ACTA ZOOL. CRACOV.	33	13	273—301	KRAKÓW, 30. IX. 1990

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The breeding bird communities of the Kamienica watershed in Gorce National Park (The Carpatians, Southern Poland)

[with 5 text-figs.]

Lęgowe zespoły ptaków zlewni Kamienicy w Gorczańskim Parku Narodowym *

Abstract. The breeding communities of birds in the forests of the Kamienica watershed consist of 22—43 species with a total density of 31—75 pairs per 10 ha. Most abundant in this respect are the beechwoods, least rich in species are coniferous forests with the spruce on northern slopes. A very high species diversity (H' = 4.6 and 4.2) is observed in the avifaunas of the semi-natural alder-spruce fen and of the natural beechwood. The avifauna of the fen is ecotonal and transitional between a mountain and a lowland fauna. The evaluation of bird community structure has been based on the detailed mapping method. The point-count methods tested against it lowers the number of species increasing, at the same time, the bird density by at least 29%.

CONTENTS

I. INTRODUCTION

Gorce constitute a fairly typical range of the Western Beskids, although some details are very individual (MEDWECKA-KORNAŚ 1955, MICHALIK et al. unpubl.). Although this range has been the subject of numerous extensive naturalist studies (see e.g. BANDOŁA-CIOŁCZYK ed. 1984), ornithological research

* Pracę wykonano w ramach CPBP — 04. 09, w części także w oparciu o środki finansowe Gorczańskiego Parku Narodowego.

on the area was either fragmentary (KOZŁOWSKI 1974) or occasional (BROŻEK 1980). In 1973—1975, estimates of bird distribution were done in the upper part of the Poniczanka watershed (GŁOWACIŃSKI, unpubl.), which have not been, however, published till now.

The most concrete though incomplete information on the birds of Gorce National Park comes from the work by KOZŁOWSKI (1974) carried out in the Turbacz Nature Reserve. The author estimated the bird density in the two principal habitats of the Reserve: the quasi-primeval Carpathian beechwood and upper zone spruce forest. The results obtained in the two breeding seasons of 1968 and 1969 are particularly important now as they were conducted with the relatively accurate mapping method and before the acute decay of the old tree stand in the Reserve, which has attained disastrous dimensions in the last years. A repetition of estimates with the same methods will permit to state the direction and scale of changes in the Reserve's avifauna.

The present study aimed at determining the content and structure of breeding bird communities in the Park in conditions more average for the Gorce range than those in the Turbacz reserve, and at showing the variations in the avifauna on the background of one of the most interesting and well-preserved watersheds of the Gorce.

This study's secondary objective was to check, in the conditions of the Beskids, the accuracy of the „audio-visual shots" taken in field points against the precise method of mapping yielding absolute results. The results of such a test might help a better use of the above-mentioned cenzuses carried out with the point-count method in the Poniczanka watershed.

The author would like to thank here his colleague, Eng. Jan FIJAŁ, for his technical help and assistance at work with the computer, and Dr. Piotr PROFUS for his collaboration in the early spring ornithological observations in the Kamienica valley. Thanks are also due to Prof. Dr. Stanisław WRÓBEL and Dr. Bronisław SZCZĘSNY for their inspiration and help in organizing the research, and to the Management of Gorce National Park for their hospitality and support of the author's activities.

II. STUDY AREA AND SAMPLE PLOTS' DESCRIPTIONS

Gorce Mts. are a Flysch range of the Western Beskids, of medium height. The highest peak, the Turbacz (1311 m a.s.l.) lies in the centre of radially-extending mountain ranges. The Turbacz massif is also an important source area, from which flow the majority of rivers and streams of the Gorce, including the main river of Gorce National Park, the Kamienica. The whole range is strongly watered, what results in the emergence of bogs and numerous water outflows. The mountains are mostly covered with woods (ca. 80%): their lower parts are dominated by the Carpathian beechwood (60% of the Park area) while conifers dominate above the line of 1100 — firs (12%), spruce (22%) and coniferous forests of transitional character (5%) (Michalik et al. unpubl.).

The Gorce group is a relatively warm Beskid massif, although mean year temperature at the Turbacz is only 3.0°C. Three climatic zones can be differentiated there: (1) the relatively warm zone up to 750 m a.s.l.; (2) the relatively cool zone between 750 and 1100 m a.s.l.; (3) the cool zone from 1100 m a.s.l. up to the highest peaks (Klein 1985). While there are no days with mean day temperature above 15°C in summer, the number of such summer days in the Kamienica valley, where the temperatures are much higher, is 48. The number of winter days (mean temperature below 0°C) in the Kamienica valley, on the other hand, is smaller by 50 than that in the highest parts of the range (Obrębska-Starklowa 1970). Precipitations are often heavy and sometimes very violent; summer rainstorms cause strong freshets in the Kamienica and its tributaries. The annual precipitation total is 750—800 mm below 500 m, exceeds 1000 mm in the crest area and reaches 1269 mm at the Turbacz.

The length of vegetation seasons is strongly dependent on the altitude and exposure of terrain, hence the significant differentiation of phenological phenomena within the watershed. E.g. in mid-April 1988, northern slopes of the Kamienica valley above 800 m a.s.l. were covered with fairly deep snow (10—60 cm) in 75—80%, while those facing South were snow-free in ca. 90% and could be earlier settled by birds.

The observations covered the Kamienica watershed from Borek Pass (1010 m a.s.l.) down to the house of the Park's management in Rzeki (660 m a.s.l.). Study areas were established in habitats most typical for that part of the Gorce. The higher plots (A—C) are situated in the most-forested and wild part of the Kamienica watershed, while the last one, the breeding one (D) lies in a region considerably modified through human activity (clearings, haygrowing and grazing meadows, farm settlements), already within the range of synanthropic fauna interaction (Fig. 1). The three mountain plots (A—C) are relatively uniform, while the lowest one (D) is visibly heterogeneous. It encompasses fairly typical habitats (part natural, part anthropogenic) for widening and settled small Gorce valleys in the zone of calmer stream courses. The plot (D) is situated outside the Park.

The plot A — beechwood on slope, is situated on a steep slope facing South at 810—950 m a.s.l.; 18.0 ha (600 ×300 m).

According to a map of vegetation of the Park (Michalik et al. unpubl.), this area is covered with the Carpathian beechwood with a clear domination of the typical variant *Dentario glandulosae-Fagetum typicum*. The slopes are cut with small streams and periodical courses. Small stretches of the association *Petasitetum kablikiani* enter the area from below, along the streams. Numerous are outflows of subsurface waters and bogs in forests with the developed association *Caltha-Chaerophyllum*. The area is dominated by a natural treestand more than 150 years old, with a considerable number of beeches *Fagus silvatica*, firs *Abies alba*, spruces *Picea excelsa* and sycamore maples *Acer pseudo-*

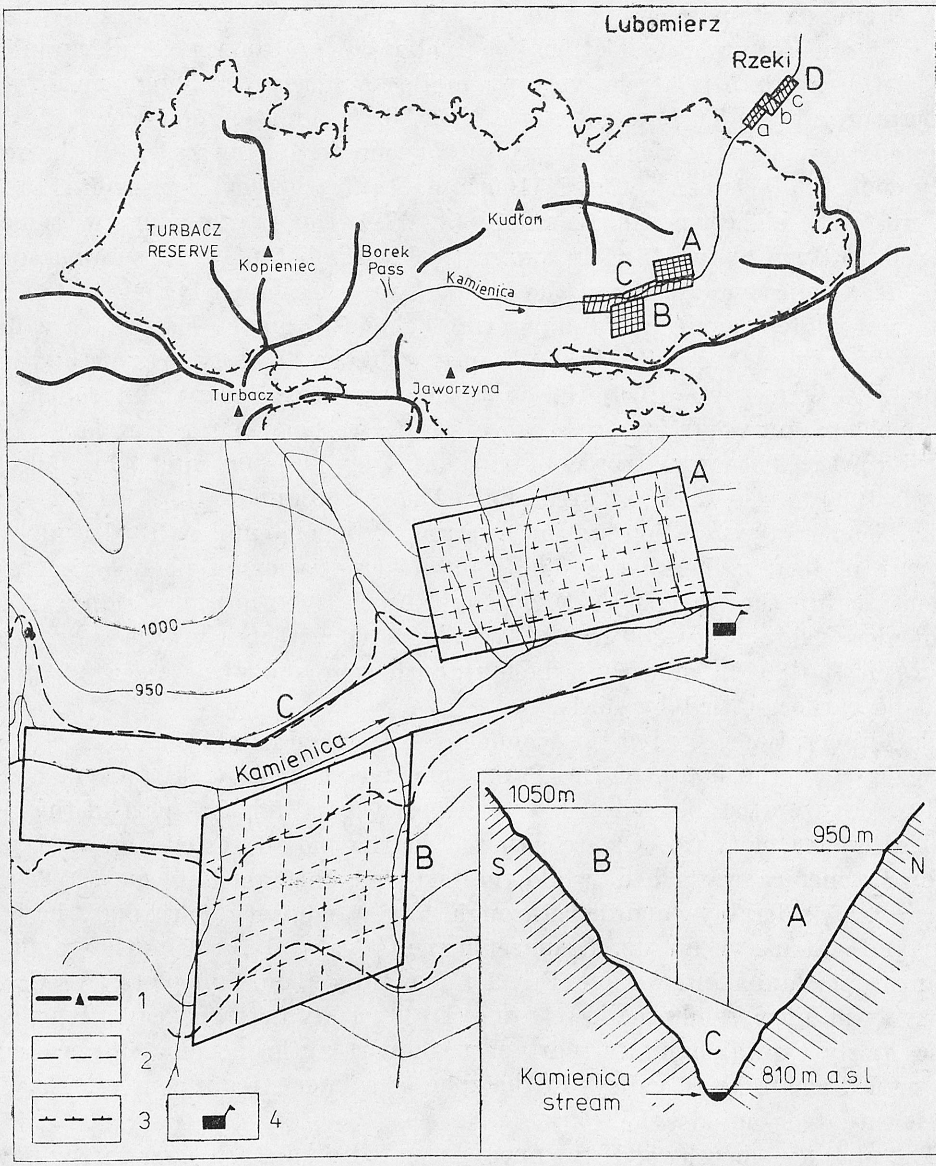

Fig. 1. Diagram of studied forest plots in the Kamienica watershed in the Gorce Mts. A — beechwood plot, B — coniferous wood with the spruce on a northern slope, C — coniferous forest with the spruce in a deep valley, D — alder-spruce fen: a) the highest part with mixed wood, b) middle part with small woods and meadows, c) the lowest part of the plot occupied by settlement and small forest areas. 1 — mountain tops and ranges, 2 — slope roads, 3 — limits of the Gorce National Park, 4 — fieldstation of the Nature Protection Research Centre, Polish Academy of Sciences

platanus, of several hundred years. The brushwood is developed according to the compactness of the tree crowns: it is barely visible in compact tree stands, and becomes abundant in well-lit places. This layer is formed by the species of the treestand with an additional important participation of the hornbeam *Carpinus betulus* and the black alder *Frangula alnus*. The best-lit places, a result of windfalls, are dominated by the raspberry bushes with *Rubus idaeus*, the blackberry bramble with *Rubus hirtus*, the racemose elder *Sambucus racemosa*, the fire-weed *Chamaenerion angustifolium* and the ferns — the lady fern *Athyrium filix-femina*, the shieldfern *Dryopteris spinulosa* and *D. filix-mas*. Characteristic for the undergrowth of the Carpathian beechwood are the toothwort *Dentaria glandulosa*, the comfrey *Symphytum cordatum* and the Christmas fern *Polystichum braunii*.

The plot B — spruce mixed forest on slope was situated on a steep northern slope at 850—1050 m a.s.l.; 25.0 ha (500 ×500 m).

The area is covered with a lower mountain zone fir-spruce forest *Abieti-Piceetum montanum* with a significant admixture of the beech. It is dominated by an old natural stand, in a large part on a rocky landslide, with local windfalls and hollows caused by them. The study area is traversed, on the level line of 900 and 1000 m a.s.l., by two forest roads causing a band loosening of the forest. Numerous willows *Salix caprea* and elders *Sambucus racemosa* and *S. nigra* penetrate the forest along the roads. The brushwood is dominated by the raspberries, locally enriched with young beeches, firs and spruces as well as bushes of the elder *S. racemosa*. The bilberry *Vaccinium myrtillus*, the fern *Athyrium filix-femina*, the sylvan wood-rush *Lusula nemorosa* and the wood-reed *Calamagrostis arundinacea* (Michalik et al. unpubl.) prevail in the undergrowth. The slope, with numerous bogs, is cut with several small tributaries of the Kamienica stream.

The plot C — mixed and solely coniferous forest in a deep valley, canyon-like in places. The elongated area covers almost 2 km of the wild Kamienica valley overgrown with a lower mountain zone fir-spruce forest *Abieti-Piceetum montanum* and, partly, with the typical variant of the Carpathian beechwood *Dentario glandulosae-Fagetum typicum*. The bottoms of the valley and of the canyons are covered with the association of riverine butterburs *Petasitetum kablikiani* (according to Michalik et al. unpubl.). The area is about 25 ha (1700 ×150 m). Two of its fragments border on the areas A and B (see Fig. 1). It is situated on landslides and rocky ravines; the slopes are strongly loosened and damp due to the numerous water outflows. Centres of windfalls occur in several places. The valley there is considerably shady and the air is highly humid, especially in the immediate vicinity of the Kamienica. The top boundaries of the area on both slopes are marked by the roads following the contour lines.

The plot D — valley with fen copses and half-open spaces. It has been located in a former flood-land terrace in Rzeki, at the threshold of the upper and the middle courses of the Kamienica, between the boundary of the Park and the Mszana Dolna — Krościenko road. The total area is 22.0 ha, that of its segments differing in size and degree of culture being respectively a) 6.5 ha of the upper (650 ×100 m), b) 4.5 ha of the middle (300 ×150 m) and c) lower

— 11.0 ha (600 ×150 m + 200 ×100 m), the latter situated in the closest vicinity of the settlement.

The sample plot is covered in half with compact or loose alder, spruce, and alder-spruce tree stands with various proportions of the grey alder *Alnus incana* and the spruce *Picea excelsa* is the tree layer and the brushwood. The fen stands are closest here to the Carpathian alderwood *Alnetum incanae*, rarely connected to the association of marsh alderwood *Caltho-Alnetum*. The spaces between the copses are filled with hay-growing meadows and pastureland. A secondary public road runs along the area, with two bridges on the river. The area lies within the zone of daily human penetration.

III. METHODS

An estimate of bird density on the sample plots was conducted in 1988 with the mapping method (Enemar 1959 and others), similar to the combined version (Tomiałojć 1980) based on determining breeding territories, finding nests and recording other symptoms of the birds' nesting in the areas studied. The cenzuses were carried out at least 5 times in a breeding season (Plot D), at most 7 times (Plot A) in intervals of some ten or twenty days. They were always undertaken in weather good enough to assure a continued activity of the majority of the birds. Mapping was interrupted in rains and strong wind. Technical and weather conditions caused the countings to be done from early morning — when the cenzuses are the most effective — until dusk. The first cenzuses were carried out on the 26th and 27th of April (beechwood and sprucewood on a slope), the final ones on the 21st and 22nd of July (woods with pine and fen in valley). The latter ones were treated as additional, especially in relation to the species difficult to discover (e.g. *Regulus ignicapillus*, *Turdus viscivorus*), difficult to identify (e.g. *Parus montanus* and *P. palustris*; *Sylvia atricapilla* and *S. borin*) in some circumstances, of not fully established character of occurrence, etc. The beechwood plot (A), the most difficult one to control, was divided into a network of squares 50 m × 50 m, carefully marked with paint, and the squares were also numbered for a better orientation in the field. The spruce plot on slope (B), easier to survey, was divided into 100 m ×100 m squares. In the case of the other two plots, on the other hand, i.e. C and D, the cenzuses were limited to the measurements based on topographical details (roads, bridges, river bends, forest boundaries, characteristic trees, etc), combined with a map of the areas.

All those species and individuals or pairs, whose nesting within the sample plot has been directly or undirectly documented, were counted into a bird community of a given habitat. The qualitative characteristics of the communities also included species recorded but in vestigial numbers (less than 0.2 breeding territory per sample plot) and nesting in a given habitat outside the sample plot. Those birds are included in the lists as present in the community (marked +) but without their quantitative participation (Tab. I—IV). Those additional species were also included in the evaluation of species diversity according to SHANNON'S H' formula with an assumed value of 2 (the smallest integer with a logarithm superior to 0).

Apart from the basic objective of the study, another method of counting birds was tentatively used. This method belongs to the so-called point-count ones (e.g. BLONDEL et al. 1970). It has been first used in Poland by KRZANOWSKI (1964). All such methods consist in a short counting, usually of several minutes, on the basis of bird voices (especially male songs) in each of selected field points in various dates of the breeding season. They yield relative data, diverging from the real state of the avifauna (e.g. WALANKIEWICZ msc.). Such methods assume that a singing male represents a breeding pair.

In the Kamienica watershed, point-count cenzuses were conducted in some parts of the sample plots at 3 dates: 13.05., 1.06. and 9.06 in the beechwood plot and on 12.05., 31.05. and 8—9.06 in woods with spruce plots. Observation points were located in regular 100 m intervals. Audial and visual observation at each point lasted for 5—10 min. and covered a circular area with a radius of 50 m (0.79 ha). Apart from that, the birds were also recorded, as a test, within a 25 m — radius circle (0.20 ha). In the summing up of the three series of cenzuses, the "maximum population" principle was adopted after PALMGREN (1930), i.e. the highest result for each species and point was assumed as valid. The results obtained were compared with the materials yielded by the same areas with the combined mapping method.

Three basic breeding groups of birds were established in respect to the type of nesting:

α — species nesting on the ground and near it (up to 1.5 m);

β — species nesting above 1.5 m above the ground;

γ — hollow-nesters.

Some of the species whose classification into any of those breeding categories was difficult, as *Passer domesticus* and *Phoenicurus ochruros*, were included half into group β half into group γ.

The species diversity of the bird communities was calculated according to SHANNON'S H' formula (e.g. LLOYD, ZAR, KARR 1968):

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i,$$

where S — number of species in a bird community, p_i — fraction of individuals belonging to the i^{th} species.

The structure of species domination within a community (evenness or equitability) was calculated with J' formula (e.g. PIELOU 1966):

$$J' = H'/H'_{max},$$

where $H'_{max} = \log_2 S$, while H' and S as above.

The formulae H′ and J′ were also used in relation to biomass by introducing, in p_i, the fraction of total biomass for the i^{th} species for the number of individuals (see GŁOWACIŃSKI, WEINER 1977, 1980).

The rarefaction $E(S_n)$ was calculated from the following formula (JAMES, WAMER 1982; RAUP, STANLEY 1984, and others):

$$E(S_n) = \sum_{i=1}^{S} \left(1 - \frac{\binom{N-N_i}{n}}{\binom{N}{n}} \right),$$

where S — number of species in a community, N — number of breeding pairs (or individuals) in a whole community, N_i — number of breeding pairs in the i^{th} species, n — any essay value (inferior to N). The index of rarefaction permits to determine the theoretical number of species on the grounds of the number and proportion of species in a sample taken. Thus calculated values are independent on the size of the area on which the community has been described.

For the evaluation of bird community similarity, the simple RENKONEN'S formula (1938) Re has been used:

$$Re = \sum_{i=1}^{S} w_i,$$

where w_i — total of minimum percentage of "i" species domination in the compared communities.

The results of cenzuses obtained with the differing methods were tested with the PEARSON corelation coefficient.

IV. RESULTS

In the Gorce beechwood, the nesting of 34 species has been recorded; of those, 6 were only vestigial in occurrence (marked +); the total density was 75.0 pairs per 10 ha (Tab. I). The decisive dominant in the bird community of this forest (participation $\geq 5\%$) is *Fringilla coelebs* (17.4%), followed by *Erithacus rubecula* (11.8%), *Sylvia atricapilla* (10.0%), *Prunella modularis* (9.2%), *Parus ater* (7.4%), *Phylloscopus collybita* and *Troglodytes troglodytes* (5.2% each). The last 8 of the species listed in Table I occur in a very low density ($N < 0.5$ pair 10 ha) and at least one of those (*Motacilla cinerea*) is accidental for a forest habitat as connected with the stream.

In the spruce and partly mixed coniferous forest of the lower mountain zone on a slope, the described bird community includes 22 species (with 3 marked +) with a total density of 31.0 pairs per 10 ha (Tab. II). The community is clearly dominated by *Fringilla coelebs* (26.1%), accounting for more than a quarter of the total numbers of the community. Then follow: *Erithacus ru-*

becula (17.6%), *Sylvia atricapilla* and *Parus ater* (9.1% each), *Prunella modularis* and *Troglodytes troglodytes* (5.8% each). Ten species occur in densities inferior to 0.5% pair/10 ha, including 1 (*Motacilla cinerea*) being accidental as in the preceding area.

Twenty-eight bird species (including 2 marked +) have been recorded to nest in the mixed and purely spruce forest in the deep-cut valley, in a total density of 40.0 pairs per 10 ha (Tab. III). As in the preceding areas, this one

Table I

The breeding bird community of the beech forest in 1988 (plot A)

No.	Species	Number of pairs		%
		18 ha	10 ha	
1.	*Fringilla coelebs* LINNAEUS, 1758	23.5	13.1	17.4
2.	*Erithacus rubecula* (LINNAEUS, 1758)	16.0	9.0	11.8
3.	*Sylvia atricapilla* (LINNAEUS, 1758)	13.5	7.5	10.0
4.	*Prunella modularis* (LINNAEUS, 1758)	12.5	7.0	9.2
5.	*Parus ater* LINNAEUS, 1758	10.0	5.0	7.4
6.	*Phylloscopus collybita* (VIEILLOT, 1817)	7.0	3.9	5.2
7.	*Troglodytes troglodytes* LINNAEUS, 1758	7.0	3.9	5.2
8.	*Phylloscopus sibilatrix* (BECHSTEIN, 1793)	4.5	2.5	3.3
9.	*Regulus regulus* (LINNAEUS, 1758)	4.0	2.2	3.0
10.	*Sitta europaea* LINNAEUS, 1758	4.0	2.2	3.0
11.	*Turdus merula* LINNAEUS, 1758	4.0	2.2	3.0
12.	*Certhia familiaris* LINNAEUS, 1758	3.0	1.7	2.3
13.	*Parus montanus* CONRAD VON BALDENSTEIN, 1827	3.0	1.7	2.3
14.	*Phylloscopus trochilus* (LINNAEUS, 1758)	3.0	1.7	2.3
15.	*Tetrastes bonasia* (LINNAEUS, 1758)	3.0	1.7	2.3
16.	*Ficedula parva* (BECHSTEIN, 1794)	2.5	1.4	1.9
17.	*Turdus philomelos* C. L. BREHM, 1831	2.5	1.4	1.9
18.	*Pyrrhula pyrrhula* (LINNAEUS, 1758)	2.0	1.1	1.5
19.	*Anthus trivialis* (LINNAEUS, 1758)	1.5	0.8	1.1
20.	*Turdus torquatus* LINNAEUS, 1758	1.5	0.8	1.1
21.	*Columba palumbus* LINNAEUS, 1758	1.0	0.5	0.7
22.	*Muscicapa striata* (PALLAS, 1764)	1.0	0.5	0.7
23.	*Parus palustris* LINNAEUS, 1758	1.0	0.5	0.7
24.	*Picoides tridactylus* (LINNAEUS, 1758)	1.0	0.5	0.7
25.	*Regulus ignicapillus* (TEMMINCK, 1820)	1.0	0.5	0.7
26.	*Turdus viscivorus* LINNAEUS, 1758	1.0	0.5	0.7
27.	*Dendrocopos leucotos* (BECHSTEIN, 1803)	0.5	0.3	0.4
28.	*Strix uralensis* PALLAS, 1771	0.5	0.3	0.4
29.	*Buteo buteo* (LINNAEUS, 1758)	+	+	—
30.	*Cuculus canorus* LINNAEUS, 1758	+	+	—
31.	*Dryocopus martius* (LINNAEUS, 1758)	+	+	—
32.	*Loxia curvirostra* LINNAEUS, 1758	+	+	—
33.	*Parus major* LINNAEUS, 1758	+	+	—
34.	*Motacilla cinerea* TUNSTALL, 1771 (river zone)	+	+	—
	Total	135.0	74.9 ≈75.0	100.0

Table II

The breeding bird community of the coniferous forest in 1988 (plot B)

No.	Species	Number of pairs 25 ha	Number of pairs 10 ha	%
1.	*Fringilla coelebs* LINNAEUS, 1758	20.0	8.0	26.1
2.	*Erithacus rubecula* (LINNAEUS, 1758)	13.5	5.4	17.6
3.	*Sylvia atricapilla* (LINNAEUS, 1758)	7.0	2.8	9.1
4.	*Parus ater* LINNAEUS, 1758	7.0	2.8	9.1
5.	*Prunella modularis* (LINNAEUS, 1758)	4.5	1.8	5.8
6.	*Troglodytes troglodytes* LINNAEUS, 1758	4.5	1.8	5.8
7.	*Phylloscopus sibilatrix* (BECHSTEIN, 1793)	3.5	1.4	4.5
8.	*Regulus regulus* (LINNAEUS, 1758)	3.0	1.2	3.9
9.	*Pyrrhula pyrrhula* (LINNAEUS, 1758)	2.5	1.0	3.3
10.	*Turdus philomelos* C. L. BREHM, 1831	2.5	1.0	3.3
11.	*Parus montanus* CONRAD VON BALDENSTEIN, 1827	2.0	0.8	2.6
12.	*Phylloscopus collybita* (VIEILLOT, 1817)	2.0	0.8	2.6
13.	*Garrulus glandarius* LINNAEUS, 1758	1.0	0.4	1.3
14.	*Turdus torquatus* LINNAEUS, 1758	1.0	0.4	1.3
15.	*Turdus viscivorus* LINNAEUS, 1758	1.0	0.4	1.3
16.	*Dendrocopos leucotos* (BECHSTEIN, 1803	0.5	0.2	0.7
17.	*Dryocopus martius* (LINNAEUS, 1758)	0.5	0.2	0.7
18.	*Turdus merula* LINNAEUS, 1758	0.5	0.2	0.7
19.	*Picoides tridactylus* (LINNAEUS, 1758)	0.2	0.1	0.3
20.	*Cuculus canorus* LINNAEUS, 1758	+	+	—
21.	*Regulus ignicapillus* (TEMMINCK, 1820)	+	+	—
22.	*Motacilla cinerea* TUNSTALL, 1771 (river zone)	+	+	—
	Total	77.0	30.7 ≈31.0	100.0

was also dominated by *Fringilla coelebs* (21.0%), followed by *Erithacus rubecula* (15.0%), *Parus ater*, *Sylvia atricapilla* and *Troglodytes troglodytes* (7.5% each), *Prunella modularis* (7.0%) and *Regulus regulus* (5.0%). As much as 13 species are very rare in this community, with densities inferior to 0.5 pair/10 ha.

In the dispersed alder-spruce fen in the vicinity of the Rzeki settlement, the nesting of 43 species has been recorded (7 marked +) with a total density of 60.0 pairs per 10 ha (Tab. IV). The community is dominated by colonies of the fieldfare *Turdus pilaris* (20.6%). Other dominants are: *Fringilla coelebs* (11.0%), *Erithacus rubecula* (6.5%), and *Prunella modularis* (5.0%). Three species are clearly connected with the river (*Motacilla cinerea, Cinclus cinclus, Tringa hypoleucos*), while three other (*Passer domesticus, Delichon urbica, Hirundo rustica*) are strictly synanthropic.

The state of other biocenotic characteristics, as the number of species S, the number of breeding pairs N, biomass B, the species diversity H', the structure of species domination J', the theoretical number of species calculated with the rarefaction index E (S_n) and other parameters are shown in Table V. Comparisons of species quantitative structure in mountain zone associations (plots

Table III

The breeding bird community of the mixed coniferous forest in the deep valley in 1988 (plot C)

No.	Species	Number of pairs		%
		25 ha	10 ha	
1.	*Fringilla coelebs* LINNAEUS, 1758	21.0	8.4	21.0
2.	*Erithacus rubecula* (LINNAEUS, 1758)	15.0	6.0	15.0
3.	*Parus ater* LINNAEUS, 1758	7.5	3.0	7.5
4.	*Sylvia atricapilla* (LINNAEUS, 1758)	7.5	3.0	7.5
5.	*Troglodytes troglodytes* LINNAEUS, 1758	7.5	3.0	7.5
6.	*Prunella modularis* (LINNAEUS, 1758)	7.0	2.8	7.0
7.	*Regulus regulus* (LINNAEUS, 1758)	5.0	2.0	5.0
8.	*Turdus philomelos* C. L. BREHM, 1831	4.5	1.8	4.5
9.	*Motacilla cinerea* TUNSTALL, 1771 (stream zone)	3.5	1.4	3.5
10.	*Phylloscopus collybita* (VIEILLOT, 1817)	3.0	1.2	3.0
11.	*Phylloscopus sibilatrix* BECHSTEIN, 1793	3.0	1.2	3.0
12.	*Parus montanus* CONRAD VON BALDENSTEIN, 1827	2.0	0.8	2.0
13.	*Turdus merula* LINNAEUS, 1758	2.0	0.8	2.0
14.	*Ficedula parva* (BECHSTEIN, 1794)	1.5	0.6	1.5
15.	*Pyrrhula pyrrhula* (LINNAEUS, 1758)	1.5	0.6	1.5
16.	*Columba palumbus* LINNAEUS, 1758	1.0	0.4	1.0
17.	*Dendrocopos leucotos* (BECHSTEIN, 1803)	1.0	0.4	1.0
18.	*Certhia familiaris* LINNAEUS, 1758	1.0	0.4	1.0
19.	*Garrulus glandarius* LINNAEUS, 1758	1.0	0.4	1.0
20.	*Regulus ignicapillus* (TEMMINCK, 1820)	1.0	0.4	1.0
21.	*Turdus torquatus* LINNAEUS, 1758	1.0	0.4	1.0
22.	*Anthus trivialis* (LINNAEUS, 1758)	0.5	0.2	0.5
23.	*Dryocopus martius* (LINNAEUS, 1758)	0.5	0.2	0.5
24.	*Phylloscopus trochilus* (LINNAEUS, 1758)	0.5	0.2	0.5
25.	*Picoides tridactylus* (LINNAEUS, 1758)	0.5	0.2	0.5
26.	*Turdus viscivorus* LINNAEUS, 1758	0.5	0.2	0.5
27.	*Cuculus canorus* LINNAEUS, 1758	+	+	—
28.	*Sitta europaea* LINNAEUS, 1758	+	+	—
	Total	100.0	40.0	100.0

Table IV

The breeding bird community of the mixed alder-spruce wood on the Kamienica river bank near Rzeki settlement in 1988 (plot D: a — the highest part of the plot covered with mixed wood, b — middle part of plot D with small woods and meadows, c — the lowest part of the plot occupied by settlement and small forest areas)

No.	Species	Number of pairs		%	Number of pairs		
		22 ha	10 ha		a = 6.5ha	b = 4.5ha	c = 11ha
1	2	3	4	5	6	7	8
1.	*Turdus pilaris* LINNAEUS, 1758	27.0	12.3	20.6	12.0	5.0	10.0
2.	*Fringilla coelebs* LINNAEUS, 1758	14.5	6.6	11.0	3.0	3.0	8.5
3.	*Erithacus rubecula* (LINNAEUS, 1758)	8.5	3.9	6.5	4.0	1.5	3.0

Table IV cont.

1	2	3	4	5	6	7	8
4.	*Prunella modularis* (LINNAEUS, 1758)	6.5	3.0	5.0	3.0	1.0	2.5
5.	*Sylvia atricapilla* (LINNAEUS, 1757)	6.0	2.7	4.6	3.5	1.5	1.0
6.	*Motacilla cinerea* TUNSTALL, 1771 (river zone)	5.0	2.3	3.8	1.0	1.0	3.0
7.	*Parus major* LINNAEUS, 1758	4.0	1.8	3.0	2.0	—	2.0
8.	*Sturnus vulgaris* LINNAEUS, 1758	4.0	1.8	3.0	—	2.0	2.0
9.	*Carduelis spinus* (LINNAEUS, 1758)	3.5	1.6	2.7	1.0	1.0	1.5
10.	*Sylvia borin* (BODDAERT, 1783)	3.5	1.6	2.7	—	1.0	2.0
11.	*Sylvia communis* LATHAM, 1787	3.5	1.6	2.7	1.0	1.0	1.5
12.	*Carpodacus erythrinus* (PALLAS, 1770)	3.0	1.4	2.3	1.0	2.0	—
13.	*Carduelis carduelis* (LINNAEUS, 1758)	3.0	1.4	2.3	—	0.5	2.5
14.	*Motacilla alba* LINNAEUS, 1758	3.0	1.4	2.3	0.5	2.5	1.0
15.	*Muscicapa striata* (PALLAS, 1764)	3.0	1.4	2.3	—	1.0	2.0
16.	*Turdus philomelos* C. L. BREHM, 1831	3.0	1.4	2.3	1.0	1.0	1.0
17.	*Emberiza citrinella* LINNAEUS, 1758	2.5	1.1	1.9	0.5	1.0	1.0
18.	*Hippolais icterina* (VIEILLOT, 1817)	2.0	0.9	1.5	—	1.0	1.0
19.	*Parus ater* LINNAEUS, 1758	2.0	0.9	1.5	1.0	—	1.0
20.	*Parus montanus* CONRAD VON BALDENSTEIN, 1827	2.0	0.9	1.5	—	1.0	1.0
21.	*Passer domesticus* (LINNAEUS, 1758) (settlement)	2.0	0.9	1.5	—	—	2.0
22.	*Phoenicurus ochruros* (GMELIN, 1774)	2.0	0.9	1.5	—	—	2.0
23.	*Phylloscopus collybita* (VIEILLOT, 1817)	2.0	0.9	1.5	—	0.5	1.5
24.	*Phyloscopus trochilus* (LINNAEUS, 1758)	2.0	0.9	1.5	—	—	2.0
25.	*Sylvia curruca* (LINNAEUS, 1758)	2.0	0.9	1.5	1.0	—	1.0
26.	*Troglodytes troglodytes* LINNAEUS, 1758	2.0	0.9	1.5	1.5	0.5	—
27.	*Pyrrhula pyrrhula* (LINNAEUS, 1758)	1.5	0.7	1.1	0.5	—	1.0
28.	*Anthus trivialis* (LINNAEUS, 1758)	1.0	0.5	0.8	0.5	—	0.5
29.	*Cinclus cinclus* (LINNAEUS, 1758) (river)	1.0	0.5	0.8	—	—	1.0
30.	*Parus caeruleus* LINNAEUS, 1758	1.0	0.5	0.8	—	—	1.0
31.	*Parus palustris* LINNAEUS, 1758	1.0	0.5	0.8	—	—	1.0
32.	*Regulus regulus* (LINNAEUS, 1758)	1.0	0.5	0.8	—	—	1.0
33.	*Serinus serinus* (LINNAEUS, 1766)	1.0	0.5	0.8	—	0.5	0.5
34.	*Tringa hypoleucos* LINNAEUS, 1758 (river)	1.0	0.5	0.8	0.5	0.5	—
35.	*Picus canus* GMELIN, 1788	0.5	0.5	0.4	—	—	0.5
36.	*Turdus torquatus* LINNAEUS, 1758	0.5	0.2	0.4	—	—	0.5
37.	*Carduelis chloris* (LINNAEUS, 1758)	+	+	—	—	+	+
38.	*Cuculus canorus* LINNAEUS, 1758	+	+	—	+	+	+
39.	*Delichon urbica* (LINNAEUS, 1758) (settlement)	+	+	—	—	—	+
40.	*Hirundo rustica* LINNAEUS, 1758 (settlement)	+	+	—	—	—	+
41.	*Pica pica* (LINNAEUS, 1758)	+	+	—	—	+	+
42.	*Scolopax rusticola* LINNAEUS, 1758	+	+	—	+	—	—
43.	*Sitta europaea* LINNAEUS, 1758	+	+	--	+	—	—
	Total	131.0	60.0	100.0	63.0	29.5	38.5

A—C) in the Kamienica watershed have been additionally done in the graphic form (Fig. 2).

The qualitative (S) and quantitative (N) participations of species in the selected nesting categories (α, β, γ) are presented in Table VI. In almost all cenzuses there prevail species nesting in the tree and shrub layer (β). The percentage of birds nesting at the ground is only higher in beechwood A (α = 41.2%).

Table V

Basic structural indices of the described bird communities in the plots A-D. Symbols explained in the text

Indices	A	B	C	D
S	34	22	28	43
S_N (for $N \geqslant 0.1$)	28	19	26	36
N (pairs/10 ha)	75.0	31.0	40.0	60.0
H'	4.17	3.55	3.93	4.55
J'	0.82	0.80	0.82	0.84
B (g/10 ha)	5140	1620	2410	5050
H'_B	3.98	3.79	3.99	2.75
J'_B	0.83	0.89	0.85	0.53
$E_{(20)}$	11.3	9.3	10.7	12.5
$E_{(30)}$	14.0	11.2	13.5	16.5
$E_{(40)}$	16.0	—	15.2	20.0
$E_{(55)}$	18.5	—	—	23.0
$E_{(75)}$	20.5	—	—	—

Table VI

Nesting groups (α, β, γ) in the bird communities described from the plots A-D. Symbols explained in the text

	A		B		C		D	
	S	%	S	%	S	%	S	%
α	9	26.5	6	27.3	8	28.6	16	37.2
δ	14	41.2	11	50.0	12	42.8	17	39.5
γ	11	32.3	5	22.7	8	28.6	10	23.3
Σ	34	100	22	100	28	100	43	100

	N	%	N	%	N	%	N	%
α	30.9	41.2	12.2	39.7	16.2	40.5	19.7	32.8
δ	29.4	39.2	14.4	46.9	18.2	45.5	30.5	50.8
γ	14.7	19.6	4.1	13.4	5.6	14.0	9.8	16.4
Σ	75.0	100	30.7	100	40.0	100	60.0	100

Table VII

Qualitative-quantitative similarity (Re) between bird communities described from the Kamienica watershed (GO and A-D) and other regions of the Polish Carpathians: Bieszczady (BI, Cichoń and Zając unpubl.), Tatras (TA, Głowaciński and Profus unpubl.) and in the Turbacz Nature Reserve (GT, Kozłowski 1974). Bw — beechwoods, Mw — mixed lower mountain zone woods with the spruce, Su — upper mountain zone sprucewoods, Fr — riverine fens. Re values grouped in blocks of communities; most similar in frames

Bw—TA	Bw—BI	Bw—GT	A Bw—GO	B Mw—GO	C Mw—GO	Su—GT	Su—TA	D Fr—GO	
—	57.8	61.5	67.1	64.5	64.0	56.2	53.5	35.5	Bw—Tatry 1981
	—	59.4	59.9	62.5	57.8	56.2	50.0	37.2	Bw—Bieszczady 1987
		—	57.0	61.3	58.0	65.0	57.3	28.8	Bw—Gorce/Turbacz
			—	73.0	80.4	51.2	49.9	41.4	Bw—Gorce (A)
				—	83.9	68.6	65.5	37.9	Mw—Gorce (B)
					—	59.2	59.0	42.4	Mw—Gorce (C)
						—	72.2	29.1	Su—Gorce/Turbacz
							—	26.7	Su—Tatry 1981
								—	Fr—Gorce (D)

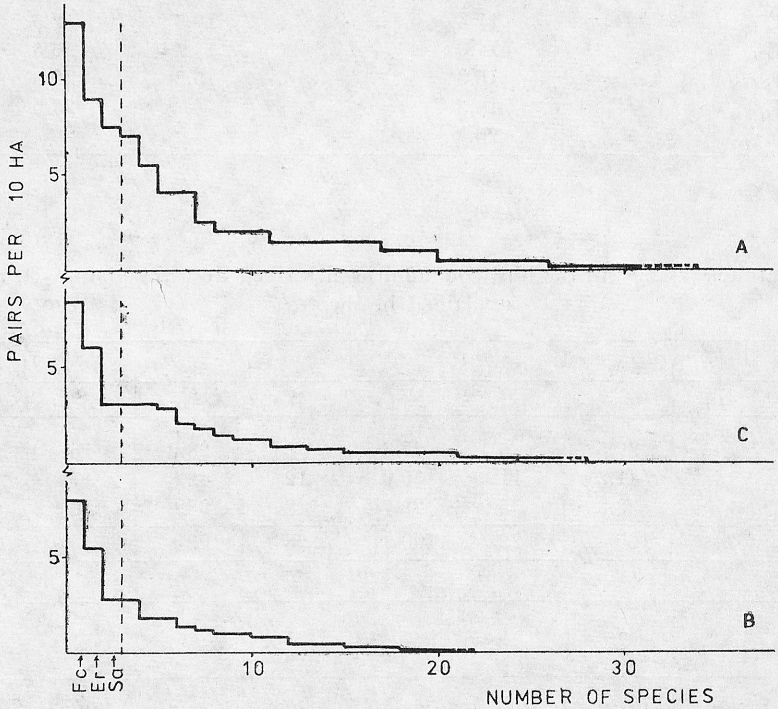

Fig. 2. Comparison of quantitative dominance of species in communities of the natural habitats A—C. Three first dominants in all bird communities observed, initialled: Fc — *Fringilla coelebs*, Er — *Erithacus rubecula*, Sa — *Sylvia atricapilla*. Horizontal dashed line is for species marked +

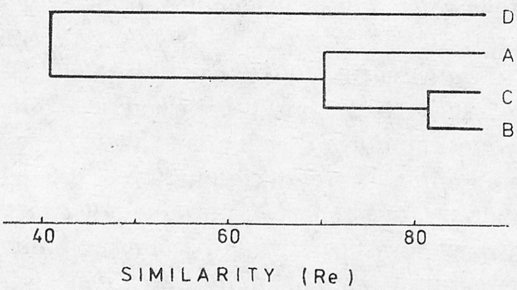

Fig. 3. Dendrogram showing the similarity of communities studied based on RENKONEN'S formula (Re). A—D — sample plots explained in the text, Tabs. I—IV and Fig. 1

The percentage similarity (Re) between the studied bird communities in the plots A—D and those described from other parts of the Carpathians is presented in Table VII. The range of similarity between the Gorce bird communities A—D is additionally presented in a dendrogram (Fig. 3).

V. DISCUSSION

Species richness. The number of species of birds in the studied areas of the Kamienica watershed is clearly differentiated in the spatial and ecological gradient. The richest in species fen association (D) is about twice bigger than the most scarce one developed in the woods with spruce on a northern slope deep in the watershed (B). The results obtained from the sample plots confirm the pressumption that the greatest number of bird species nest in the riverine fens in lower parts of the mountains, followed by the higher-situated Carpathian beechwood and mixed forest with the spruce and variable dominance of the spruce. The fen area (D) represents a heterogeneous, mosaic habitat, so its faunistic receptivity is relatively high. The species richness and other characters are also strongly influenced by the effect of the ecotone and the insularity of the habitats. Also, the fen plot is situated in a transitive zone between the faunas of the mountains and of the lowlands, with a high participation of synanthropic species. The situation of the other sample plots at higher altitudes among a more or less compact forest is the cause for the smaller number of bird species there than in the fen habitats at the mouth of the valley. The phenomenon of relative qualitative (and quantitative) impoverishment of the avian fauna inside large forest complexes is commonly known (e.g. TOMIAŁOJĆ, PROFUS 1977, TOMIAŁOJĆ, WESOŁOWSKI, WALANKIEWICZ 1984) and fairly comprehensively explained (e.g. CIEŚLAK 1985, GROMADZKI 1970). Of decisive influence on the bird species number differentiation among the habitats A—C are, most probably, the coefficients of the structural development of the forests, the volume of the ecological niches as well as the species diversity of the tree stands and the lower layers of the forest. This sort of dependency has already been shown in many ornithological-ecological studies (Cody 1974, Cyr 1977, Fujimaki 1981, Holmes 1980, James, Wamer 1982, Jermaczek msc., MacArthur, MacArthur 1961, Recher 1969). The structure and trophic conditions of the Carpathian beechwood are much more favourable for birds (a full and most uniform development of the forest layers, numerous hollow trees, the predominance of deciduous trees, which decay faster and keep up a more numerous invertebrate fauna included in the birds' diet) than the poorer in this respect forests with pine and a predominance of the spruce. Biotical conditions are supplemented here with physical factors (air temperature, insolation, snow cover persistence, type of bedrock, etc.), which become important in the mountains and considerably shape the faunistic relationships. Those factors do not act uniformly over all areas. The beechwood on a southern slope offers milder weather conditions and several days earlier breeding season than the mixed coniferous forest with the spruce with a northern exposition. Particularly, the persistence of snow might significantly influence the presence of birds nesting on the ground. It comes out that, in terms of the number of bird species, the forest with the spruce of the upper mountain zone is an even poorer forest formation in the Gorce. Kozłowski (1974) reports from such a habitat from below the Turbacz as little as 14 species quantitatively classified, i.e. a number of species smaller by several (some 20%) species than that in the only somewhat lower-situated coniferous forest with the spruce with an admixture of the fir and the beech in the Kamienica watershed. The suggested differences in species richness between the described bird communities seems to be valid as research dealt with plots of similar or identical size. It is known from elsewhere that the number of species recorded is a function of plot size (or route length), and this dependency has a logarithmic course (e.g. Cyr 1977, James, Wamer 1982).

A closer study of the rarefaction lines for the communities studied (Fig. 4) presenting the theoretical relation between the number of species expected and the value of the sample shows that the greatest accumulation of avian species occurs in the mixed fen (D) while the lowest one in the forest with the spruce on the northern slope (B).

Bird density. The density of breeding pairs of the particular communities undergoes differentiation, gradual and pretty regularly by a more or less the same value ($\approx$ 10 pairs per 10 ha) (Fig. 3, Tab. I—VI). In terms of the density index, the communities constitute a clear gradation from the community of fertile beechwood birds (A) to the poorer habitat of the coniferous forest (B). Thus the quantitative state of breeding bird communities in the forests of the Gorce Mts. presents a different pattern from that of the number of species. The fen association (D), inhabited by the greatest number of species, is in this respect clearly behind the beechwood. This is most probably caused by the spatial development modes and the trophic abundance of the habitats. A number of studies (e.g. Blondel et al. 1980, Cyr 1977, James, Wamer 1982, Jermaczek msc.) show that the index of bird density is particularly sen-

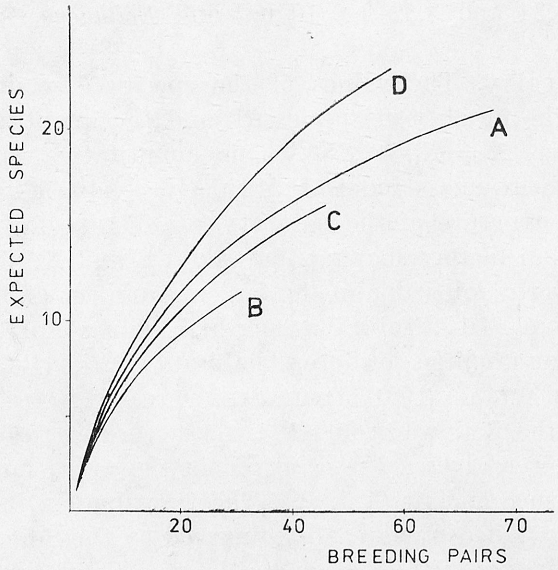

Fig. 4. Rarefaction curves showing the dependencies between the expected number of species and the number of birds of the studied habitats in plots A—D

sitive to structural changes and the volume of the forest. The Carpathian beechwood in the Gorce range is the best-developed and the most attractive trophically forest habitat. The data of Kozłowski (1974) from the "Turbacz" reserve show that the climactic Carpathian beechwood is also inhabited by a greater number of birds (35.5 pairs/10 ha in 1968, 32.5 in 1969) than is the climactic upper mountain zone forest with the spruce (24.3 and 23.0 pairs/10 ha). The data from the "Turbacz" reserve and the Kamienica watershed, although taken at different breeding season, have been acquired with the same method and from sample plots almost the same in size. Bird cenzuses carried out in mountain forests for more than one season (Głowaciński, Profus unpubl., Jakubiec 1972, Kozłowski 1974) show that fluctuations in the number of birds are small and within the error of the field methods employed.

Biomass of adults. The total biomass of adult birds (without reproductive material) in the described communities is 1.62—5.14 kg/10 ha (Tab. V). The birds of the beechwood (A) and the fen (D) attain a biomass higher by a factor of some 2.5 than that in the forest with spruce habitats (B and C). The high individual biomass of the avifaunas of the beechwood and the fen has been influenced by the high mean body weight of some species in the communities as well as by the high bird densities there. Those species mainly include, in the beechwood, *Tetrastes bonasia* (1.05 kg/10 ha, i.e. about 1/5 of the total community biomass), *Columba palumbus* (0.5 kg), *Strix uralensis* (0.5 kg) and representatives of thrushes *Turdus* spp. (0.9 kg). The biomass of birds in the mixed and spruce forests, is dominated by thrushes *Turdus* spp. (plot C — 0.54, plot B — 0.36 kg/10 ha) and the species quantitatively dominant:

Fringilla coelebs (0.34 and 0.32 kg /10 ha) and *Erithacus rubecula* (0.21 and 0.20 kg/ha).

Species diversity. The values of the species diversity coefficient H' are derived from the number of species (S) and the quantitative proportions in the communities ($N = N_i + \ldots N_S$). This quantitative species proportion is described by the evenness index J'. Primary conditions for the diversity H' lie this in the structure of the habitats (e.g. KARR, ROTH 1971, RECHER 1971) and concern all factors shaping the values S and N. The coefficient H' of birds attains a very high value in the fen environment (4.55 bits per indiv.) and in the beechwood (4.17; Tab. V). Such high values of H' are attained by the richest bird communities of forest habitats in the European temperate zone (see e.g. GŁOWACIŃSKI 1981, JERMACZEK msc., TOMIAŁOJĆ et al. 1984 — e.g. H' in a fen in the Białowieża forest ≈ 4.5, according to own calculations). A proportionally lower diversity is observed in the avian fauna of coniferous forests with the spruce and fir (Tab. V). The H' values in the bird communities of the habitats studied was greatly influenced by the S factor, as the structure of species dominance in those communities was almost identical (J' = 0.80 to 0.84).

Similar values of the species diversity index have been shown for biomass evaluation in relation to the communities A—C. Although it is somewhat lower ($H'_B = 3.98$) than in its version based on the number of individuals (H' = 4.17), the discrepancy is due to the methodical approach, as its calculation did not include six species with a density inferior to 0.1 pair/10 ha (+). On the other hand, those sporadically nesting species were considered in the calculation of H' of individuals. In the case of the fen association (D), seven sporadic species have not been included in the evaluation of H'_B; the very low of H' in the bird community of habitat D was however a result of disproportion between the species in terms of body mass. This is shown by the very low evenness index J'_B, attaining there only 0.53 (Tab. V).

Evenness. The structure of species dominance is one of the most significant indices of community organization. It is generally uniform in the bird breeding communities of the Kamienica watershed. The evenness index J' is almost identical in the all described bird aggregations (Tab. V), in spite of the fact that they differ significantly in the number of species and the number of individuals (Fig. 2). It is noteworthy that it is the same species that are the three first dominants in the mountain zone bird communities (A—C): *Fringilla coelebs*, *Erithacus rubecula* and *Sylvia atricapilla*. This suggests that the basis of the breeding avifauna of the lower mountain zone, in spite of their phytosocial and typological differentiation is common, or at least related in the broad group of the dominants (Tab. I—IV). The structure of quantitative dominance in the Gorce bird communities (Fig. 2) is fairly similar in comparison with the same feature of bird communities in the primeval habitats of the Białowieża forest (TOMIAŁOJĆ et al. 1984). A careful assumption may be attempted here that the avian fauna of the Gorce group has a character natural in terms of organization. This would be further confirmed by the high and uniform values of J'.

The evenness index J'_B is uniformly and similarly high in terms of biomass distribution on the species in the three mountain zone communities (A—C); it is even higher — 0.83 to 0.89 (Tab. V). As has already been mentioned, this does not concern the community of anthropogeneous and semi-natural fen habitats (D) outside Gorce National Park. The value of the J'_B index there is surprisingly low: only 0.53. An unambiguous interpretation of that fact is difficult. It might be only speculated that this community is not stabilized enough in terms of functionality.

Nesting groups. The distribution of species with varying nesting type changes in the particular communities (Tab. V), although it is very similar in the coniferous forest associations (plots B—C). In mountain zone habitats (plots A—C) there significantly prevail birds nesting in the shrubbery and tree crown level (β for S = 41—50%, for N = 39—47%). In the woods with spruce, the number of species nesting at the ground (α) and in hollow trees (γ) is almost the same but nearly twice smaller than in the remaining group β. In terms of numbers (N), the proportions between the groups α and β in the avifauna of coniferous forests (B, C) are more alike than in terms of the number of species (S) and strongly diverging between the two first groups (α and β) and the hollow-nesters. This would suggests that the insufficient number of hollow trees is a factor limiting the numbers of hollow-nesters. The resinous coniferous forests, e.g. spruce ones, are resistant to decay, which accounts for the smaller number of such hollow trees than in deciduous tree stands. Only a few species, e.g. *Picoides tridactylus* have the ability to carve hollows in such trees so as to make them habitable for broods (HAAPANEN 1965, KOZŁOWSKI 1974). The greatest percentage of hollow-nesters occurs in the beechwood (γ for S = 32%), as evidenced also in terms of the number of individuals (γ for N = 20%). The birds of the beechwood have a relatively even structure of nest situation. In terms of the number of species (S), least numerous are the representatives of the ground group (α). The situation reverses, however, because of the number of individuals (N), where the participation of particular breeding groups decreases from α through γ. The quantitative dominance of birds nesting in the beechwood at the ground can be explained by the abundant and varied development of the undergrowth and the brushwood in that type of forest. The beech stand is also very rich in hollow trees, which are only partially used by the birds. This gives no grounds for the assumption that the number of hollow trees would constitute a factor limiting the hollow-nester group. The participation of breeding groups in the fen (D) follows the mean state observed in the avian fauna of natural mountain zone forests.

Comparison of the studied bird communities. The bird communities described from the Kamienica watershed exhibit, to various extents, a differentiation in terms of the basic structural features (S, $E(S_n)$, N, B, H', H'_B, J'_B etc.) (Tab. I—V). The qualitative-quantitative comparisons also show that the three lower mountain zone communities A—C exhibit a high similarity (Tab. VII), exceeding 70% (Re = 73 to 84) in terms of RENKONEN'S method. This shows that, in fact, those communities constitute a certain faunistic and ecological whole, differentiated in the gradient from the fertile, insolated Carpathian beechwood to the poor, shady coniferous woods dominated by the spruce. Those natural lower mountain zone communities are clearly different from the bird community of the fen (D) at the foothills of the Gorce range (Re = 38 to 42, Tab. VII, Fig. 2). This is a community with a very high species diversity caused both by the mosaic pattern of the habitats and by its geographical situation in the interaction sphere (through valleys of large rivers) with the fauna of the Polish Lowland (e.g. *Sturnus vulgaris*, *Hippolais icterina*, *Sylvia curruca*, *Carpodacus erithrinus*, *Carduelis carduelis*, *Pica pica*) enriching the species composition of the community.

The exchange of the faunistic elements at the level of the Rzeki settlement is best seen in some congeneric species. The ranges of the warblers *Sylvia curruca* and even *S. borin*, common in lower localities, become discontinued in the Kamienica valley at the boundary of Gorce National Park. The higher situated, undestroyed mountain zone is almost exclusively dominated by *Sylvia atricapilla*. Among the thrushes, the Blackbird *Turdus merula*, common in the lowland and in the mountains, is missing in the stretch of the valley near Rzeki, probably displaced by *Turdus pilaris*, nesting there in exceptional quantities. The Park boundary more or less marks the end of the regular occurrence of the Grey-headed Woodpecker *Picus canus*, and also probably of the Great Spotted Woodpecker *Dendrocopos major*, observed near the hut — research station of the Nature Protection Research Centre of the Polish Academy of Sciences, (PAN), Kraków (see Fig. 1) in the autumn of 1987. The latter species is mainly superseded in the Gorce by the White-backed Woodpecker *Dendrocopos leucotos*.

In comparison with other Carpathian regions (Tab. VII), the lower mountain zone bird communities of the Kamienica watershed stand out by their understandable (the same season of research, identical methodical bases, the same observer, etc.) high reciprocal similarity (Re = 73—84), but, in comparison with mountain zone bird communities described from the Bieszczady range (CICHOŃ, ZAJĄC unpubl.) from the Tatras (GŁOWACIŃSKI, PROFUS unpubl.) or the Turbacz reserve in the Gorce (KOZŁOWSKI 1974), this similarity is 57—67% for beechwood and 59—72% for coniferous forests. Different here are the upper mountain zone spruce woods quantitative described only from the Gorce, in the Turbacz reserve, and from the Tatras (Re = 72). In all, the mountain zone bird communities of the Polish Carpathians usually have the similarity level Re exceeding 50%. The community of the semi-natural alder-spruce fen at Rzeki clearly diverges from the above.

R e m a r k s o n t h e o c c u r r e n c e o f s o m e s p e c i e s. Quantitative studies on the plots selected and occasional observations of the Kamienica valley from the Borek Pass to the Rzeki settlement suggest a relatively frequent occurrence of species so rare as *Picoides tridactylus* (at least 2 pairs), *Dendrocopos leucotos* (at least 3 pairs), *Strix uralensis* (10 recordings, including 8 audial ones, in various parts of the watershed done by P. Mielczarek — pers. comm. — in 1984—1987) and *Cinclus cinclus* (2—3 pairs on the Kamienica stream). There are also fairly numerous populations of e.g. *Tetrastes bonasia* (recorded at about 10 different points), *Carduelis spinus* (lower parts of the valley) and *Motacilla cinerea* (about 15 pairs and territories on the Kamienica and its tributaries) there. This confirms Kozłowski's (1974) remark on the relatively low number of daily raptors in the Gorce group. Only a pair of the Common Buzzard *Buteo buteo* was constantly noted near the research station (Fig. 1) and single birds, possibly belonging to another pair, were present in the vicinity of the Park Management building at Rzeki. In the beechwood and other forests, there is a total lack of the usually sympatrically-occurring flycatchers *Ficedula hypoleuca* and *F. albicollis*. Also Kozłowski (1974) has not recorded those species below the Turbacz. On the other hand, they appear in similar habitats in the Bieszczady range (Głowaciński 1969) and in the Sudeten foreland (Jakubiec 1972); those flycatchers occur interchangeably in the other mountain ranges of Southern Poland (e.g. Bocheński 1960, 1970, Dyrcz 1973, Głowaciński 1974). The presence of the Capercaillie, *Tetrao urogallus*, given by some employees of the Park (according to data of Z. Żurek, unpubl.) in the amount of several individuals in the slopes of the Jaworzyna Mt., has not been confirmed.

VI. COMPARISON OF CENZUSES OBTAINED WITH THE POINT-COUNT AND WITH THE MAPPING METHODS

The mapping method is a mean of absolute quantity evaluation, the most precise one ever developed for terrestrial vertebrates. Its combined version (Tomiałojć 1980) has an accuracy close to 100%. An adequate use of this method, even in the most difficult forest habitats of the temperate zone can have the error no greater than 10% (see Walankiewicz msc.). The results obtained with this method were then assumed as the real ones. The point-count method (e.g. Blondel et al. 1970) is a relative method of limited utility (Walankiewicz 1977, msc.). The comparison of birds cenzuses carried out with those two methods was done for the beechwood (A) and the mixed coniferous forests dominated by the spruce (B).

The comparisons (Tab. VIII and IX) show that the point-count method in its here-selected version (3 counts per season, observation points number 18 for A and 10 for B) in the conditions of the Gorce forests basically deforms the image of its bird communities. This mainly concerns cenzuses from points with a small radius of observation (r = 25 m). This taxation variant ommitted almost about a half of the species while the bird numbers per a standard area unit is overestimated by a factor of as much as 2.4 (beechwood) and 4.5.

The methodical variant with an increased observation radius (r = 50 m), yields much smaller deformations, which still are very significant. Thus 11 bird species were ommitted (32% — beechwood) and 7 (37% — coniferous woods with the spruce) from the 28 and 19 recorded (apart from occasional and accidental species marked +) with the mapping method. Also, the number of pairs (individuals) was too high by 29% in the beechwood and by 137% in the woods with the spruce (Tab. I, II, VIII and IX). The worse effects of the point-count cenzuses in the woods with the spruce (Plot B) might result from methodology, especially from the lower number of points controlled (n= 10) than in the beechwood (n = 18). The number of surveys per season in the beechwood (a three-fold count on 18 points = 54 surveys) almost twice exceeded that in the coniferous woods with the spruce (3 ×10 = 30). It is well

Table VIII

Comparison of quantity evaluation of birds with the mapping and point-count methods on "points" in the beechwood plot. "Audio-visual shots" were taken there in 18 "points". The detection index W shows the percentage of individuals detected during the point-count in comparison with the mapping evaluation; the frequency index F shows the relation of the number of points in which a given species was observed to the number of all "points" controlled, i.e. 18. The results obtained with the mapping method include only the species also detected with the point-count method

Species	Mapping Method	Point Count Method						
		for r≈25 m (0.20 ha)			r≈50 m (0.79 ha)			
	p/10 ha	pairs per 3.6 ha	pairs per 10 ha	W	pairs per 14.2 ha	pairs per 10 ha	W	F
Fringilla coelebs	13.1	14	38.9	297	30	21.0	160	1
Erithacus rubecula	8.9	7	19.4	218	18	12.7	143	0.56
Sylvia atricapilla	7.5	12	33.3	444	21	14.8	197	0.94
Prunella modularis	6.9	4	11.1	160	8	5.6	81	0.44
Parus ater	5.6	4	11.1	316	7	4.9	88	0.33
Troglodytes troglodytes	3.9	5	13.9	356	11	7.7	197	0.61
Phylloscopus collybita	3.9	3	8.3	213	9	6.3	162	0.50
Phylloscopus sibilatrix	2.5	4	11.1	444	7	4.9	196	0.39
Sitta europaea	2.2	2	5.6	255	2	1.4	64	0.11
Regulus regulus	2.2	1	2.8	127	1	0.7	32	0.06
Turdus merula	2.2	—	—	0	2	1.4	64	0.11
Certhia familiaris	1.7	2	5.6	329	2	1.4	82	0.11
Phylloscopus trochilus	1.7	1	2.8	165	4	2.8	165	0.22
Parus montanus	1.7	1	2.8	165	3	2.1	124	0.17
Tetrastes bonasia	1.7	—	—	0	1	0.7	41	0.06
Ficedula parva	1.4	3	8.3	593	7	4.9	350	0.33
Turdus philomelos	1.4	1	2.8	200	2	1.4	100	0.06
Pyrrhula pyrrhula	1.1	—	—	0	1	0.7	64	0.06
Turdus torquatus	0.8	—	—	0	2	1.4	175	0.11
Total: N	75.0	64	177.8	237	138	97.0	129	
S	28		15			19		

known that evaluations in too-small plots, transects, or on few points lead to a decrease of observed species (logarithmic relations) and to an increase of quantity evaluations. As shown by the results of ornithological methodology tests carried out by WALANKIEWICZ (1977, msc.) in the Białowieża forest, a different effectivity of the used point-count method was to be expected for the beechwood and the coniferous forest. More univocal results of the studied habitats would be possible if totally identical methodical conditions were maintained.

Table IX

Comparison of the numbers of birds obtained with the mapping method and the point-count method in "the points" in the mixed coniferous woods with a domination of the spruce. "Audio-visual shots" were taken there in 10 "points". Symbols W, F and the principle of limited list of results for the mapping method as in Table VIII

Species	Mapping Method	Point Count Method						
		for r≈25 m (0.20 ha)			r≈50 m (0.79 ha)			
	p/10 ha	pairs per		W	pairs per		W	F
		2.0 ha	10 ha		7.9 ha	10 ha		
Fringilla coelebs	8.0	10	50.0	625	18	22.8	285	1
Erithacus rubecula	5.4	3	15.0	277	13	16.5	305	1
Sylvia atricapilla	2.8	5	25.0	893	9	11.4	407	0.80
Parus ater	2.8	3	15.0	534	4	5.1	182	0.40
Troglodytes troglodytes	1.8	3	15.0	833	3	3.8	211	0.30
Prunella modularis	1.8	1	5.0	278	1	1.3	72	0.10
Pyrrhula pyrrhula	1.0	—	—	0	1	1.3	130	0.10
Phylloscopus collybita	0.8	2	10.0	1250	5	6.3	787	0.50
Turdus philomelos	1.0	—	—	0	1	1.3	130	0.10
Parus montanus	0.8	—	—	0	1	1.3	163	0.10
Turdus torquatus	0.4	1	5.0	1250	1	1.3	325	0.10
Picoides tridactylus	0.2	—	—	0	1	1.3	650	0.10
Total: N	30.7	28	140.0	456	58	73.4	239	
S	19		8			12		

The comparison of the results of bird cenzuses carried out with the point-count and the mapping methods with the use of correlation indices (Fig. 5) shows a strong relationship between the data collected at the points and the number of birds on the plots A and B obtained with the described mapping method ($r = 0.88$ to 0.95). Correlation dependencies for the small and large point variants of the point-count method tentatively calculated for plot A are almost as high as those for the results obtained with the mapping method. For an average correlation index $= 0.92$, the value of the determination coefficient r^2 is superior (or equal) to 0.84%. This means that this is the value by which the dependent variable x (i.e. results of counts at points) depends on the variable y (e.i. the real bird density in the habitat). Apart from that, the high correlation dependency ($r = 0.90$ for plot A and 0.97 for plot B) occurs between data collected at "large" (0.79 ha each) and "small" (0,20 ha each) points of the relative method.

The point-count method "loses" especially rare and difficult to discover species. The surprisingly low detection (W) on "large points" was yielded for e.g. *Regulus regulus* (32%), although it belongs to the quantitative subdominants of the Kamienica watershed. The cenzus of that species on "small points" leads, on the other hand, to results increased by 27% (Tab. VIII). The total numbers in the communities are most overestimated by the dominant and common species, as *Fringilla coelebs, Erithacus rubecula, Sylvia atricapilla, Phylloscopus sibilatrix, Ph. collybita* and *Troglodytes troglodytes*, which, to a large extent, invade the observation field from the vicinity and are counted several times at various field points. The very high detection coefficient has been yielded e.g. for *Ficedula parva* (W = 330% and 593%), the recordings of which in the beechwood in "small points" are overestimated by as much as 400% (Tab. VIII).

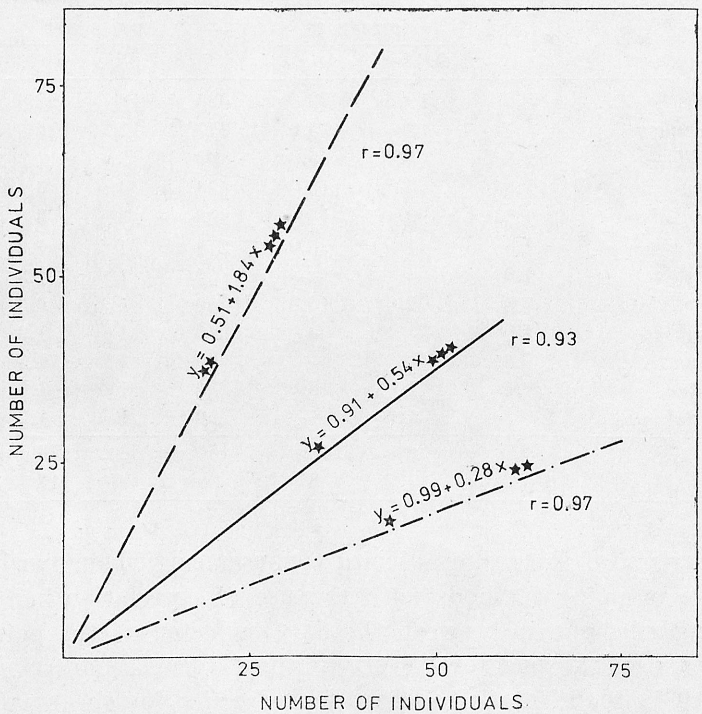

Fig. 5. Regression and correlation dependencies between the results of cenzuses by mapping (*) and point-count method in „small points" (**) and in „large points" (***) for the avifauna of the beechwood (see Fig. 1: A). All $p < 0,001$

In all, the presented version of the point-count method in its most reliable variant (0.79 ha plots) overestimates the evaluations of the number of birds by about 1/3 of the real state in the beechwood and more than twice in coniferous forests with the spruce (Tab. VIII and IX). Among the many imperfection of that type of relative evaluation methods (Walankiewicz 1977, msc.), controversial in this study is the principle of considering the highest values for observation sites controlled several times, adopted after Palmgren (1930). It might be expected that the employed principle of "maximum population" overestimates, to an unprecised extent, the evaluations of bird numbers.

Translated into English
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STRESZCZENIE

Celem przeprowadzonych badań było określenie składu i struktury lęgowych zgrupowań ptaków w głównych siedliskach zlewni Kamienicy w Gorczańskim Parku Narodowym. Zadaniem ubocznym było sprawdzenie w warunkach beskidzkich miarodajności i użyteczności metody liczenia na punktach (inaczej „zdjęć wizualno-słuchowych") w odniesieniu do wysoce precyzyjnej i dającej bezwzględne wyniki kombinowanej metody kartograficznej.

Oceny zagęszczeń ptaków prowadzono metodą kartograficzną w czterech siedliskach charakterystycznych dla niższych położeń zlewni: A — w buczynie karpackiej na stoku o ekspozycji południowej; B — dolnoreglowym borze świerkowym i mieszanym na stoku o wystawie północnej, C — dolnoreglowym borze mieszanym i świerkowym w głęboko wciętej dolinie potoku Kamienica i D — rozdrobnionym i półnaturalnym łęgu olchowo-świerkowym w Rzekach k. Lubomierza (ryc. 1). Liczenia prowadzono 5—7-krotnie w sezonie lęgowym 1988 na powierzchniach próbnych o rozmiarach od 18 do 25 ha. Niektóre obserwacje jakościowe pochodzą także z sezonu wiosenno-letniego 1987.

W skład lęgowych zespołów ptaków lasów reglowych zlewni Kamienicy wchodzi 22—34 gatunków o łącznym zagęszczeniu 31—75 par na 10 ha (tab. I—III). Najbogatsza jest pod tym względem żyzna buczyna karpacka (S = 34 gat., N = 75 p/ha), najuboższe są bory na północnym stoku (S = 22, N = 31). Zbliżona jest struktura dominacji liczebnej gatunków w dolnoreglowych zespołach ptaków (ryc. 2). Dominowały w nich w tej samej kolejności 3 gatunki: zięba *Fringilla coelebs* (17—26% stanu liczebnego), rudzik *Erithacus rubecula* (12—17,5%) i pokrzewka czarnołbista *Sylvia atricapilla* (7,5—10%). Od zespołów reglowych dość wyraźnie różni się zespół ptaków antropogenicznie przekształconych siedlisk lęgowych w rejonie przysiółka Rzeki poza granicami GPN (tab. IV, ryc. 3). Awifauna łęgu ma relatywnie najwyższą (i wyjątkowo wysoką jak na lasy środkowoeuropejskie) różnorodność gatunkową (H' = 4,55), co należy tłumaczyć mozaikowością siedliskową, wpływami efektu ekotonu i położeniem w strefie nakładania się na faunę górską elementów typowo nizinnych (np. zaganiacz *Hippolais icterina*) i synantropijnych (np. wróbel *Passer domesticus*). Te czynniki jedynie w niewielkim stopniu oddziaływały na awifaunę powierzchni wytyczonych w lasach i borach dolnoreglowych, stąd wartości H' są tam wyraźnie niższe (4,17 i 3,55—3,93). Wśród ptaków łęgu olchowo-świerkowego szczególne znaczenie biocenotyczne przypada kolonijnie gnieżdżącemu się kwiczołowi *Turdus pilaris*, który jest tu domi-

nantem liczebnym (N = ok. 12 p/10 ha, tj. ok. 21%) i tworzy ponad połowę biomasy (B = ok. 3,0 kg/10 ha, tj. 60%) zespołu.

Z uwagi na biomasę ptaków dorosłych zespoły buczynowy i łęgowy (5,1 kg/10 ha) są około 2,5 raza bogatsze niż borowe (po 1,6—2,4). Wynika to z większej chłonności faunistycznej buczyny i heterogenicznego łęgu (lepiej rozwinięta struktura siedliskowa, więcej nisz ekologicznych i miejsc gniazdowych, łagodniejsze warunki klimatyczne, zasobniejsza baza pokarmowa), a bezpośrednio zależy mniej więcej w równym stopniu od zagęszczenia i przeciętnego ciężaru ciała ptaka w zespołach. Silniejsze zróżnicowanie ciężaru ciała ptaków w zespole łęgowym D (J'_B = 0,53) wpłynęło na znacznie niższą różnorodność gatunkową zespołu wychodzącą z oceny biomasy (H'_B = 2.75) niż to wykazano w odniesieniu do liczby osobników. Wskaźniki H' i H'_B są natomiast prawie tak samo wysokie w zespołach ptaków reglowych A—C (tab. V), które odznaczają się bardziej wyrównanymi proporcjami między gatunkami pod względem biomasy.

Z analizy wydzielonych wśród ptaków trzech kategorii gniazdowych α, β i γ (tab. VI) wynika generalnie, że w opisanych zespołach przeważają gatunki wijące gniazda w warstwie drzew i krzewów (β). W ujęciu liczebnościowym (wartości N) zbliżony udział mają ptaki gnieżdżące się na i tuż nad ziemią (α). Dziuplaków (γ) najwięcej jest w buczynie, która jest zasobna w dziuple na tyle, że obserwuje się ich nadmiar. Niedobór dziupli jest natomiast bardzo prawdopodobnym czynnikiem, wpływającym na stosunkowo małą liczebność dziuplaków w borach gorczańskich.

Oceny rarefakcji (tab. V), oparte na rachunku prawdopodobieństwa, określają oczekiwane liczby gatunków w zespołach na podstawie próbek osobników pobranych z poszczególnych siedlisk. Krzywe rarefakcji zbiegają się z danymi empirycznymi wskazującymi, że największa akumulacja gatunków ptaków zachodzi w łęgu olchowo-świerkowym, a najniższa w borze na północnym stoku (ryc. 4).

Dolnoreglowe zespoły ptaków A—C łączy wysokie podobieństwo jakościowo-ilościowe (Re = 73—84). Prowadzi to do wniosku, że zespoły te tworzą w gruncie rzeczy pewną faunistyczno-ekologiczną całość, zróżnicowaną w gradiencie od żyznej, nasłonecznionej buczyny po ubogie, cieniste bory z dominacją świerka. Wyraźnie wydziela się w tym zestawieniu (Re = 38—42) i w porównaniu z zespołami ptaków opisanymi w innych rejonach Karpat polskich awifauna łęgu D (tab. VII). W ogólnym ujęciu karpackie zespoły ptaków mieszczą się na poziomie podobieństwa zwykle wyższym niż 50%, przy czym podział na zespoły górno- i dolnoreglowe zaznacza się tu dość wyraźnie. W granicach 51—68% kształtuje się podobieństwo awifauny dolnoreglowej zlewni Kamienicy i klimaksowych lasów gorczańskiego rezerwatu przyrody „Turbacz".

Testowana metoda liczenia na punktach w wersji potrójnego cenzusu na polach o promieniu ok. 25 m i 50 m, w porównaniu z precyzyjną metodą kartograficzną, zaniża istotnie liczbę gatunków w najlepszym przypadku o około 30% stanu rzeczywistego oraz co najmniej o tyle samo zawyża liczebność ptaków (tab. VIII i IX). Zdecydowanie lepsze wyniki daje wariant liczenia na „dużych punktach" (0,79 ha); wariant „małych punktów" (0,20 ha) jest niewskazany do stosowania. Zależności korelacyjne między wynikami osiągniętymi obydwiema metodami są bardzo ścisłe (r = 0,88—0,95; ryc. 5), co przy współczynniku determinacji $r^2 = 84\%$ znaczy, że wyniki liczeń na "punktach dużych i małych" w takim stopniu oddają stan rzeczywisty zagęszczenia ocenionego metodą kartograficzną.

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