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ENVIRONMENTAL FACTORS SHAPING BIRD COMMUNITIES IN QUARRIES

CZYNNIKI ŚRODOWISKOWE KSZTAŁTUJĄCE ZESPOŁY AWIFAUNY W KAMIENIOŁOMACH

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Abstract: In 20 quarries situated in Kielce Voivodship 34 species of breeding birds were recorded (among others the Stone Curlew *Burhinus oedicnemus*, the Little Ringed Plover *Charadrius dubius*, the Ringed Plover *Charadrius hiaticula*, the Tawny Pipit *Anthus campestris*). Thirty species of non-breeding species were also recorded in quarries. Within an adjacent area of 500 meters from the quarries' scarp breeding of 79 species was recorded. The most important factors influencing the number of species in quarries were the heterogeneity of the habitat and their size. Only in case of a few species the type of surrounding habitat influenced their occurrence inside quarries. The exploitation of the quarries had no negative effect upon birds.

Key words: community structure, birds, habitat choice, quarry, environmental factors, Kielce Voivodship, Poland.

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Treść: W 20 kamieniołomach położonych w województwie kieleckim stwierdzono występowanie 34 gatunków ptaków lęgowych (m.in. kulona *Burhinus oedicnemus*, sieweczki rzecznej *Charadrius dubius*, sieweczki obrożnej *Charadrius hiaticula*, świergotka polnego *Anthus campestris*) oraz 30 gatunków ptaków nielęgowych. W promieniu 500 metrów od kamieniołomów stwierdzono 79 gatunków ptaków lęgowych. Najważniejszymi czynnikami decydującymi o liczbie gatunków w kamieniołomie były: heterogeniczność siedliska i wielkość wyrobiska. Tylko w przypadku kilku gatunków typ otaczającego siedliska wpływał na zasiedlenie wnętrza wyrobiska. Eksploatacja w kamieniołomie nie wywierała na ptaki istotnego wpływu.

INTRODUCTION

Quarries are very specific, usually enclave habitats very different from adjacent areas. Though the landscape is altered and devastated, it resembles a natural one, formed by geomorphogenic processes. This makes quarries a kind of substitute for natural rocky habitats.

To my knowledge, there are no studies of bird communities in quarries. The only data about the avifauna of quarries is short and scattered information in regional monographs. In Poland such information can be found in Tomiałojć (1990), Dyrcz et al. (1991), Walasz and Mielczarek (1992). These are just brief notes placed within a description of the distribution and habitat preferences of a given species. This paper is the first qualitative and quantitative elaboration of the avifauna of quarries.

The main aim of this study was to determine factors shaping bird communities in quarries and their adjacent areas. I assumed that the most important factors for the composition of bird assemblages in stone-pits are: heterogeneity of habitat (due to exploitation and ecological succession), size of the quarry and their situation in an open or forested area. I prepared both qualitative and quantitative description of the avifauna.

This information can be important to understand the role of quarries as habitats for birds. Isolated and scattered, quarries may play an important role for some species, according to the metapopulation model. Well-run renaturization of stone-pits after the end of exploitation will enable more effective protection of birds inhabiting bare, semi-rocky habitats at the metapopulation level.

STUDY AREA AND METHODS

All 20 quarries studied are located in the Kielce Voivodship (Fig. 1, Table 1; the numbers of quarries applied in Fig. 1 and Table 1 are consistently used in this paper, following the names of quarries). This area is the most important region for the openpit mining industry in Poland (Jurkiewicz 1982).

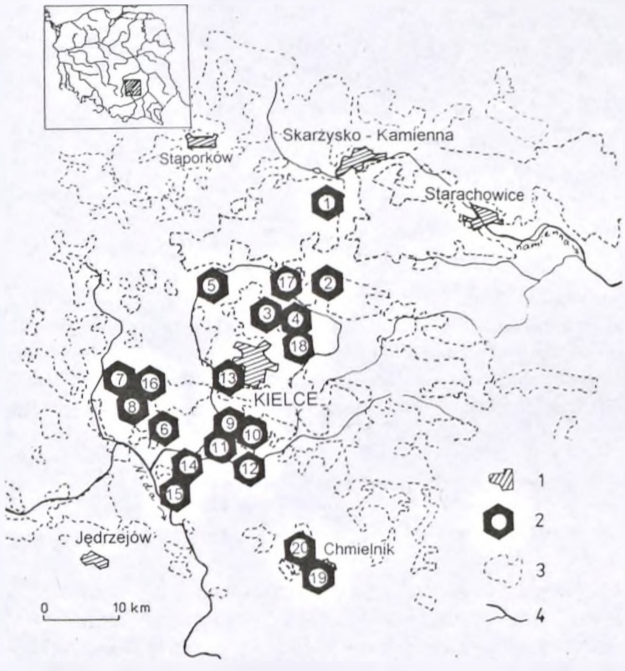

Fig. 1. Distribution of the studied quarries. 1– cities, 2 – quarries (numbers as in table 1), 3 – forests, 4 – rivers.

Ryc. 1. Rozmieszczenie badanych kamieniołomów. 1 – miasta, 2 – kamieniołomy (numeracja jak w tabeli 1), 3 – lasy, 4 – rzeki.

The quarries are placed in different kind of environments:

a) quarries placed in open surroundings, more than 60% of the zone 100 meters from the scarp without trees or with single trees and bushes (n = 12),

b) quarries placed in overgrown surroundings, more than 60% of the zone 100 meters from the scarp covered with trees and /or bushes (n = 5),

c) intermediate quarries, the zone 100 meters from the scarp not fitting the above categories (n = 3).

Ten of 20 quarries were working, in the other 10 exploitation had ceased. Exploitation was often very intensive and continued up to 24 hours a day. Usually it was conducted at several flats (levels), sometimes simultaneously. Raw material was obtained by gradual detonation of the higher flat. Detonations caused great strains in the rock and trembling of the ground could be felt within a radius of a few hundred meters. It was accompanied by very loud explosion, a cloud of smoke, dust and chips of the rock falling within a radius of 300 meters. Detonations usually took place once a day. Detonated rock was loaded with mechanical shovels on big tipping-lorries and taken away for further processing. Up to 50 loadings of lorries took place in a single quarry within one hour. The constant noise level on the flats during their exploitation was so high that normal conversation was very difficult. Often exploitation was carried out at the foothills which led to cliff-like walls, up to 100 meters high. Succeeding flats were incised increasingly deep into the rock wall, "destroying" higher flats and only rock ledges of different size remained.

The bottom and the walls of quarries around places of exploitation were bare rock. In places where the exploitation had ceased, ecological succession took place and sometimes water reservoirs of different sizes appeared. There were water reservoirs of varying size in 6 of the 20 studied quarries.

Closed-down quarries gradually lose their rocky character due to ecological succession. Herbaceous plants and then bushes and trees overgrow the rocky bottom. Also the scarp is being overgrown by plants. In small quarries these changes took place relatively quickly. Quarries which had not been exploited for a long time were sometimes hard to distinguish from the surroundings, especially when the scarp was not very high. In most cases, areas surrounding a working quarry were wastelands devastated by tipping-lorries and other machines and used as industrial waste sites. But sometimes, even in intensively exploited quarries, adjacent areas were close to their natural state. In the case of closed-down quarries, if any effects of the past exploitation remained, they were usually not very marked.

During the preliminary control of quarries I drew a plan of each area including three zones:

– zone I: inside the quarry up to the edge of the scarp,
– zone II: the adjacent area up to 100 meters off the scarp,
– zone III: the adjacent area up to 500 meters off the scarp.

During the breeding season in 1994 each of the 20 quarries was controlled 4 times:

– control 1: from 16th to 23rd of April,
– control 2: from 17th to 21st of May,
– control 3: from 3rd to 6th of June,
– control 4: from 26th to 30th of June.

Controls began before dawn. Depending on the size of the quarry each control lasted from about 1 to 6 hours (about 2 hours on average). I avoided controlling quarries at midday and during strong wind and rain. If a control took place at midday, I compensated for the low detectability of birds by staying longer at a given place and the next control there was carried out at a different time of day. The controls were carried out until dusk.

If exploitation was going on in quarries during controls, I noted its location and intensity. A 100 meter zone around working mechanic shovels was marked on the

Table 1. Characterisation of the quarries. Surrounding (see method): V – overgrown, N – not overgrown, I – intermediate. Relays – number of exploiting relays; "–" – quarry not exploited. Material – raw material obtained (at present or in the past). Machines – mean number of working machines. Flats – number of exploited flats (levels). Bottom – type of bottom coverage: R – rocky, H – herbaceous plants, W – water reservoir, E – reed bed, T – trees. Area – area of a quarry. Expl. – percent of the area under direct influence of exploitation. Mean height – mean height of the scarp. Max. depth – maximum depth of the quarry. HI – heterogeneity index (see method).

Tabela 1. Charakterystyka kamieniołomów. Otoczenie (patrz metoda): V – zadrzewione, N – nie zadrzewione, I – pośrednie. Zmiany – liczba zmian eksploatacyjnych; "–" – kamieniołom nie eksploatowany. Surowiec (pozyskiwany obecnie lub w przeszłości): potter's clay – iły ceramiczne, sandstone – piaskowiec, quartzite – kwarcyt, dolomite – dolomit, limestone – wapień, clay – glina, marl – margiel. Maszyny: średnia liczba pracujących maszyn. Poziomy – liczba eksploatowanych poziomów. Dno (typ pokrycia dna): R – skaliste, H – roślinność zielna, W – zbiornik wodny, E – trzcinowiska, T – drzewa. Pow. – powierzchnia kamieniołomu. Expl. – procent powierzchni pod bezpośrednim wpływem eksploatacji. Śr. wysokość – średnia wysokość skarpy. Maks. głęb. – maksymalna głębokość kamieniołomu. HI – wskaźnik heterogenności (patrz metoda).

Quarry Kamieniołom	Surrounding Otoczenie	Relays Zmiany	Material Surowiec	Machines Maszyny	Flats Poziomy	Bottom Dno	Area (ha) Pow.	Expl. %	Mean height (m) Śr. wysokość	Max. depth (m) Maks. głęb.	HI
Baranów (1)	V	1	potter's clay sandstone	4	2	R/H	24	50	5	10	4
Bukowa góra (2)	V	2	quartzite	4	4	R	14	100	10	25	3
Maia wisniówka (3)	V	–	quartzite dolomite	–	2	W	20	–	20	25	2
Skałnik (4)	V	3	quartzite	3	4	R/W/E	36	25	10	25	4
Wykień (5)	V	–	sandstone	–	1	H	0.4	–	8	10	1
Chęciny (6)	I	–	dolomite	–	2	H	5	–	8	15	1
Miedzianka i (7)	I	–	limestone	–	3	H/T/R	20	–	9	20	4
Miedzianka ii (8)	I	–	limestone	–	1	H/T	3	–	8	15	3
Sitkówka – Nowiny (9)	N	1	limestone marl clay	2	1	W/E/R/T	4	40	5	10	6
Kowala (10)	N	2	limestone	6	3	R/H/W	63	30	12	30	3
Radkowice (11)	N	2	dolomite	3	2	R	25	40	10	25	3
Morawica (12)	N	1–3	limestone	5	2	R/H	80	30	10	30	3
Ślichowice (13)	N	–	limestone marl	–	2	R/H	0.55	–	25	30	1
Siedlce (14)	N	–	limestone	–	3	H/T	5	–	8	25	4
Sobków (15)	N	–	limestone	–	3	R/H/T	10	–	10	25	3
Ostrówka (16)	N	3	limestone	7	4	R/W/E	75	40	20	100	6
Zachełmie (17)	N	–	dolomite	–	2	R	11	–	8	12	2
Marczakowe doły (18)	N	–	quartzite	–	1	R/W	6	–	6	10	2
Ptaszniki (19)	N	1	limestone	2	2	R	19	30	8	20	3
Celiny (20)	N	1	limestone	2	2	R	44	30	9	30	3

plan, within the level of exploitation. The radius of this zone around smaller working machines was 50 meters. At both sides of roads on which the raw material was transported, I marked strips of 50 meter width. All these areas were later treated as places very exposed to disturbance due to exploitation.

All observations of birds in zones I and II were noted in the plan, whereas in zone III – only observations of rarer species: e.g. birds of prey, corvids and shrikes. For recording birds, symbols and signs proposed for the territory mapping method by Tomiałojć (1976) were applied. I also followed other injunctions for controls with that method (Tomiałojć 1980). During the first control all areas (zones I–III) were thoroughly searched to detect nests of birds of prey. Zone I was also searched to find owl pellets. Vocal activity of the Tawny Owl *Strix aluco* and the Eagle Owl *Bubo bubo* was stimulated, using tape recordings. In all zones I noted traces of carnivorous mammals (tracks, preys, excrement).

Field data was transposed to species maps and interpreted according to injunctions by Tomiałojć (1980). A proper breeding category was assigned to every species of bird: A – breeding possible (an individual of given species recorded at least two times at the same place, a singing male, a pair in a habitat suitable for breeding, courtship); B – breeding probable (copulation, nest building behaviour, nest not accessible, fledglings); C – breeding recorded (a nest with eggs or nestlings, egg shells, food collection).

The dependence of the number of species in zone I on its size and heterogeneity was determined by means of the rank correlation test. In these calculations species of breeding category A were not taken into consideration. Heterogeneity for each quarry was obtained by summarising the number of habitat types in its zone I. The rank of each habitat was 1, thus e.g. heterogeneity of a quarry with 3 types of habitats was 3, with 4 types – 4 and so on.

RESULTS

QUALITATIVE AND QUANTITATIVE DATA ON SPECIES OCCURRENCE

Breeding birds

Eighty nine species of breeding birds were recorded in all studied areas in all zones together. In zone I, 34 species were recorded (Table 2), of which 10 species were present only in that zone. In zones II and III, 79 species were present (Table 3).

In two quarries, Wykień (5) and Ślichowice (13), there were no breeding birds in zone I. The Sitkówka – Nowiny (9) quarry was the most abundant in birds – 10 species were recorded there. On the average, there were 5 bird species in zone I.

Wheatear *Oenanthe oenanthe* – the most typical species of zone I. It was recorded in 17 quarries of all types, reaching a density from 0.3 to 6.0 pairs/10 ha, 2.1 pairs/10 ha on average.

White Wagtail *Motacilla alba* – bred in 16 quarries of all types. Twenty nests were found, of which 10 were placed in rock crevices and 10 in buildings and other constructions. The density of this species ranged from 0.1 to 1.7 pairs/10 ha, 0.6 pairs/10 ha on the average.

Black Redstart *Phoenicurus ochruros* – recorded in 12 quarries. Seven nests were placed in rock crevices, 6–7 in different constructions (e.g. 1 nest under a broken-down digger, 1 in a non-operating openpit exploitation machine). The densities of the Black Redstart ranged from 0.2 to 2.5 pairs/10 ha, 1.1 pairs/10 ha on average.

Little Ringed Plover *Charadrius dubius* – recorded in 11 quarries in which the bottom was, at least in part, rocky. The density of this species was from 0.3 to 3.3 pairs/10 ha, 1.0 pair/10 ha on average.

Tawny Pipit *Anthus campestris* – present in 7 non-overgrown or moderately overgrown quarries of a rocky or barely vegetated bottom.

Tree Sparrow *Passer montanus* – bred in 5 quarries. Thirty eight nests were placed in rock crevices and 1 on a high lighting mast. The type of the bottom coverage was not important for this species.

Yellowhammer *Emberiza citrinella* and Greenfinch *Carduelis chloris* – present in quarries with bushes and trees in zone I. They were recorded in 5 and 4 quarries, respectively.

Each of the remaining 26 species of birds recorded in zone I was present only in 1 or 2 quarries providing a suitable habitat.

The most interesting species seen during the studies was the Stone Curlew *Burhinus oedicnemus* recorded in one of working quarries. I observed one specimen during a temporary break in exploitation. For the sake of the safety of this species which is extremely endangered in Poland, the exact situation of the place of the observation is not given.

Another interesting observation was the breeding of Starlings *Sturnus vulgaris* in rock crevices in Kowala (10).

Non breeding birds in quarries

I recorded 30 species of non breeding birds in zone I:

Goshawk (*Accipiter gentilis*)
Sparrowhawk (*Accipiter nisus*)
Buzzard (*Buteo buteo*)
Black Stork (*Ciconia nigra*)
Common Sandpiper (*Tringa hypoleucos*)
Black-headed Gull (*Larus ridibundus*)
Woodpigeon (*Columba palumbus*)
Collared Dove (*Streptopelia decaocto*)
Cuckoo (*Cuculus canorus*)
Swift (*Apus apus*)
Lesser Spotted Woodpecker (*Dendrocopos minor*)
Wolark (*Lullula arborea*)
Yellow wagtail (*Motacilla flava*)
Waxwing (*Bombycilla garrulus*)
Green Woodpecker (*Picus viridis*)
Redstart (*Phoenicurus phoenicurus*)
Fieldfare (*Turdus pilaris*)
Blackcap (*Sylvia atricapilla*)
Pied Flycatcher (*Ficedula hypoleuca*)
Coal Tit (*Parus ater*)
Red-backed Shrike (*Lanius collurio*)
Great Grey Shrike (*Lanius excubitor*)
Jay (*Garrulus glandarius*)
Magpie (*Pica pica*)
Hooded Crow (*Corvus corone*)
Rook (*Corvus frugilegus*)
Siskin (*Carduelis carduelis*)
Ortolan Bunting (*Emberiza hortulana*)
Corn Bunting (*Emberiza calandra*)
Jackdaw (*Corvus monedula*)

Table 2. Bird species recorded in zone I. 1–20: numbers of quarries (consistent with table 1). A,B,C – categories of breeding (explained in "Study area and methods", p.3); for each species, the number of pairs and the highest recorded category of breeding was given; in cases where the exact number of pairs is not known, the possible range is given with the more probable value first. The exact situation of the Stone Curlew observation is not given (*).

Tabela 2. Ptaki stwierdzone w strefie I. 1–20: numery kamieniołomów (zgodne z tabelą 1). A,B,C – kategorie lęgowości (objaśnione w rozdziale "Study area and methods", str. 3); dla każdego gatunku podano liczbę par i najwyższą zarejestrowaną kategorię lęgowości; w przypadku gdy dokładna liczba par nie jest znana, podano zakres liczebności, a bardziej prawdopodobna liczba jest podana jako pierwsza. Nie podano dokładnej lokalizacji obserwacji kulona (*).

Species Gatunek	Quarry Kamieniołom																				Total Suma
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Anas platyrhynchos	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2C	–	–	–	–	1
Falco tinnunculus	–	–	–	–	–	–	–	–	–	1C	–	–	–	–	–	–	–	–	–	–	1
Perdix perdix	–	–	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	1
Gallinula chloropus	–	–	–	–	–	–	–	–	1B	–	–	–	–	–	–	–	–	–	–	–	1
Fulica atra	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	1
Burhinus oedicnemus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1
Charadrius dubius	–	–	–	1C	–	–	–	–	1C	5C	1C	4C	–	–	1B	7–8C	1B	2C	1C	2C	11
Charadrius hiaticula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	1
Vanellus vanellus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2C	–	–	–	–	1
Tringa totanus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	–	1
Jynx torquilla	–	–	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	1
Alauda arvensis	–	–	–	–	–	–	–	–	–	1A	–	2–3C	–	–	–	–	–	–	–	–	2
Delichon urbica	–	–	–	–	–	–	–	–	20C	–	–	–	–	–	–	–	–	–	–	–	1
Anthus campestris	–	–	–	–	–	1B	1B	–	–	1B	–	2C	–	–	–	1A	–	–	1C	1B	7
Anthus trivialis	1B	–	–	–	–	–	–	1B	–	–	–	–	–	–	–	–	–	–	–	–	1
Motacilla alba	1B	1C	1B	2C	–	–	1B	–	1C	2C	1A	3A	–	1B	1C	1–4C	1C	1C	1A	1C	16
Erithacus rubecula	–	–	–	–	–	–	–	–	–	–	–	–	–	2B	–	–	–	–	–	–	1
Phoenicurus ochruros	1B	1C	–	1B	–	–	–	–	1B	2B	1A	3C	–	–	1C	3C	2C	1C	–	1C	12
Oenanthe oenanthe	1C	1B	–	1C	–	2C	3C	1C	2C	7C	5C	6–10C	–	3C	5C	3–8C	2C	2C	3–4C	4C	17
Turdus merula	1B	–	–	–	–	–	–	1C	–	–	–	–	–	–	–	–	–	–	–	–	2
Turdus philomelos	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	1
Acrocephalus palustris	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	1
Acrocephalus arundinaceus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1B	–	–	–	–	1
Sylvia communis	1B	–	–	–	–	–	–	–	–	–	–	–	–	1C	–	–	–	–	–	–	2
Phylloscopus trochilus	2B	–	–	–	–	–	–	1A	–	–	–	–	–	2B	–	–	–	–	–	–	3
Parus caeruleus	–	–	–	–	–	–	–	–	1C	–	–	–	–	–	–	–	–	–	–	–	1
Parus major	–	–	–	–	–	–	–	–	1B	–	–	–	–	–	–	–	–	–	–	–	1
Sturnus vulgaris	–	–	–	1A	–	–	–	–	–	10C	–	–	–	–	–	–	–	–	–	–	2
Passer domesticus	–	–	–	–	–	–	–	–	3C	1C	–	–	–	–	–	–	–	–	–	–	2
Passer montanus	–	–	–	–	–	–	–	–	–	20C	3C	–	–	3C	–	16–21C	–	–	1	–	4
Carduelis chloris	–	–	–	–	–	–	1B	1B	1C	–	–	–	–	1C	–	–	–	–	–	–	4
Carduelis cannabina	–	–	–	–	–	–	3C	–	–	–	–	–	–	3C	–	–	–	–	–	–	2
Emberiza citrinella	1C	–	–	–	–	–	0–2B	1C	–	–	–	–	–	3C	1C	–	–	–	–	–	5
Emberiza schoeniclus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2C	–	–	–	–	1
Total Suma	8	3	1	5	0	2	6	7	12	10	5	7	0	11	6	12	4	4	5	5	–

Table 3. Bird species recorded in the zones II and III. „+" – breeding recorded but the number of pairs not known; other explanations as in table 2.

Tabela 3. Ptaki stwierdzone w strefach II i III. „+"– stwierdzono gniazdowanie lecz liczba par nieznana; pozostałe oznaczenia jak w tabeli 2.

Species Gatunek	Quarry Kamieniołom																				Total Suma
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Circus aeruginosus	–	–	–	–	–	–	–	–	–	–	–	–	–	1B	1C	–	–	–	–	–	2
Accipiter gentilis	1A	–	1A	1A	–	–	–	–	–	–	1A	–	–	1A	–	–	–	–	–	–	5
Accipiter nisus	1B	–	–	–	–	–	1A	1A	–	–	–	–	–	–	–	1A	1A	1A	–	1A	7
Buteo buteo	–	–	–	1A	1A	–	–	–	–	–	1A	2B	–	–	1A	1B	–	1A	–	1A	8
Falco tinnunculus	–	–	–	–	–	–	–	1C	1A	–	1B	1A	–	–	–	1B	–	–	1C	1C	7
Falco subbuteo	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	–	–	1
Tetrastes bonasia	–	–	–	+A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Perdix perdix	–	–	–	–	–	–	–	1B	–	–	–	–	1B	–	–	2B	1B	1A	1B	–	6
Coturnix coturnix	–	–	–	–	–	–	–	–	–	–	–	–	–	1B	–	–	–	–	–	–	1
Phasianus colchicus	–	–	–	–	–	1B	1A	1A	–	1A	–	1A	–	–	–	1A	–	–	1A	+B	8
Vanellus vanellus	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	–	–	–	–	–	1
Columba palumbus	1B	–	1B	1B	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Streptopelia decaocto	–	–	1B	–	–	–	–	1C	–	–	–	–	–	–	–	1B	–	–	–	1B	4
Cuculus canorus	+B	–	–	+B	–	–	+B	–	–	–	–	+B	–	–	+B	+B	+B	–	–	+B	8
Jynx torquilla	–	–	–	–	–	–	1A	1B	1A	–	–	–	–	–	1B	1A	–	–	1A	–	6
Picus viridis	–	–	–	–	–	–	1A	1A	–	–	–	–	–	–	–	–	–	–	–	–	2
Dryocopus martius	–	–	1A	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Dendrocopos major	1A	–	1A	1A	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Dendrocopos medius	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Dendrocopos minor	–	–	–	–	–	–	–	–	–	–	1A	–	–	–	1A	1A	–	–	–	–	3
Lullula arborea	1A	–	1B	1B	–	1B	1C	1C	–	1B	1C	1B	–	–	3C	–	–	–	–	–	10
Alauda arvensis	–	–	–	–	–	2C	–	–	–	8C	3C	5C	2B	7C	4C	5C	4B	2B	4C	2B	12
Hirundo rustica	–	–	–	–	–	–	–	+B	–	–	–	–	–	–	–	–	–	–	+A	–	2
Delichon urbica	–	–	–	–	–	–	–	–	–	–	–	+A	–	–	–	–	–	–	–	+A	2
Anthus campestris	–	–	–	–	–	–	–	1A	–	2A	1C	–	–	–	1B	4B	–	1A	–	–	6
Anthus trivialis	1B	1B	3C	3C	–	4C	1B	1B	2C	–	–	7C	–	2B	–	2B	–	2B	2B	3B	14
Motacilla flava	–	–	–	–	–	–	1A	–	2C	1A	2C	2C	–	1B	–	2C	–	1A	1B	2C	10
Motacilla alba	1C	–	–	–	–	–	–	1B	1C	1B	–	–	1B	1B	1C	4-2C	–	–	1A	1A	10
Troglodytes troglodytes	–	–	–	1C	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Prunella modularis	–	–	–	2B	–	–	3A	1B	–	–	–	–	–	–	–	–	–	–	–	–	3
Erithacus rubecula	4B	2B	6C	6B	4A	2B	1A	3B	–	–	–	1B	–	1B	–	2B	2A	4A	1B	1B	15
Luscinia luscinia	–	–	–	–	–	–	3B	–	–	–	–	2B	–	–	–	4B	–	–	1B	–	4
Phoenicurus ochruros	1B	–	1C	–	–	–	–	1B	1B	–	1C	2C	2A	–	–	2C	–	1C	2B	1C	11
Phoenicurus phoenicurus	–	–	2C	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Saxicola torquata	–	–	–	–	–	1B	1B	–	–	–	1B	–	–	–	–	2B	2C	–	2B	1B	7
Oenanthe oenanthe	–	–	–	–	–	–	1C	–	–	–	–	5-1C	3C	–	–	5-1C	–	–	1B	–	5
Turdus merula	–	–	3C	3B	1B	1B	2C	–	1B	–	–	2B	–	3C	–	1C	–	3B	1B	1B	12
Turdus pilaris	–	–	–	–	–	–	+A	–	+A	–	+A	+B	–	+A	–	+A	–	–	+A	+A	8
Turdus philomelos	–	1B	2C	2B	1A	–	2B	2B	–	–	–	2B	–	1A	–	–	1B	1A	2B	1B	8
Hippolais icterina	–	–	–	–	–	–	–	1A	2B	–	–	1B	–	–	–	3B	–	–	1B	2B	6
Sylvia curruca	–	–	1B	–	–	–	2A	1A	1C	1B	2A	–	–	1A	–	3B	1B	–	–	1B	10
Sylvia communis	–	1B	4B	2B	–	2C	3C	1C	2B	5B	5C	7C	3B	4B	1B	7C	2B	1A	3B	4C	18
Sylvia borin	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1A	–	–	2
Sylvia atricapilla	2B	2B	4C	10C	2B	1B	2A	–	–	–	1A	1B	–	–	–	2B	1B	–	1B	–	12
Phylloscopus sibilatrix	1A	3B	1B	2B	3A	2B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6

Table 3 cont.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Phylloscopus collybita	–	1B	3B	3C	3A	–	–	1A	–	–	–	2B	–	–	–	–	1A	–	–	–	7
Phylloscopus trochilus	2A	2B	18C	8C	2A	3C	8C	4–9C	6C	1B	2B	–	1B	–	–	6C	3C	3A	–	2B	16
Parus regulus	–	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Parus cristatus	2B	–	1B	–	1B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Parus ater	3B	1A	1B	4B	2A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Parus caeruleus	2B	–	1B	–	–	1B	2B	–	–	–	–	2B	–	–	–	1B	–	–	–	–	6
Parus major	3C	1A	4C	2B	3A	–	3B	1A	1B	–	–	1C	–	1B	1B	2B	2B	–	1B	1B	15
Sitta europea	1B	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Oriolus oriolus	1A	–	–	–	–	–	–	1A	1A	–	–	1B	–	–	–	2A	–	–	–	1A	6
Lanius collurio	–	–	–	–	–	1B	1C	–	1A	3B	–	–	–	2C	1C	–	–	1C	1B	2B	9
Lanius excubitor	–	–	–	–	–	–	–	–	–	–	–	2C	–	1B	1B	–	–	–	1B		4
Garrulus glandarius	2B	–	1B	1A	1A	–	–	–	–	–	1A	–	–	1B	–	–	–	1A	–	1B	8
Pica pica	–	–	–	–	–	–	1A	–	2A	1C	3C	1C	2C	–	–	2B	2C	–	–	–	8
Corvus monedula	–	–	–	–	–	+B	+C	+C	+A	–	–	–	–	–	–	+C	–	–	–	–	5
Corvus frugilegus	–	–	–	–	–	+B	101C	101C	+B	–	25C	+A	3C	–	–	+C	–	–	+A	+A	10
Corvus corone	–	–	–	–	1A	–	–	–	1A	2B	1C	1A	–	–	–	+A	1B	–	–	–	7
Corvus corax	1A	–	–	–	1A	–	1A	–	–	–	–	–	–	1A	–	–	–	–	–	–	4
Sturnus vulgaris	–	–	1B	–	–	–	–	+C	+B	–	+A	+B	–	+A	–	+C	+A	–	+A	+B	10
Passer domesticus	–	–	–	–	–	–	–	+C	+C	3B	5C	+C	+B	–	–	4C	–	–	–	+C	8
Passer montanus	–	–	–	–	–	–	+A	–	2A	–	–	–	–	5C	+A	1C	–	–	1A	–	6
Fringilla coelebs	3C	2B	5C	5C	3A	1A	–	–	3B	–	–	–	–	–	–	2B	1B	1A	1C	2C	12
Serinus serinus	–	–	1B	–	–	–	1A	1B	2B	–	1A	–	–	–	–	–	–	–	–	–	5
Carduelis chloris	1B	2B	3B	–	–	–	2C	2A	5C	1B	1B	2B	1A	4A	2B	–	2B	–	–	1C	14
Carduelis carduelis	–	–	–	–	–	–	–	–	–	1B	1A	–	–	1B	1B	3B	–	–	1A	2C	7
Carduelis spinus	–	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Carduelis cannabina	–	1B	–	1A	–	2B	3C	2C	3C	4B	3B	5B	3B	2C	2C	5B	1B	–	4C	4C	16
Pyrrhula pyrrhula	–	–	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Coccothraustes coccothraustes	–	–	–	1A	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Emberiza citrinella	2B	3B	3B	4B	–	3C	5–4C	1A	2C	4C	3C	4B	–	1C	1C	5C	4C	3C	2C	5C	18
Emberiza hortulana	–	–	–	–	–	–	–	–	–	–	–	–	–	1B	–	1B	–	–	–	–	2
Emberiza calandra	–	–	–	–	–	–	–	–	–	6C	4C	2C	–	7C	3C	–	1B	–	4–7B	1A	8
Total Suma	26	11	32	27	21	18	33	32	28	18	27	35	12	26	19	41	21	18	31	34	–

Birds came into the quarries to forage, rest or bathe. Families of birds were often seen. Quite unusual was the observation of a Black Stork *Ciconia nigra* foraging at a distance of 100 meters from working machines.

Predators in quarries

Four species of birds of prey were present in zone I.

Goshawk *Accipiter gentilis* – recorded in 5 areas altogether but only seen once in zone I, flying low over the bottom of the quarry.

Sparrowhawk *Accipiter nisus* – present in 7 areas altogether, of which in zone I of 5 quarries. It usually hunted by suddenly flying into the quarry from behind the scarp and then low over the bottom. Twice I observed this species perching on a tree near the scarp.

Buzzard *Buteo buteo* – in 3 quarries seen in zone I and in 8 areas in all. Birds hunted perching on rock projections of the scarp or gliding along it. After the end of the breeding season I saw families of Buzzards (4 and 6 specimens) in two quarries in which this species was not present during the season.

Kestrel *Falco tinnunculus* – recorded in 8 areas in all. In zone I it was observed in 5 quarries. In 1 quarry it bred. After the end of the breeding season I saw this species in 2 quarries in which I had not record it before (2 and 4 specimens). Kestrels usually perched on rock projections and glided along the scarp.

In 7 quarries I recorded the Fox *Vulpes vulpes*. According to information from workers, some martens were present in 2 quarries (species determination was not possible).

FACTORS INFLUENCING BIRD COMMUNITIES

Of the analysed factors, heterogeneity of habitat was the most important one. It positively influenced the number of species in quarries. Correlation between the number of species in zone I and heterogeneity of the habitat in that zone was very strong: $r_s = 0.790$; n = 20; p = 0.0006 (Fig. 2).

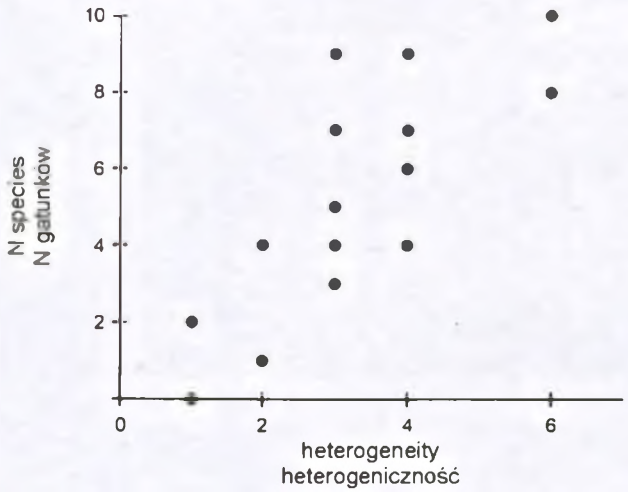

Fig. 2. Correlation between heterogeneity of zone I in the quarries and the number of bird species breeding there.

Ryc. 2. Korelacja między heterogennością strefy I w kamieniołomach i liczbą gatunków ptaków gniazdujących w tej strefie.

The influence of the quarries' size was measured as the correlation between the number of species in zone I and its size. Its value was not as high as in case of heterogeneity: $r_s = 0.427$; n = 20; p = 0.06 (Fig. 3). The size of quarries acted directly in two cases, in Wykień (5) and Ślichowice (13), as a limiting factor making the colonization of these quarries impossible for any birds. Larger quarries usually held more habitats, although some small quarries were also heterogeneous, e.g. the Sitkówka – Nowiny (9).

The situation of quarries in a forested or non-overgrown neighbourhood was important for a few species. The Little Ringed Plover avoided quarries placed in overgrown surrounding (found only in 1 quarry of this kind) and so did the Tawny Pipit and the Tree Sparrow (absent in all quarries of this type). The Tree Pipit and the Blackbird chose quarries of a forested zone II and advanced succession in zone I. For other common species the criterion of quarries' situation was not important. It is difficult to determine its role for the 26 species recorded only in 1 or 2 quarries. Seventeen of these species (65.4%) were found only in quarries of non-overgrown surrounding in zone II, whereas no species was recorded exclusively in quarries where zone II was forested. In total, there were 10 bird species recorded in quarries of forested surrounding, 29 species in quarries of unforested surrounding and 10 species in quarries of an intermediate situation.

Altogether there were 27 bird species recorded in working quarries and 16 species in those closed-down. Some

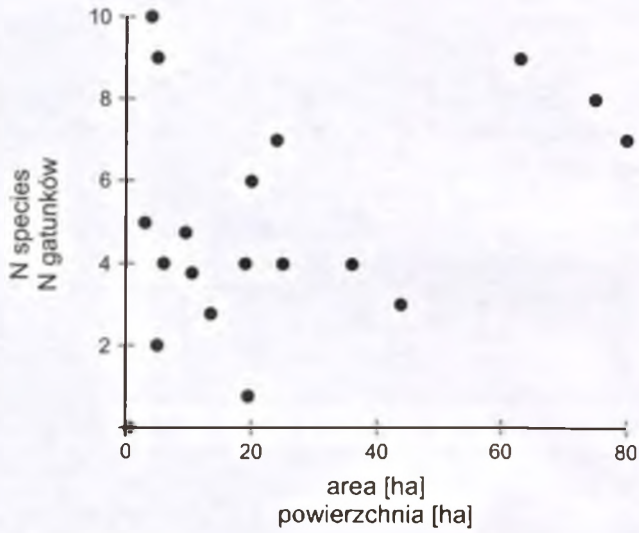

Fig. 3. Correlation between the area of zone I in the quarries and the number of bird species breeding there.

Ryc. 3. Korelacja między powierzchnią strefy I w kamieniołomach i liczbą gatunków ptaków gniazdujących w tej strefie.

species connected with rocky or semi-rocky habitats preferred working quarries. The White Wagtail was present in all 10 of the working quarries comparing to its presence in 6 out of 10 closed-down (Fisher exact test, P = 0.043). Also the Black Redstart was present more often in working quarries – in 9 out of 10 – than in closed down ones – in 3 out of 10 (Fisher exact test, P = 0.01). Little Ringed Plovers were found in 8 out of 10 working quarries and only in 3 out of

Table 4. Species under the direct influence of exploitation effects (see method). N.Q. – number of quarries in which the species was present in the zone of direct exploitation. N.P. – total number of pairs in that zone.

Tabela 4. Gatunki pod bezpośrednim wpływem skutków eksploatacji. N.Q. – liczba kamieniołomów, w których gatunek był stwierdzony w strefie bezpośredniej eksploatacji. N.P. – całkowita liczba par w tej strefie.

Species Gatunek	N.Q.	N.P.
Gallinula chloropus	1	1
Charadrius dubius	6	6–7
Alauda arvensis	1	1
Anthus campestris	2	2
Anthus trivialis	1	1
Motacilla alba	7	8–9
Phoenicurus ochruros	3	3
Oenanthe oenanthe	8	10–12
Turdus merula	1	1
Sylvia communis	1	1
Phylloscopus trochilus	1	1
Sturnus vulgaris	1	3
Passer domesticus	1	1–5
Passer montanus	3	20–22
Carduelis chloris	1	1

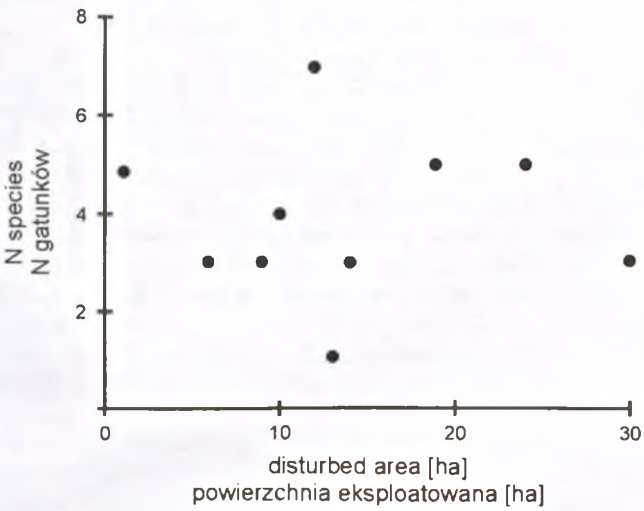

Fig 4 Correlation between the size of area disturbed by direct exploitation effects and the number of bird species.

Ryc. 4 Korelacja między wielkością powierzchni narażonej na bezpośrednie skutki eksploatacji i liczbą gatunków ptaków gniazdujących w tej strefie.

Table 5 Bird succession in quarries. Regular occurrence is marked with solid line and irregular, with thin line.

Tabela 5. Sukcesja ptaków w kamieniołomach. Pogrubiona linią oznaczono występowanie regularne, a cienką nieregularne.

Species Gatunek	Rock Skała	Herbaceous plants Roślinność zielna	Bushes Trees Krzewy Drzewa
Charadrius dubius	—		
Phoenicurus ochruros	—	—	
Sturnus vulgaris	—	—	
Passer domesticus	—	—	
Motacilla alba	—	—	—
Oenanthe oenanthe	—	—	—
Passer montanus	—	—	—
Burhinus oedicnemus	—		
Anthus campestris	—		
Alauda arvensis		—	
Anas platyrhynchos		—	
Gallinula chloropus		—	
Vanellus vanellus		—	
Acrocephalus arundinaceus		—	
Emberiza schoeniclus			—
Sylvia communis			—
Emberiza citrinella			—
Carduelis chloris			—
Acanthis cannabina			—
Anthus trivialis			—
Erithacus rubecula			—
Phylloscopus trochilus			—
Parus major			—
Total Suma	9	14	11

10 closed-down ones (Fisher exact test, P = 0.035). Analogically, as in case of quarry's situation, it is difficult to determine the role of exploitation for those species that were present only in 1 or 2 quarries. Of these 26 species, 16 (61.5%) were present only in working quarries and 5 (19.2%) only in closed-down ones.

I recorded 15 species of birds in areas very exposed to disturbance due to exploitation (Table 4). These species were generally common in quarries: Little Ringed Plover, White Wagtail and Wheatear. Exceptionally, the Black Redstart, although common, tended to avoid disturbed places and so did the Tawny Pipit. The remaining species occurred in these places sporadically but they were generally rare in quarries. The size of the areas under the direct exploitation did not influence the number of species breeding there: rs = - 0.02; n = 10 (Fig. 4).

Each stage of ecological succession of plants in zone I changed its heterogeneity and was accompanied by characteristic bird species (Table 5). Only the occurrence of the White Wagtail, the Wheatear and the Tree Sparrow was not connected with any particular stage of succession. The number of species was higher in quarries where ecological succession was advanced.

DISCUSSION

METHODS

The method applied allowed sufficiently precise determination of species composition and the abundance of birds in quarries. The number of controls was low but quarries are relatively poor, open habitats, easy for an observer to penetrate. Sometimes it was difficult to estimate the exact number of pairs breeding within one zone because their territories were placed on the border between two zones or in both zones. That difficulty had little influence on the overall results.

QUALITATIVE AND QUANTITATIVE DATA

Four species were decidedly the most common in the studied quarries – the Wheatear, the White Wagtail, the Black Redstart and the Little Ringed Plover. The low number of species (4–5) in zone I was typical and there were only 2 quarries with no birds in this zone.

During the studies I recorded the breeding of some species of birds not mentioned thus far in literature in relation to quarries. Some of these birds were common species, not connected with quarries in any special way. They just profitted from the suitable habitats which originated due to ecological succession. Still, the occurrence of these birds in quarries is interesting in view of their breeding biology. These species are: Mallard *Anas platyrhynchos*, Moorhen *Gallinula chloropus*, Skylark *Alauda arvensis*, House Martin *Delichon urbica*, Tree Pipit *Anthus trivialis*, Robin *Erithacus rubecula*, Blackbird *Turdus merula*, Great Reed Warbler *Acrocephalus arundinaceus*, Whitethroat *Sylvia communis*, Great Tit *Parus major*, Blue Tit *Parus caeruleus*,

Greenfinch *Carduelis chloris*, Linnet *Carduelis cannabina*, Yellowhammer *Emberiza citrinella*, Reed Bunting *Emberiza schoeniclus*, and perhaps also Partridge *Perdix perdix*, Coot *Fulica atra*, Wryneck *Jynx torquila*, Song Thrush *Turdus philomelos* and Marsh Warbler *Acrocephalus palustris*.

The Lapwing *Vanellus vanellus* that I recorded breeding in one quarry, was mentioned from gravel-pits (Dyrcz et al. 1991). The Little Ringed Plover breeds in the quarries of Silesia (Dyrcz et al. 1991) but not in Małopolska (Walasz, Mielczarek 1992), where it was found only in gravel-pits. According to the results presented in this paper, Little Ringed Plovers are, also in Małopolska, quite common in quarries – they were recorded in 10 of them.

In the literature I have not found any report on the Ringed Plover *Charadrius hiaticula* in quarries. Lewartowski and Winiecki (1992) mention this species from brown coal surface excavation. I saw one specimen in the Sobków (15) quarry in the second half of May.

The rarest species that I recorded during the studies was the Stone Curlew. The late date of observation (3rd of June) and the suitability of the habitat suggest the possibility of a breeding attempt. According to personal information from Sławomir Chmielewski, a Stone Curlew was seen at the same place during the next season. This species is classified as endangered in the „Polish Red Data Book of Animals" (ed. Głowaciński 1992). There are only a few pairs of this species breeding in Poland at present (Tomiałojć 1990; ed. Głowaciński 1992), in the Narew, Bug and maybe Vistula valleys. In recent years in Małopolska the Stone Curlew was seen only once in the Błędowska Desert (Walasz, Mielczarek 1992).

In the literature I did not find any information about the Tawny Pipit *Anthus campestris* breeding in quarries. Dyrcz et al. 1991 classified it as breeding in gravel-pits and sand-pits in Silesia. Walasz and Mielczarek (1992) classified this species as a very scarce and locally scarce one and do not mention it from quarries. I recorded 18 pairs of Tawny Pipits in 11 areas (of 20 studied), which suggests that quarries and adjacent devastated areas are very suitable habitat for this species.

It is surprising that Walasz and Mielczarek (1992) mentioned the Wheatear only from closed-down gravel-pits, whereas I encountered it in almost all quarries both working and closed-down. According to these authors the Wheatear is a scarce and locally very scarce species in Małopolska. The densities that I recorded allow classification of this species as locally abundant and very abundant. This might be explained by the fact that the total area of rocky habitat in quarries was not only the bottom, but also the scarp surface. Many times I observed conflicts between Wheatears on the scarps and defence of their territories only at one level of a quarry which indicates partitioning of the space in quarries both horizontally and vertically.

Also the Little Ringed Plover had relatively high densities in a few quarries. Walasz and Mielczarek (1992) classified this species as scarce and locally fairly numerous. Its densities recorded during my studies allow classification of the Little Ringed Plover as locally numerous and locally very numerous.

The density of White Wagtail and Black Redstart found during these studies did not stray from the results given by other authors (see Walasz, Mielczarek 1992).

Only Harrison (1991) writes about breeding of the Tree Sparrow in quarries but I have found no such data in Polish literature. I recorded breeding of this species in 5 places.

Surprisingly, the Kestrel bred in only 1 out of 20 studied quarries. According to Dyrcz et al. (1991), Kestrels are quite common in the quarries of Silesia. The reason for the lack of this species in the studied quarries is not clear. It is possible that the occurrence of some species in quarries is restricted to certain geographical regions.

Other authors list birds from quarries which I did not record during this study.

In the quarries of Silesia 2 broods of the Eagle Owl were found (Dyrcz et al. 1991). I could not confirm a personal report of this owl's occurrence in the Marczakowe Doły (18) quarry. The stimulation ofvocal activity brought no effect. Harrison (1991) mentioned the Barn Owl *Tyto alba*, the Little Owl *Athene noctua* and the Stock Dove *Columba oenas* from quarries but I have not found such information in Polish literature. I did not record the Crested Lark *Galerida cristata* or the Sand Martin *Riparia riparia* which were mentioned from quarries by Walasz and Mielczarek (1992) and Harrison (1991). Dyrcz et al. (1991) wrote about an observation of the Wallcreeper *Tichodroma muraria* in the Strzegom quarry but this case was very unusual and connected with the close vicinity of mountains.

Crevices in natural rocks can be the unusual breeding places for some species. Bocheński and Harmata (1962) mentioned the breeding of the Jackdaw *Corvus monedula*, Blackbirds and the Spotted Flycatcher *Muscicapa striata* in rock crevices of Jura Krakowsko-Częstochowska. Also breeding of the Barn Swallow *Hirundo rustica* in a similar habitat is known (Weiner 1967). But there is no information about these species from quarries.

FACTORS INFLUENCING BIRDS IN QUARRIES

The type of quarry bottom and, in turn, heterogeneity, depend on a combination of both biotic and abiotic factors. The state of exploitation influences the presence of rocky patches and the stage of ecological succession determines the type of vegetation. The bottom is bare rock in areas where exploitation is still being carried out and gradually is overgrown by plants in places where exploitation is finished. In large working quarries different stages of succession were present at the same time providing high heterogeneity of habitats. This is why large quarries were usually inhabited by a relatively large number of bird species (Fig. 3). Still, the correlation between the size of a quarry and the number of species in zone I is weakened by small yet very heterogeneous quarries, like the Sitkówka – Nowiny (9). Begon and Mortimer (1989) cited the results of a few authors to confirm a general thesis that larger habitats are inhabited by many more plant and animal species than the

terrain of smaller areas. According to the authors, this rule is the result of either higher habitat diversity connected with large areas (indirect influence), or specific properties of insular habitats (e.g. larger areas are more likely to be colonized) that are characteristic for many natural and entirely continental areas (direct influence). These factors usually act together and are difficult to separate. It seems that quarries are interesting examples of insular habitats. One of the features that differentiates quarries from other environments is that the heterogeneity of habitat inside quarries does not always increase with its area. Insular properties of quarries are certainly much more important for low-mobility organisms, e.g. amphibians, than for birds. Some amphibians (frogs and toads) were commonly recorded in some quarries, yet not studied. The influence of the size of quarries upon their colonization by birds is discussed later in this paper.

The correlation between the heterogeneity of zone I and the number of birds in that zone is very strong (Fig. 2). Similar relationships are commonly recorded in different types of environs (Pianka 1981).

Marking out and controlling zones II and III was carried out in order to check whether the presence of quarries had any influence on the species communities in the adjacent areas. Only when those areas were in a great part devastated by exploitation, which was not the rule, the presence of quarries directly influenced bird species composition in their surroundings. The type of habitats in these areas and, in turn, bird communities were not always connected with the presence of the quarry. The long species list suggests that the neighbourhood of even intensively exploited quarries had no negative influence on birds. At a distance of 70 meters off the scarp of the working Skalnik (4) quarry I observed the Hazel Hen *Tetrastes bonasia* which is regarded as quite a timid bird. Territories of many pairs of different species directly bordered with the scarp or were placed both in zones I and II.

The division of the quarries into working and closed-down was done to find any differences in species composition as the direct result of some negative effects of exploitation. But the reaction of birds to direct disturbances caused by exploitation was surprisingly weak not only in the closest neighbourhood of the quarries but also inside them. Comparison between species found in working and closed-down quarries brought an unexpected result – there were more birds in those under exploitation (27 species) than in those not exploited (16 species). One should remember, however, that most of these species were found only in 1 or 2 quarries and therefore it is difficult to draw any reliable conclusions from this result (the sample size could have been too small and the result may not reflect reality).

There was no correlation between the size of the zone under the direct influence of exploitation and the number of species inhabiting it (Fig. 4). Most of these areas were similar (poor, bare rock) which in turn caused the similarity of species recorded there.

Summarising the role of exploitation in shaping bird communities: it was an important but rather indirect factor influencing the heterogeneity of habitat by creating rocky and semi-rocky habitats. This enabled penetration into quarries of species connected with this type of habitat.

For most of the birds which are common in quarries, their situation in non-overgrown or forested neighbourhoods seemed to not be an important factor. Only Little Ringed Plovers, Tawny Pipits and Tree Sparrows decidedly preferred quarries situated in a non-overgrown neighbourhood. The occurrence of species recorded only in 1 or 2 quarries could result from the presence of some specific habitats in zone I and might not depend on the quarry's adjacent areas. It seems that quarries situated among fields or meadows are easier for birds to colonize than those situated in forests. That conclusion can be drawn first of all because the number of breeding species recorded in quarries of a non-forested neighbourhood was higher (29 species) than in the case of quarries surrounded by forest (10 species) and secondly because there was no bird species found exclusively in quarries of a forested neighbourhood, whereas 17 species (50% of all species recorded in zone I) were found exclusively in quarries of a non-overgrown neighbourhood.

Another factor which influenced bird communities in quarries was their area. It was undoubtedly the limiting factor in the Wykień (5) and Ślichowice (13) quarries, where their small area (0.3 and 0.55 ha respectively) was the reason for the lack of birds in zone I. The third of the smallest quarries (3 ha) was Miedzianka II (8), inhabited by 5 species of birds. But its zone II was partly overgrown with trees and bushes, the scarp was low and succession in zone I advanced. Therefore the interior of that quarry and its neighbourhood were very similar and difficult to separate. If a quarry remains a kind of bare, rocky island situated in forested neighbourhood, the minimum area for birds to colonize it is probably larger than in case of quarries situated on an open field. Although surrounded by forest, a rocky quarry can not be colonized by any typical forest bird species. On the other hand, birds of the open field are reluctant to penetrate into small glades or clearcuts surrounded by forest. Bukowa Góra (2) was a good example of such a quarry. Despite quite a large area (14 ha) it was colonized by only 3 species. Disturbances caused by exploitation were certainly not the only factor accounting for this. Closing the quarry down would probably not allow new species to colonize it until new habitats were created due to ecological succession.

THE IMPORTANCE OF QUARRIES FOR BIRDS

Only one of the 20 studied quarries, Ślichowice (13) is protected as a reserve because of its geological values and one more reserve, Siedlce (14) is planned. Some of the quarries are included in the recently created Chęcińsko-Kielecki Landscape Park which is the first geological landscape park in Poland. The results of this studies suggest that some quarries could be also worth protecting in view of their avifauna. They might turn out to be one of the last refugees for Stone Curlew in Poland. Tomiałojć (1990) and Głowaciński (1992) postulate protection of every breeding site of this species. According to a Decree of the Minister of Environmental Protection, Natural Resources and Forestry of 6th of January 1995 on animal species protection, areas within a radius of 500 meters from the Stone Curlew's breeding sites and places of constant inhabitation are to be protected. Protec-

tion of the site recorded during this study would be difficult though, because the quarry was under very intensive exploitation.

It is also possible that two other rare species, mentioned in the "Polish Red Data Book of Animals" (ed. Głowaciński 1992) breed in quarries: the Ringed Plover, classified in that book as a vulnerable species, and the Eagle Owl, reported from quarries by Dyrcz et al. (1991), classified as a rare species. The Ringed Plover and the Tawny Pipit, common in quarries, are also valuable species, scarce in other areas.

Comparison of the species list between quarries with advanced stages of succession and those in which that process was in its early stages indicates that the latter ones are more valuable in view of the avifauna. Although quarries with advanced ecological succession usually had a long species list, these were mostly common, eurybiontic birds. The species list in quarries at the early stages of this process was usually shorter, but included many rare and valuable species, connected with rocky habitats. It seems then that well-run protection of quarries should involve prevention of succession development beyond the stage of xerothermic plants. Often some measures are undertaken to recultivate quarries after exploitation, in order to regain a landscape as similar as possible to the one before the beginning of exploitation. Considering the arguments mentioned above, this not always is necessary and sometimes can bring more harm than profit.

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STRESZCZENIE

Celem pracy było poznanie awifauny kamieniołomów i określenie czynników wpływających na jej strukturę. Badania prowadzono w 20 kamieniołomach położonych w województwie kieleckim (ryc. 1). Były one zróżnicowane pod względem wielkości, stanu eksploatacji i rodzaju otoczenia (tab. 1). W sezonie lęgowym 1994 przeprowadzono 4 kontrole kamieniołomów. Badano wnętrze wyrobiska i otoczenie w promieniu 500 metrów od skarpy. Kontrole przeprowadzano w sposób przyjęty dla kombinowanej metody kartograficznej (Tomiałojć 1976, 1980). Zebrany materiał został opracowany zgodnie z tą metodą. Sprawdzono zależność liczby gatunków od wielkości kamieniołomu, heterogenności siedliska i stanu eksploatacji.

Ogółem stwierdzono 89 gatunków ptaków. We wnętrzu kamieniołomów obserwowano 34 gatunki ptaków lęgowych (tab. 2) i 30 gatunków nielęgowych. Liczba lęgowych gatunków w poszczególnych wyrobiskach wahała się od 0 do 10 (średnio 5). Najczęściej występujące w kamieniołomach ptaki to: białorzytka (w 17 wyrobiskach), pliszka siwa (16), kopciuszek (12), sieweczka rzeczna (11), świergotek polny (7), mazurek (5), trznadel (5) i dzwoniec (4). Pozostałe gatunki występowały tylko w 1 lub 2 kamieniołomach. Obserwowano nietypowe miejsca gniazdowania białorzytki, pliszki siwej, mazurków i szpaków w szczelinach skalnych, a także gniazdowanie kopciuszka w maszynach eksploatacyjnych. Najciekawszym z obserwowanych gatunków był kulon (możliwe, że był to ptak lęgowy). Ptaki nielęgowe wykorzystywały wyrobiska jako miejsca żerowania, kąpieli i odpoczynku. Stwierdzono w kamieniołomach 4 gatunki ptaków drapieżnych (w tym lęgową pustułkę) oraz lisy i kuny. W promieniu 500 metrów od skarpy kamieniołomów stwierdzono 79 gatunków lęgowych (tab. 3). Były to ptaki typowe dla danego siedliska.

Najważniejszymi czynnikami wpływającymi na liczbę gatunków ptaków w kamieniołomie były: heterogeniczność siedliska (ryc. 2) i w mniejszym stopniu wielkość wyrobiska (ryc. 3). Tylko w przypadku kilku gatunków typ otaczającego siedliska był czynnikiem wpływającym na zasiedlenie wnętrza kamieniołomu. Eksploatacja wyrobiska nie wywierała na ptaki negatywnego wpływu. W kamieniołomach eksploatowanych liczba gatunków była wyższa niż w kamieniołomach nie eksploatowanych. Pliszki siwe, kopciuszki i sieweczki rzeczne preferowały kamieniołomy eksploatowane. W miejscach szczególnie narażonych na skutki eksploata-

cji stwierdzono 15 gatunków. Liczba gatunków w tych miejscach nie zależała od ich powierzchni (tab. 4, ryc. 4). Najczęstszymi gatunkami były tu: sieweczka rzeczna, pliszka siwa i białorzytka, czyli ptaki na ogół liczne w kamieniołomach.

Poszczególnym stadiom sukcesji roślin w wyrobiskach towarzyszyły charakterystyczne gatunki ptaków (tab. 5). Jedynie występowanie pliszki siwej, białorzytki i mazurka nie było związane z żadnym konkretnym stadium sukcesji.

W czasie badań stwierdzono gniazdowanie kilku gatunków, o których nie było dotąd doniesień z kamieniołomów. Były to: krzyżówka, kokoszka wodna, czajka, świergotek polny, świergotek drzewny, skowronek polny, rudzik, kos, trzciniak, ciemiówka, sikora bogatka, sikora modra, szpak, wróbel, dzwoniec, makolągwa, trznadel, potrzos. Możliwe jest również gniazdowanie sieweczki obrożnej, kuropatwy, łyski, kulona, krętogłowa, drozda śpiewaka i łozówki.

Nie potwierdzono doniesień z literatury o gniazdowaniu w kamieniołomach następujących gatunków: rycyk, rybitwa zwyczajna, puchacz, płomykówka, pójdźka, siniak, dzierlatka, brzegówka, kląskawka.

Rezultaty badań wskazują, że niektóre kamieniołomy zasługują na ochronę ze względu na ich cenną awifaunę. Podstawowym zadaniem jest powstrzymanie sukcesji roślin poza stadium kserotermów, co pozwala na zasiedlanie wyrobisk przez rzadkie ptaki związane z ubogimi, skalistymi siedliskami. Rekultywacja kamieniołomów po zakończeniu ich eksploatacji, polegająca na sadzeniu drzew i krzewów, prowadzi do ich zasiedlania przez pospolite, eurybiontyczne gatunki ptaków.