wpływa na stosunki wewnątrzgatunkowe.

Między lasem a zadrzewieniem śródpolnym istnieje szereg różnic wyrażających się w:

1. Odmiennych składach gatunkowych zgrupowań ptaków;
2. Odmiennych stosunkach ilościowych gatunków o różnym pochodzeniu;
3. Zwiększeniu w zadrzewieniach zagęszczenia w porównaniu z lasem (tab. XVII);
4. Odmiennym rozmieszczeniu ptaków;
5. Zmianie struktury przestrzennej populacji.

W miarę zwiększania wielkości zadrzewienia śródpolnego zamieszkujące go zgrupowanie ptaków zbliża się coraz bardziej do zgrupowania ptaków lasu, by stać się nim po osiągnięciu przez zadrzewienie pewnej wielkości. Różnica między zadrzewieniem i lasem jest więc różnicą ilościową.

Mimo szeregu podobieństw łączących zadrzewienie śródpolne ze skrajem lasu, wydaje się, że nie jest ono jego analogiem. Jest ono elementem biocenozy pól – agrocenozy.

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