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Accuracy of the mapping technique for a dense breeding population of the Hawfinch *Coccothraustes coccothraustes* in a deciduous forest

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Abstract. The accuracy of the territory-mapping technique for estimating the abundance of densely breeding Hawfinches was tested in an old and unfragmented lime-oak-hornbeam forest in the Białowieża National Park, E Poland. Hawfinch numbers estimated from counts of the whole bird community carried out with the application of the standards of the improved mapping technique were compared with seven-year data on the bird's true numbers, which are known from parallel intensive nest searches and persistent tracking of the movements of pairs. In a forest with a dense population of Hawfinches the mapping technique underestimated their numbers by 20% in years of moderate density and by 35% during high-density years. Even though the underestimation was negatively correlated with the true density of Hawfinches, the figures obtained by both methods reflected year-to-year changes in a similar way. An improvement in mapping data is achievable either by closer attention being paid to the species during standard visits (the best ones for surveying it), or *post factum* by the introduction of a correction factor into the mapping-technique figures.

Key words: Hawfinch, *Coccothraustes coccothraustes*, bird census accuracy, deciduous forest

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INTRODUCTION

The territory-mapping technique, or spot-mapping, originally was designed to estimate the abundance of typically territorial birds (Enemar 1959, IBCC 1969), and only later it has been extended to estimate the numbers of all the species constituting the bird community (Tomiałojć 1980, Marchant 1983, Bibby et al. 1992). Recently it is widely used for counting all the breeding land birds, including those violating the original assumptions of the method. The reasons of its failure to estimate accurately the densities of some difficult species are still poorly known, as only a few field tests have been performed, and this was mostly for typically territorial species. Of woodland birds, tests concerned mostly the territorial species from three taxonomic groups, the leaf-warblers of genus *Phylloscopus* (Tomiałojć 1980, Tiainen & Bastian 1983, titmice *Paridae* (Tomiałojć 1980, Morozov 1994, Nowakowski 1994), thrushes *Turdidae* (Tomiałojć & Lontkowski 1989), as well as a Collared Flycatcher *Ficedula albicollis* population (Walankiewicz et al. 1997). More tests are required to check how this method works under other and various field conditions and for weakly territorial bird species.

The Hawfinch *Coccothraustes coccothraustes* is a monogamous, single-brooded, only mildly territorial passerine (Mountfort 1957, Cramp & Perrins 1994, Glutz von Blotzheim & Bauer 1997) breeding in deciduous and mixed forests across the European plains. The Białowieża lime-oak-hornbeam stands constitute its optimal breeding habitat, quite different from the fragmented west-European woodland, where the previous censuses of its population were carried out (Bijlsma 1979, Krüger 1982, Hustings et al. 1985). While most Hawfinches are spread uniformly, some form loose aggregations of 3–5 pairs; consequently, in the Białowieża Forest active nests happen to be 20–30 m, sporadically 7 m, apart (Tomiałojć in Glutz & Bauer 1997). Proper counting this species is a difficult task with any method used (Mountfort 1957, Bijlsma 1979), what has been confirmed in a preliminary field test for Białowieża Forest (Tomiałojć 1994). There, these birds: are known to stay permanently in the forest canopy 15–40 m above the ground; do not alarm at the presence of human observer when nesting high (7–34 m above the ground); do not have discrete and overtly defended territories; do not proclaim their nesting area with a loud song; have their agonistic behaviour and song activity displayed also outside nesting sites; leave nesting sites for hours to feed elsewhere; are extremely secretive during the incubation and nestling periods.

The aim of the present study is to evaluate the accuracy of the Hawfinch census results obtained with the help of an improved territory-mapping technique (Tomiałojć 1980) and when applied to surveying a dense Hawfinch population inhabiting a mostly deciduous and closed-canopy high forest. Additionally it was aimed to check how the territory-mapping technique reflects the year-to-year population fluctuations of the species.

STUDY AREA

The field tests were performed within two census plots established for a long-term monitoring of bird numbers in the primeval forest of the Białowieża National Park (BNP), NE Poland. Both plots represent the locally favoured by Hawfinches lime-oak-hornbeam *Tilio(Querco)-Carpinetum* association: forest edge adjoining plot W (25.5 ha) and forest-interior plot M (30 ha). The tree-stand in both plots differed only slightly (less than 20%) by a lower admixture of old spruces *Picea abies* and a higher of the continental maple *Acer platanoides* in plot M, which does not seem to undermine their comparability. For orientation the plots have been provided with 50 × 50 m grid. In both areas the bush and young-tree layers were scarce, while a complex and multispecies (ca. 15 tree species, including some old spruces) and multilayer forest canopy extended up to 30–45 m above the ground (for details see: Tomiałojć et al. 1984, Wesołowski & Tomiałojć 1997). For this type of habitat the averaged many-year data from the territory-mapping estimates of the Hawfinch abundance were 4.7 and 3.3 pairs/10 ha respectively (with extreme single-year values being 2.0 and 7.0). However, the true breeding densities were found there to be between 5.9 and 7.7 pairs/10 ha, in exceptional years up to 15.2 pairs/10 ha (Tomiałojć in Glutz & Bauer 1997).

METHODS

As defined in preliminary report (Tomiałojć 1994) two kinds of field data were collected by different observers using two different methods to get independent results to be subsequently compared with each other.

True numbers (T), of 95–100% accuracy. These have been obtained during seven years (1991-1994, 1996-1998) of intensive study of the Hawfinch abundance. Each year 12–18 half-day visits to each of two plots were made between mid-April and early June by the author himself. In contrast to typical for mapping-technique short-time point records based on voices heard, here the Hawfinch pair movements were followed persistently and registered on the map to the scale 1:1000. Mutually exclusive nesting ranges of particular pairs were drawn mostly on the basis of contemporary records of neighbouring pairs, not so much on clusters of "point" records. Simultaneous records were five — seven times more numerous than in the mapping technique data. Only the rules of elaborating in the office of the early-season (prior to nesting) field records were identical with the mapping technique. E.g. only the half-range was included into the plot in case when the nest was exactly on the plot boundary or when about a half of records in a cluster was falling outside. By the end of April, after elaboration of results from the first 4–5 visits, the preliminary outlines of occupied nesting ranges were obtained. This allowed then for the second phase of field work: the concentrated search for nests under construction, usually successful owing to undeveloped leaf cover. By the 10 May the nests were found in 80–94% of ranges. In single cases the missing nests were found later, even during the next-year April at the total absence of leaves. This was possible, because the old Hawfinch nests remain in trees for a year or two (own data). Total time effort was 90–124 hours of observation per plot and season, depending on a current Hawfinch abundance.

Thanks to many simultaneous records of neighbouring pairs and almost all nests known the number of revealed nesting ranges seems to be very close to their true abundance, in spite of the fact that the birds were not marked individually. An argument in favour of this can be that missing nests found during the next season were always falling within one of the previous-year nesting range, denoting usually a repeated nesting attempt (though very infrequent — own data) or (sporadically) an overlooked nest in an earlier known nesting range. Only in single cases per season there was a doubt if there was one or two pairs at a particular site. Such a method does not exclude, however, a possibility of sequential breeding, i.e. that within the same nesting range a new pair settled after its desertion by earlier owners. Yet in both methods merely the numbers of occupied "nesting sites" were compared, not the true numbers of pairs attempting to breed.

The mapping estimates (ME). They were collected by a team of census takers, unaware of true distribution of Hawfinches. Nine to eleven half-day visits to the same plots were paid per season, during which all the breeding species were mapped by one of five experienced observers, replacing each other on subsequent visits in order to spread an individual error over all census plots. The visits were uniformly scattered in time between mid-April and c. 20. June. The combined version of the method applied in BNP differs from the old international standard (IBCC 1969) in the increased attention paid to collecting simultaneous records and in a little more prolonged stay on the census plot (2–2.5 hours per 10 ha), that made watching some bird movements and finding a few bird nests possible (Tomiałojć 1980, Marchant 1983, Tomiałojć et al. 1984). A total time expenditure for censusing all birds was ca. 55 hours per plot per year, of which roughly one fourth falls on the part of season, on fragments of habitat and on quiet moments without confusing singing of other birds, when the Hawfinches had a chance to be recorded. This means that in the mapping technique survey the time expenditure devoted to the Hawfinch alone was roughly ten times lower than that in the case of the first method. As concerns the elaboration of mapping data, all the records from valid for the Hawfinch 8–9 visits were put on the species map. Usually they form clusters, "paper territories", designed according to the mapping-technique rules. Two analysts (W. Walankiewicz and T. Wesołowski), both with experience of many years of the field work in Białowieża Forest but unaware of the current-season true abundance and distribution of Hawfinches, and differing in amount of experience with the mapping data analysis, were asked to draw independently the "paper territories" on identical copies of the species map. Their averaged numbers of "paper territories" equal here to the mapping estimate (ME) tested below.

RESULTS

The territory-mapping results, understood as the numbers of "papers territories", are considered below as The Mapping Estimates" (ME). They have been compared with the "True Numbers" (T) of the Hawfinch nesting ranges in the 13 plot/season sets of data, like that one shown in Fig. 1. Two nests within a range denote on this map two nesting attempts within the same nesting range. It is worth mentioning here that a cluster of nests within the uppermost belt shown on census map (not surveyed with the territory mapping) would probably still lower the efficiency of the mapping result if included into the test. In order to reduce the confusing effect of low number of Hawfinch pairs per plot the data from both plots were combined to get seven firm yearly results (Table 1). In every case the mapping results have appeared to be underestimated, by 15–33%, depending on the season. During the years with low and moderate Hawfinch density the estimates were lower than the true numbers on average by one fifth (ca. 20%). In years with twice higher Hawfinch density they were lower by 32–39%, which means the efficiency of the mapping censuses being only 61–68%. The higher density the more underestimated mapping result ($r = -0.81$, $n = 7$, $p < 0.05$, Fig. 2). The individual differences between the two analysts'estimates, rather considerable during the first year of experiment,

Table 1. Comparison of the true population density (p/10 ha), true numbers of nesting ranges (T) and mapping estimates (ME), the latter ones shown as a span between results of two analysts. A% — average accuracy of mapping result, * — comparison based on single plot W.

Year	True density (p/10 ha)	Number of ranges /methods		A %
		T	ME	
1991	6.8	37.5	25–32	76.6
1992	5.9	33	25–26	76.4
1993	6.2	34.5	26	76.4
1994	7.8	43.5	35–37	82.7
1996	13.8	76.5	51–54	68.6
1997	6.8	37.5	31–33	85.3
1998	13.7	35*	19.5–23	60.7
Total/Average	8.7	297.5	223	75

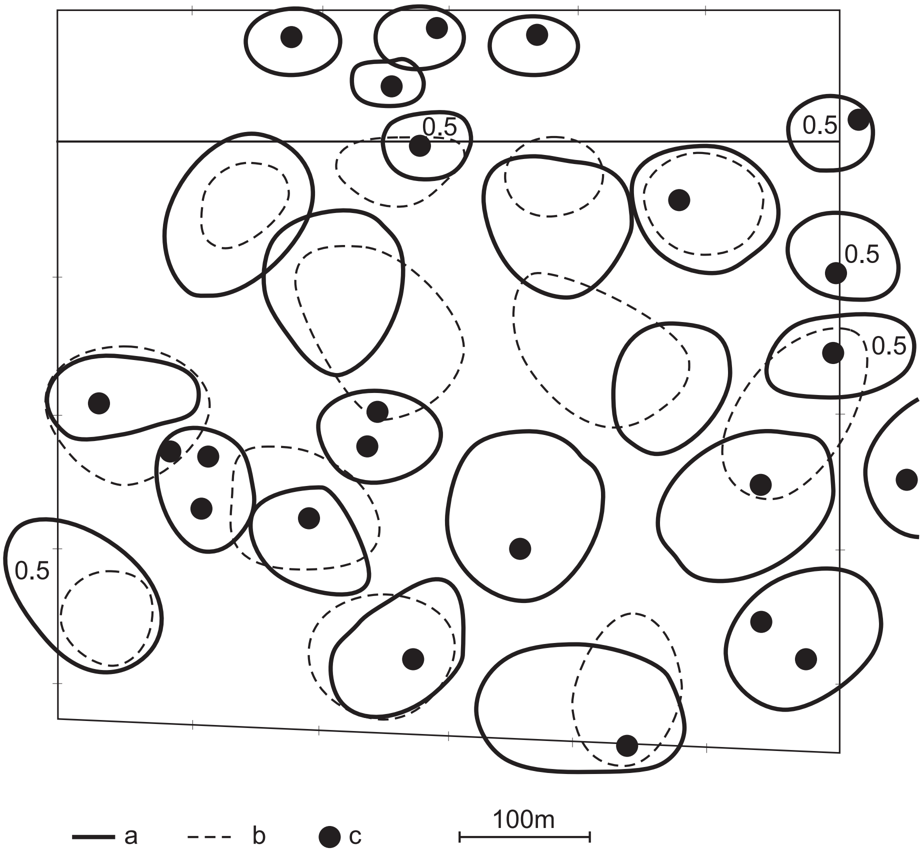

Fig. 1. The mapping "paper territories" (MR = b) shown against the true Hawfinch nesting ranges (T = a) and the known nest (c) distribution within the forest-edge plot W in 1992. The map shows the result of the more experienced analyst.

later converged, chiefly during the low-density years; they are responsible for a span in the ME numbers for some years (Table 1).

A more detailed analysis can be made when both results are superimposed on the same map (as exemplified by Fig. 1). While comparing data I have omitted those nesting ranges about which I was not quite sure, e.g. those at the edge or corner of the plot, if the nest was not found. The following 3 categories have been noticed (n = 200 true nesting ranges compared with the "paper territory" distribution): 1) good agreement between both methods — in 106 ranges (53% of all); 2) mapping underestimates (77 cases or 38 %), like: two true ranges assumed as one "paper territory" 37 (18%) cases, or a true nesting range overlooked in the mapping estimates 29 (14%) cases, or one and a half range (marginal one but with the nest known) assumed in the mapping results as just one "territory" 10 (5%) cases, etc.; 3) mapping overestimates (17 or 8.5%): in eight cases a "paper territory" was drawn in a site with no actual nesting range, and sporadically a true nesting range was assumed to be two "paper territories" (9 cases).

To sum up, in 53% of cases the "paper territories" agreed well with the true localization of the Hawfinch nesting ranges. The remaining part of agreement between two methods comes from a compensatory arithmetic. The most disappointing case (four nesting ranges assumed to one "paper territory") was during the high Hawfinch-density year (1998), when nest aggregations were formed within the plot.

The causes of errors

The following sources of errors in the mapping technique data elaboration have been identified, chiefly in the estimates of the less experienced analyst:

1. Obviously wrong analysts' decisions while drawing clusters, such as an inclusion of too distant records or combining discrete two clusters of records into one "paper territory" in spite of a presence of a pair of contemporary records.

2. Accepting as a single "paper territory" a cluster with too many records, because the clusters with markedly higher than average number of records, chiefly when with some pairs of double-records from the same visit, tend to comprise two pairs.

3. Accepting a wrong assumption that even a single and early in the season agonistic encounter between Hawfinch pairs is an indication of two neighbouring nesting ranges; in fact not seldom surplus pairs attempt in vain to overtake a part of occupied territory.

4. Wrong decision on the presence of a „paper territory"judged from a presence of a family with fledglings; the Hawfinch families may enter the areas of neighbouring pairs on the very first day after fledging, and some may split into two parties (own obs.).

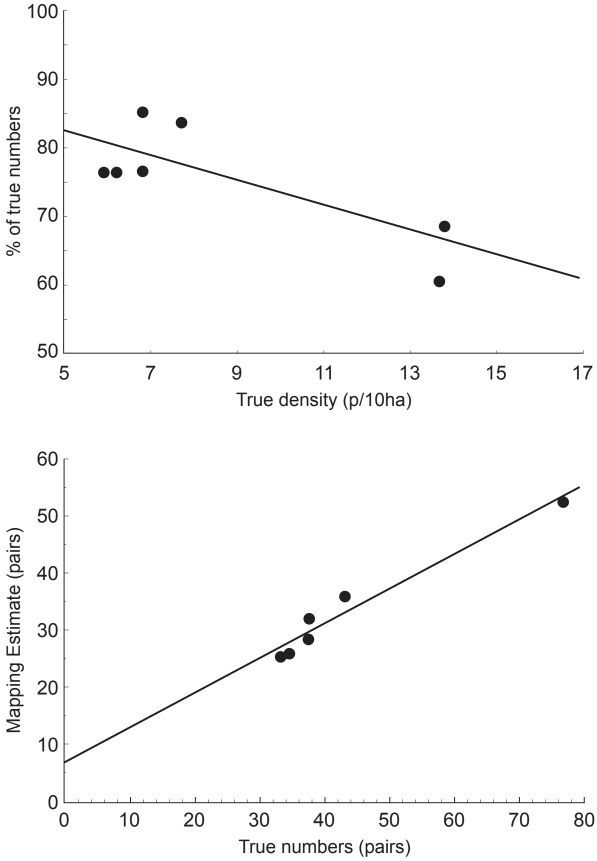

Fig. 2. Relationship between Hawfinch true breeding numbers (T) and the accuracy of the combined territory-mapping technique (%). Lower graph documents a good correlation between the results of both methods.

DISCUSSION

Accuracy of the territory mapping method

For species difficult to study, like the Hawfinch, even the laborious mapping technique offers only approximate estimates. Additionally, their accuracy is density dependent (Fig. 2): at the moderate population density only every fifth settled pair remains overlooked, while during high (Hawfinch) density years — every third one. The result of the test was especially unsatisfactory when a loose cluster of 3–5 closely nesting pairs happened to occur within the census plot boundaries.

The first general question concerning application of the mapping technique data is, to what extent rough mapping results are suitable for the monitoring of yearly changes in the Hawfinch numbers. The answer is approving because there is a significant positive correlation ($r = 0.978$, $n = 6$, $p < 0.05$) between True Numbers and Mapping Estimates. Some dumping of the high-density numbers is by no means strong enough to spoil comparability. Such low-accuracy results, as those for the Hawfinch and Song Thrush, are in fact the relative figures only, suitable for within-species comparisons, but not for between-species ones (Tomiałojć & Lontkowski 1989).

However, in the case of use of Hawfinch mapping data for comparing with other species, chiefly those easy to census, or for calculating the biomass, there is a necessity to improve rough data either while working in the field or later during their elaboration. Post factum, in the laboratory, we can introduce a correction of rough data, as this was suggested for the low-quality results for the Song Thrush *Turdus philomelos* (Tomiałojć & Lontkowski 1989). The rough Hawfinch mapping figures need multiplying on average by 1.25, though for the years and habitats with low or moderate "mapping densities" (2–5 p/10 ha) a proper correction factor would be 1.2 and for the higher-density sites or years 1.35. While suggesting this I am aware of a difficulty, that observers censusing the birds for the first year in a new site may be unable to decide even roughly which, relatively low or high, the Hawfinch density they face is. Such knowledge may become possible either after a series of the census years in a plot or basing on between-plot comparisons.

The results for the Hawfinch and other difficult species under tests support a claim that any farther reduction in the time expenditure would probably yield the figures of below 50% accuracy, thus, being truly the relative indices not the absolute (true density) figures. This conclusion can be also a warning against a significant reduction in the number of visits to the plot or to marked shortening of time for plot penetration, quite usual within the frames of so-called quick mapping versions.

How to count breeding Hawfinches in a high forest

There is no easy way to overcome the difficulties with counting the highly secretive species in a high and unfragmented forest. However, the breeding season of mostly migratory central-European Hawfinches is shorter and better synchronized than in resident western populations (Mountfort 1957, Bijlsma 1979, Hustings et al. 1985) and only few pairs re-nest in June (unpubl. own data). Most pairs return to their breeding sites by mid-April, but during first days after arrival the presence of numerous migrants and non-breeders introduces much of confusion to have reliable census results. In the Białowieża Forest the best period for counting this species is, therefore, between the 20th of April and 10th of May. An absence of full leaf-cover causes birds shy but visible from a distance, which makes some simultaneous records possible. The second half of May, contrarily, is a period of the most secretive their behaviour. At that time most vocal and visual cues lose their importance, the more that most Hawfinch pairs are by that time already deprived of their broods due to heavy predation (ca. 80 % on average, unpubl.data). They become highly mobile again, confusing observer. During the end of May and early June, before fledging of most young, it is necessary to keep in mind that only 10–20% of pairs succeed in avoiding nest predation, thus only a minority may continue feeding their young (Mountfort 1957, Glutz von Blotzheim & Bauer 1997). Pairs feeding their nestlings behave silently but the adults (chiefly males) can be traced in their direct flights with food (as recommended for an open Dutch landscape by Bijlsma 1979 and Hustings et al. 1985). Other recommendations may be split into two groups, as applicable either to the field or to laboratory phase.

In the field, while counting Hawfinches in a high-canopy forest, it is recommended to ignore birds in flight above the canopy, atop of emergent trees, or single males (unmated?) when during the pre-incubation period, as well as the rarely heard song, as it may be emitted far from nesting site. Contrarily, it is useful to try:

a) to check visually whether a Hawfinch heard is a lonely individual or a pair; when seeing a pair the active searching for simultaneous records with other pairs is crucial for the accuracy of estimates;

b) to pay attention to aggregations of peacefully feeding two-four pairs in crowns of maples or oaks in blossom; these are important sites to have the first contact with the silent Hawfinches;

c) to pay special attention to agonistic encounters and to incidences of area defence against nest predators (jays, squirrels, woodpeckers); these are cues suggesting the presence of nest, while a prolonged predator mobbing, contrarily, may be confusing as it attracts the mobbers from a larger area;

d) to record early in May audible acts of courtship feeding, which happen on the nest or close to it;

e) to find possibly many fairly conspicuous Hawfinch nests before leaf development, by checking with binoculars the crowns of deciduous trees and mistletoe *Viscum album* bunches; nests started in April or early in May are easy to spot in leafless crowns, though difficult to distinguish from the previous-year nests until incubation commences.

In the laboratory, while drawing the "paper territories", it is advisable to keep in mind that:

a) with the number of 7–8 valid visits, the mapping technique critical requirement for at least three records of territorial importance to accept a "paper territory" is too rigid in the case of this species; two close to each other records, when of high territorial importance and/or located apart of other clusters, should allow drawing a distinct "paper territory";

b) it is important to rely on simultaenous records of spaced pairs, but not to overestimate the value of single agonistic encounters between them, as these may involve passing transients;

c) chases and fights between Hawfinch males or pairs happen not seldom at the nesting range centre which makes a difference in comparison to typically territorial birds;

d) Hawfinch nesting ranges differ in size more than of other species, yet a cluster two-three times larger than average usually includes 1.5 or 2 actual nesting ranges; if repeated double-records occur within such a "paper territory" it is better to assume two pairs present; e) peaceful feeding of two-three pairs in a crown of a maple or oak does not necessarily mean a semi-colony nearby; such aggregations at attractive food sources are a common event without territorial meaning.

It is concluded that in the mapping technique the number of 10 standard visits to the plot appears still not satisfactory for so difficult species, as the Hawfinch or Song Thrush. Rather 12 visits (10 valid ones) would be an optimum, but often this is too costly. A compromise solution could be twofold: a) to increase field efficiency of a survey by devotion a special attention to counting Hawfinches during the best visits (those during the late April and early May), and b) to improve the mapping technique data by implementation of a rough correction coefficient (multiplying by either 1.20 or 1.35, depending on the Hawfinch density) to have the results comparable with those for the easy-to-count species and more suitable for a recalculation the population numbers into a biomass.

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STRESZCZENIE

[Test na dokładność metody kartograficznej w odniesieniu do populacji grubodziobów gniazdujących w wysokich zagęszczeniach w lesie liściastym (Białowieski Park Narodowy)]

Przez siedem sezonów lęgowych (1991–1994, 1996–1998) w wysokopiennym grądzie sprawdzano dokładność wyników uzyskiwanych dla grubodzioba w trakcie standardowych liczeń wszystkich ptaków lęgowych, wykonywanych zgodnie z zasadami kombinowanej metody kartograficznej. Średnią liczbę "papierowych terytoriów" na kopiach mapki gatunkowej, każdorazowo ocenianych niezależnie przez dwie osoby nie znające rzeczywistego stanu populacji (W. Walankiewicz i T. Wesołowski), traktowano tu jako poddawane testowaniu oceny z metody kartograficznej (ME). Wartości te skonfrontowano z liczbą rewirów lęgowych grubodzioba uzyskaną w wyniku równolegle prowadzonych przez autora wielokrotnie bardziej intensywnych obserwacji, uznaną tu za rzeczywistą liczebność (T). Obserwacje te były oparte na długotrwałym śledzeniu przemieszczeń poszczególnych par lęgowych i wyszukaniu większości gniazd (80–94%, zależnie od sezonu). Bliską kompletności dokładność tej drugiej oceny potwierdzało wykrywanie bardzo niewielkiej części przeoczonych gniazd w kwietniu roku następnego (na bezlistnych drzewach) i to niemal zawsze w obrębie wyznaczonych w poprzednim roku rewirów.

W sezonach o średnim (rzeczywistym) zagęszczeniu populacji metoda kartograficzna powoduje przeoczenie 20% rewirów lęgowych gatunku, ale w latach jego wysokiej liczebności niedoszacowanie sięga 35% (Tab. 1). Dokładność wyniku jest odwrotnie zależna od zagęszczenia populacji gatunku (r = -0.81, n = 7, p < 0.05, Fig. 2). Pomimo znacznego zaniżenia, wyniki metody kartograficznej jednak w prawidłowej proporcji odzwierciedlają fluktuacje rzeczywistej liczebności gatunku. Praca instruuje ponadto jak zwiększyć dokładność wyniku uzyskiwanego w terenie i jak poprawnie zarysowywać "papierowe terytoria"na mapce gatunkowej. W przypadkach, gdy konieczna jest znajomość rzeczywistej liczebności tego gatunku (np. dla obliczania biomasy lub dla porównywania do liczebności łatwo wykrywalnych gatunków) proponuje się albo zwiększenie nakładu pracy terenowej (zwłaszcza uwagi poświęcanej grubodziobom w najlepszym dla ich liczenia okresie: koniec kwietnia do ok. 10 maja), albo korygowanie wyniku z metody kartograficznej *post factum* poprzez przemnażanie go przez wskaźnik korekcyjny 1.2 dla lat niskiej liczebności lub przez 1.35 dla wyraźnie wysokiej liczebności grubodziobów wywnioskowywanej z jakichś danych porównawczych (z innych lat lub z innych powierzchni).

T. Cofta