A C T A T H E R I O L O G I C A

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STUDIES ON THE EUROPEAN HARE XVII.

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Estimation of European Hare Population Density Depending on the Width of the Assessment Belt

[With 6 Figs. & 5 Tables]

The average results of assessment and estimation of variations in density were compared, using assessment belts 50, 100 and 150 m. in width. Timidity and distribution of the hares in space were also examined. Over-estimation of numbers decreases with an increase in the width of the assessment belt. A belt 50 m wide is too narrow to assess numbers correctly, as results are distinctly over-estimated when this width is used. The occurrence of hares in concentrations, and their starting up in whole groups tend to create errors in assessment. The number of hares outside the assessment belt is thus dependent on the latter's width. The density of hare populations affects errors in assessment. Estimates of the timidity of hares show a tendency to decrease with increasing width of the assessment belt.

1. INTRODUCTION

Intensive research on the biology and ecology of the hare, *Lepus europaeus* (Pallas, 1778), has been undertaken in Poland in recent years (Andrzejewski & Pucek, 1965; Andrzejewski & Jezierski, 1966; Jezierski 1965; Matuszewski, 1966; Mazurkiewicz, 1966; Pielowski, 1966). One of the particularly important problems in scientific research on game is the elaboration of methods of assessing the numbers of hares living in a given region (Andrzejewski *et al.*, 1964).

Several methods of making such estimates are given in literature: (1) counting hares on their feeding places (Pielowski, 1966); (2) tracking (Stachrowski, 1930, 1932; Ruskov & Petrov, 1957); (3) line assessment, that is, an assessor counts the hares starting up on the route he is walking along (Szederjei, 1957; Pielowski, 1965); belt assessment, that is, conducting beaters along a belt of definite length and width, embracing all habitat variants and counting the hares within the belt (Ruskov & Petrov, 1957; Jezierski & Pielowski, 1958; Pielowski, 1962; Andrzejewski & Jezierski, 1966); (4) sample drives carried out on areas representation of the district, with several assessors to count the hares (R u s k o v & P e t r o v, 1957; S z e d e r j e i, 1957; P i e l o w s k i, 1966); (5) defining numbers by a straight line of regression of hares caught in squares enclosed by nets (A n d r z e j e w s k i & J e z i e r s k i, 1966).

The above methods give results which cannot be compared and in principle it is only the method used by A n d r z e j e w s k i & J e z i e r s k i (1966) which makes it possible to assess absolute numbers. R u s k o v & P i e t r o v (1957) made an attempt at comparing several methods with each other, but this comparison did not permit of final reference of the density indices obtained by means of these methods to actual density.

At present in Poland the use of belt assessment is recommended as a method of taking stock of the hare population, both for scientific and practical purposes, as it is an easy method making it possible to cover a large area. Different authors, however, hold different opinions as to the recommended width of the assessment belt. If an assessment belt 50 m wide produced the same results as a belt 150 or 100 m wide, or it was possible to determine a regular relation between these results, it would permit of using this more convenient and economical width of belt.

The aim of the present study is to ascertain whether the use of belts of different widths affects the estimate of the numbers of hares, and to determine any possible relations between the estimated density and width of the assessment belt.

2. METHODS AND MATERIAL

Three variants of the method consisting in varying the width of the belt were used in order to compare results obtained by belt assessment: (1) assessment by a 50 m belt — one assessor and four beaters, (2) assessment by a 100 m belt — one assessor and eight beaters, (3) assessment by a 150 m belt — two assessors and eleven beaters.

The beaters moved forward along a belt of the given width, while the assessor kept a record of all the hares starting up, noting the time at which they started up and distance from the line of assessors. Hares starting up outside the belt were recorded separately. Knowing the width and length of the assessment belt calculation was made of the area to which the hares observed in the belt could be referred.

In reports on assessment using a 100 m belt, a separate record was kept of hares starting up from a 50 m wide belt separated from the 100 m belt, and in the case of assessment by the 150 m belt, of hares starting up from the 100 m belt. In this latter case the observations were made by a second assessor.

Assessment by means of 50, 100 and 150 m belts was carried out in the given area at intervals of two or three days in order to obtain comparable results, after which the cycle was repeated in the next area. As far as possible comparable weather conditions were maintained.

In effect examinations were usually carried out every three weeks in a given area. One sample consisted of 30 km of assessment, *i. e.* 10 km each of 50, 100 and 150 m belts, carried out in one area over the course of one week. A total amount of 720 km of assessment were made, *i. e.* 240 km of assessment for each belt respectively, 360 km of which were carried out in the Dziekanów Leśny area, 180 km in the Czosnów area and 120 km in the Racot area. A total number of 1196 hares were observed to start up in the assessment belt, and 480 hares outside the belt.

3. STUDY AREA

3.1. Physiographic Description

The State Farm of Racot in the Kościan district, Poznań province, is situated in the Kościan lowland area. The soils are pseudo-podzolized, with marshy and rotting soils in the depressions. The fields mostly belong to large farms, and are intensively cultivated. Crops are of wheat-beet type.

The experimental shoot of the Dept. of Game Animal Mgmt. of the Institute of Ecology, Polish Academy of Sciences, which forms part of the surroundings of the Kampinos National Park, is situated between the left bank of the Vistula, the edge of the Kampinos Forest, the boundary of Greater Warsaw and the buildings of the village of Czosnów. The soils are pseudo-podzolized and podzolized, with Vistula silts on the terrace subject to flooding. Fields belonging to the Łomna State Farm are on a fairly high level of agrotechnical operations. The privately-

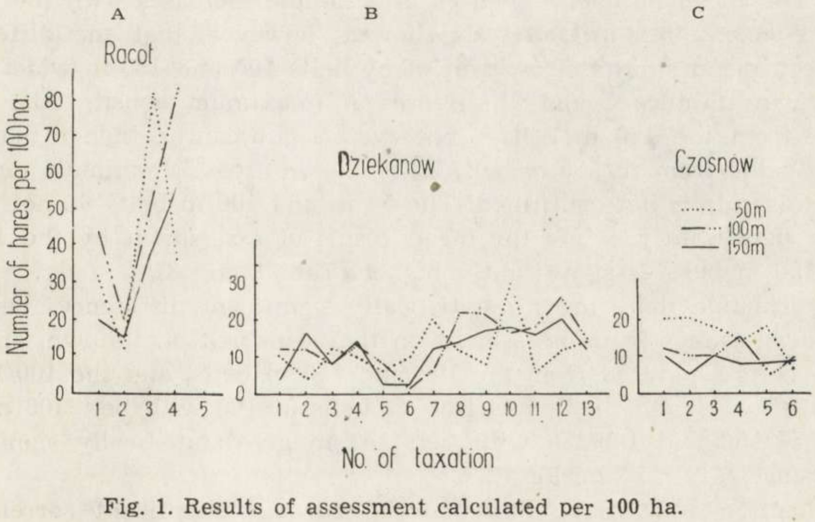

Fig. 1. Results of assessment calculated per 100 ha.

owned farms are moderately intensively cultivated, agrotechnical operations are fairly primitive. Rye-beet type of crops. Two assessment belts were mapped out in two different parts of the area, which will be called Dziekanów Leśny and Czosnów in the further part of this study.

3.2. Density of Hares in the Study Areas

The areas in which assessments were carried out differed as regards relative density of hares (Fig. 1). Racot (A) had the highest numbers, then Dziekanów (B), while Czosnów (C) is the area in which the density of hares is lowest.

4. ANALYSIS OF RESULTS

4.1. Analysis of Mean Results of Assessment

4.1.1. Results of Assessment Not Calculated per 100 ha

The results of assessment made along belts of different width were used to calculate mean values and their errors for the different belts. The significance of differences between mean results of assessment was also established by means of the *t* Student test. Calculation was next made of the indices of linear correlation between the corresponding results of assessment. A diagram of the analyses made is given in Fig. 2.

All these calculations were made for the whole of the material (collective analysis) and for each area separately (Tables 1 and 3).

The result of belt assessment depends on the width of the assessment belt. The mean numbers of hares in a sample increases with the width of the belt. Statistical analysis showed, however, that the difference between mean results of assessment by belts 100 and 150 m wide is not significant (Tables 1 and 3). In area A (maximum density) the mean value from the 150 m belt is not even significantly higher than the mean value from the 50 m belt. It is only in area C (minimum density) that this rule is not confirmed. The 50 m and 100 m belts do not differ there significantly, while the mean result of assessment by the 100 m and 150 m belts is significantly higher (Tab. 1 and 3).

In principle there are no statistically significant differences between the mean values from assessment on the 50 m belt on its own, and the 50 m belts separated from the 100 and 150 m belts, and the 100/150 m belt [1]) (Tab. 1 and 3). Comparison of belts 50/100 with belt 100 m and belts 50/150 and 100/150 with belt 150 m give statistically significant differences (Tab. 1 and 3).

Collective analysis of the material reveals significant correlations between the results of all assessments, with the exception of belts 50/150 and 50 m. If each area is considered separately, the correlation coefficients often have an even lower value than the limit of significance (Tab. 3).

It can be seen from the above that with a large number of samples the correlations between results of assessment are significant and that assessment using the 50 m belt gives a result lower than assessment by the 100 and 150 m belts, with the exception of area C (where density is very low), and assessment by the 150 m belt does not give a higher result (also with the exception of area C).

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[1]) 100/150 m means the 100 m belt separated from the 150 m belt, and analogically 50/100 means the 50 m belt separated from the 100 m belt.

Table 1.

Mean results of assessment and their erros.

Tax. belt (m.)	Racot (n = 4)		Dziekanów (n = 13)		Czosnów (n = 6)		Total	
	$\sum x$	$\bar{x} \pm S_{\bar{x}}$	$\sum x$	$\bar{x} \pm S_{\bar{x}}$	$\sum x$	$\bar{x} \pm S_{\bar{x}}$	$\sum x$	$\bar{x} \pm S_{\bar{x}}$
50	81	20.25 ± 6.410	77	5.92 ± 0.91	48	8 ± 0.333	210	8.75 ± 1.6084
100	195	48.75 ± 10.88	179	13.78 ± 1.8405	62	10.33 ± 1.22	447	18.62 ± 3.4711
150	193	48.25 ± 14.028	235	18.08 ± 2.425	76	12.67 ± 1.0041	539	22.46 ± 3.4616
50/100	119	29.75 ± 9.3566	—	—	—	—	159	12.23 ± 4.3559
50/100	76	19 ± 3.2596	—	—	—	—	119	9.15 ± 2.1326
50/150	45	11.25 ± 4.9418	93	7.15 ± 1.3444	21	3.5 ±0.8079	179	7.45 ± 1.3378
100/150	148	37 ± 7.7621	142	10.92 ± 4.9385	55	9.16 ± 0.8091	360	15 ± 3.2667

Table 2.

Mean results of assessment of density of hares per 100 ha.

Tax. belt (m.)	Racot (n = 4)		Dziekanów (n = 13)		Czosnów (n = 6)		Total	
	$\sum x$	$\bar{x} \pm S_{\bar{x}}$	$\sum x$	$\bar{x} \pm S_{\bar{x}}$	$\sum x$	$\bar{x} \pm S_{\bar{x}}$	$\sum x$	$\bar{x} \pm S_{\bar{x}}$
50	162	40.5 ± 12.8136	154	11.85 ± 1.8114	96	16 ± 2.000	420	17.50 ± 3.1902
100	195	48.75 ± 10.8944	179	13.77 ± 1.8405	62	10.33 ± 1.22	447	18.62 ± 3.4711
150	128.66	32.16 ± 8.1311	156.66	12.05 ± 1.6167	50.63	8.45 ± 0.6528	359.34	14.98 ± 2.3273
50/100	238	59.5 ± 18.7134	—	—	—	—	318	14.46 ± 8.7119
50/100	152	38 ± 6.5191	—	—	—	—	240	18.46 ± 4.2427
50/150	90	22.5 ± 9.8837	186	14.31 ± 2.6801	42	7 ± 1.6159	348	14.5 ± 2.5365
100/150	148	37 ± 7.7621	140	10.77 ± 1.6392	55	9.17 ± 0.6763	360	15 ± 3.2667

Table 3.

Significance of differences and correlation coefficients.

Comparison of belts	Absolute								Relative							
	Racot		Dziekanów		Czosnów		Total		Racot		Dziekanów		Czosnów		Total	
	γ	Δ	γ	Δ	γ	Δ	γ	Δ	γ	Δ	γ	Δ	γ	Δ	γ	Δ
50 : 100	0.2917	+	0.0229	+	0.3997	—	0.5891	+	0.2912	—	0.0226	—	0.1329	+	0.6161	—
100 : 150	0.8178	—	0.7769	—	0.8230	+	0.7909	—	0.9403	+	0.7801	—	0.1069	—	0.9171	+
50 : 150	0.3840	—	0.0687	+	0.7773	+	0.5924	+	0.4427	—	0.2284	—	0.2629	+	0.9812	—
50/100 : 50	0.0148	—	—		—		0.5108	—	0.0148	—	—		—		0.5108	—
50/100 : 50	0.9299	—	—		—		0.8779	—	0.9577	—	—		—		0.8721	—
50/150 : 50	0.0981	—	0.2536	—	0.31	+	0.1125	—	0.0982	—	0.2589	—	0.1031	—	0.1322	—
100/150 : 100	0.8890	—	0.2055	—	0.6823	—	0.7262	—	0.8891	—	0.6042	—	0.7956	—	0.7262	—
50/100 : 100	0.9607	+	—		—		0.9529	+	0.9594	—	—		—		0.9708	—
50/100 : 100	0.9299	+	—		—		0.8886	+	0.5878	—	—		—		0.9073	—
50/150 ; 150	0.8129	+	0.7709	+	0.7313	+	0.8052	+	0.9355	—	0.7697	—	0.7332	—	0.8153	—
100/150 : 150	0.7495	—	0.2811	—	0.5114	+	0.7528	+	0.9746	—	0.8319	—	0.5789	—	0.7653	—

+ significant, — non significant.

4.1.2. Results of Assessment Calculated per 100 ha

In order to obtain density indices defined by means of assessment, which would be comparable with each other, 100 ha was taken as a unit of area and the results of assessment reconsidered after calculation per 100 ha (Tab. 2 and 3).

The mean result of assessment by 100 m belt is higher than the mean result of assessment by 50 and 150 m belts. It is only the area with lowest density which does not confirm this rule, giving a decrease in assessment of density together with an increase in width of belt (Table 2 and 3).

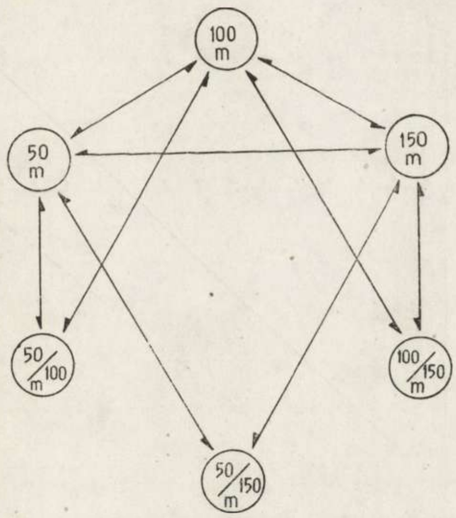

Fig. 2. Diagram of statistical analysises (comparison of mean results of assessments and correlations between different results of assessment).

When analysing the whole of the results, only the difference between mean results of assessment by 100 and 150 m belt is statistically significant. Analysis of mean value for area B does not reveal statistically significant differences (test *t*). Area A (maximum density) confirms the results of analysis of the combined material (Table 2 and 3). Area C does not confirm this, but rather suggests that with low density the mean result of assessment by 50 m belt is statistically significantly higher than that of assessments by belts 100 and 150 m wide (Tab. 2 and 3).

Comparison of mean results of assessment by the 50/100, 50/150 and 100/150 m belts with mean results of assessment by the 50, 100 and 150 m belts (according to the diagram shown in Fig. 2) does not in principle yield any statistically significant differences (Tab. 2 and 3).

For the material as a whole correlations are significant for comparing all the results of assessment with the exception of belts 50/150 and 50 m. Analysis of results from different areas does not reveal correlations between all the belts (Tab. 3).

4.2. Estimating Numbers of Hares in the Dziekanów Area by Means of Assessment Belts of Different Widths

Within the area of the shoot at Dziekanów Leśny results of assessment increase regularly in time. P i e l o w s k i (1966), who carried out assessments from 1959—1964 in the same area, obtained the same regularity.

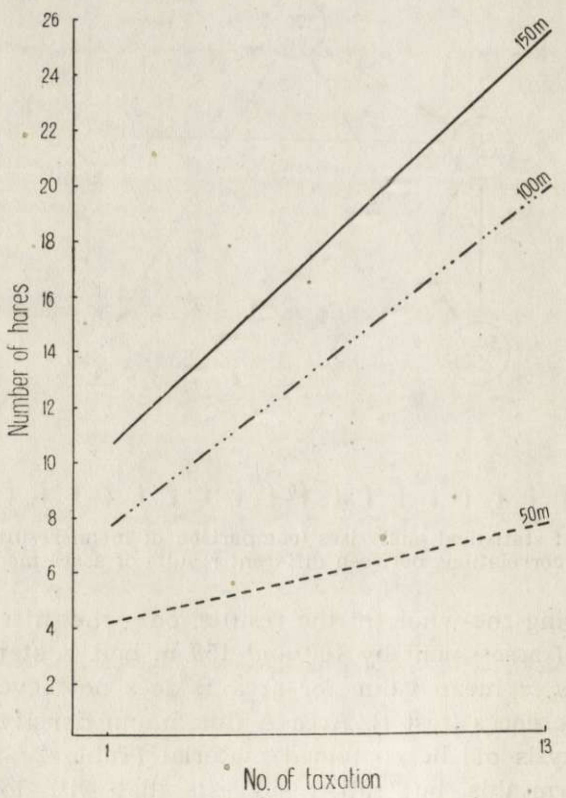

Fig. 3. Regression lines between results of assessment in the Dziekanów area and time.

This fact permits of drawing a straight line of regression between the results of assessment for each width of belt and time; in order to ascertain whether variations in numbers obtained by means of these belts are reciprocally proportionate.

Equations of linear regression for the various belts are as follows:

belt 50 m $y = 0.2975\ x + 3.8655$
belt 100 m $y = 1.0054\ x + 6.7422$
belt 150 m $y = 1.2396\ x + 9.4028$

Right angles for belts 100 and 150 m wide do not differ, but the angle of regression line for the 50 m belt is smaller, which means that the results of assessment by the 50 m belt do not increase with an increase in numbers in proportion to the results of assessment. In other words the smaller the number of hares in a given area, the greater the number of these hares, relatively speaking, shown by the 50 m belt (Fig. 3).

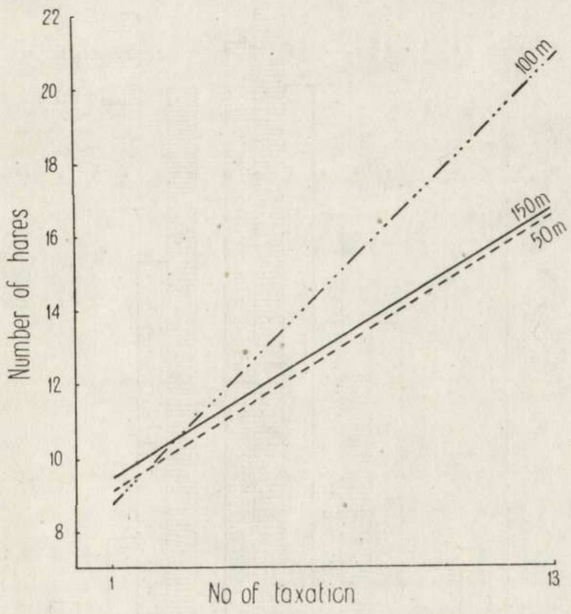

Fig. 4. Regression lines between results of assessment in the Dziekanów area calculated per 100 ha and time.

Regression lines were also drawn between results of assessment calculated per 100 ha and time. The equations are as follows:

belt 50 m $y = 0.6256\ x + 7.4708$
belt 100 m $y = 1.054\ \ x + 6.7422$
belt 150 m $y = 0.6051\ x + 7.8143$

These straight lines (Fig. 4) illustrate the over-estimation of numbers of hares by the 100 m belt in relation to assessment by the 50 and 150 belts, which also agrees with the numerical analysis of assessment results.

4.3. Timidity of Hares

In order to examine the possible effect of the width of the assessment belt on the shyness of hares (the distance at which the hares starts up from the line beaters being taken as a measure of timidity), calculation was made of the distribution of timidity and the mean distance at which hares start up, for each assessment belt (Fig. 5). A total number of 1071 hares were analysed in this respect, 194 from the 50 m belt, 369 from the 100 m belt and 508 from the 150 m belt.

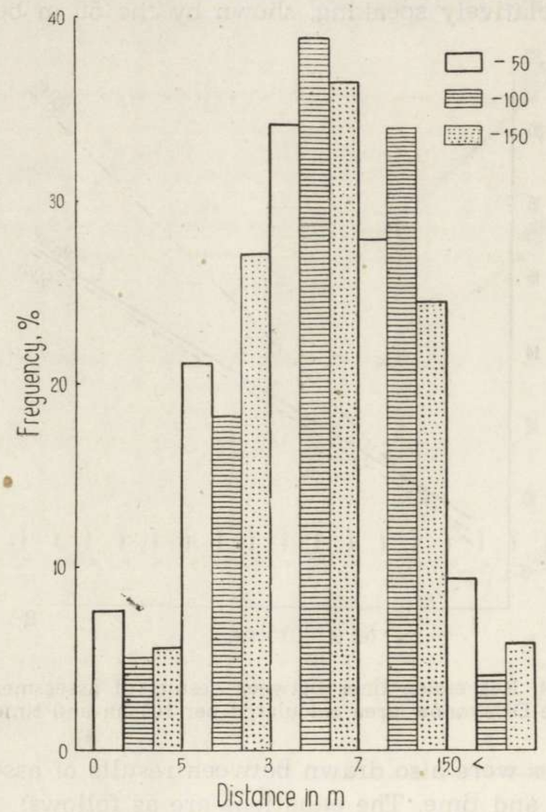

Fig. 5. Distribution of timidity of hares.

The maximum number of started hares comes in the class of 30—70 m, except that in the case of the 50 and 150 m belts the class of 70—150 m contains only slightly lower numbers than the first class. With assessment by 150 m belt there is a slight predominance of the 5—30 m class in relation to the 70—150 m class (Fig. 5).

For the 50 m belt the mean distance of starting up is 75.02 m, for the 100 m belt — 70.47 m and for the 150 m belt — 65.25 m. It will be seen that the mean distance at which the hares are put up decreases with an increase in the width of the belt.

4.4. Spatial Distribution of Hares

In order to discover the possible effect of the way hares form groups on the estimate of numbers by assessment belts of different width, calculation was made of the distribution of the number of hares encountered in samples and the measure of tendency to concentration according to formula $V_k = S^2/\bar{x}$, where V_k — measure of tendency to concentration, S^2 — variance, $\bar{x}$ — mean number of hares encountered in a sample- A 200 m section of the assessment belt was taken as a sample. These calculations were made separately for different belts and different areas (Table 4). The distribution and measure of tendency to concentration were next calculated, taking into consideration all hares starting up within the field of vision, that is, including hares outside the assessment belt (Tab. 4).

Table 4.

Measures of hares' tendency to concentrations.

Locality		Czosnów (n = 210)			Dziekanów (n = 600)			Racot (n = 200)		
Belt width (m.)		50	100	150	50	100	150	50	100	150
On the belt	$\bar{x}$	0.23	0.29	0.37	0.12	0.28	0.37	0.39	0.96	0.87
	V_k	1.196	1.2868	1.6038	1.3733	1.5361	1.8089	2.0077	4.8023	2.9149
Scared away	$\bar{x}$	0.32	0.40	0.47	0.18	0.35	0.43	0.93	1.23	1.21
	V_k	1.5578	1.7212	1.7307	1.4983	1.8267	2.2230	2.6499	9.6731	4.0528

The distribution of the number of hares differs from the corresponding Poisson distribution, exhibiting a tendency to concentrations. It is only in the area with the minimum density that this distribution is non--significantly different from the corresponding Poisson distribution. The measure of tendency to concentration for each area increases with increased width of the belt (Tab. 4). If we include hares starting up outside the assessment belt, the measure of tendency to concentrations calculated for each belt increases accordingly (Tab. 4).

In order to illustrate in another way the effect exerted by tendency to form concentrations on the results of assessment the distribution of distances between hares, or properly speaking the distribution of projections of these distances on a straight line drawn through the middle of the belt, was used. The maximum numbers in class 0—200 m is evidence of the tendency to concentrations in the distribution of hares. Increase in width of the assessment belt causes a distinct increase in numbers in class 0—200 m, that is, an increase in the percentage of the number of hares occuring in concentrations (Fig. 6).

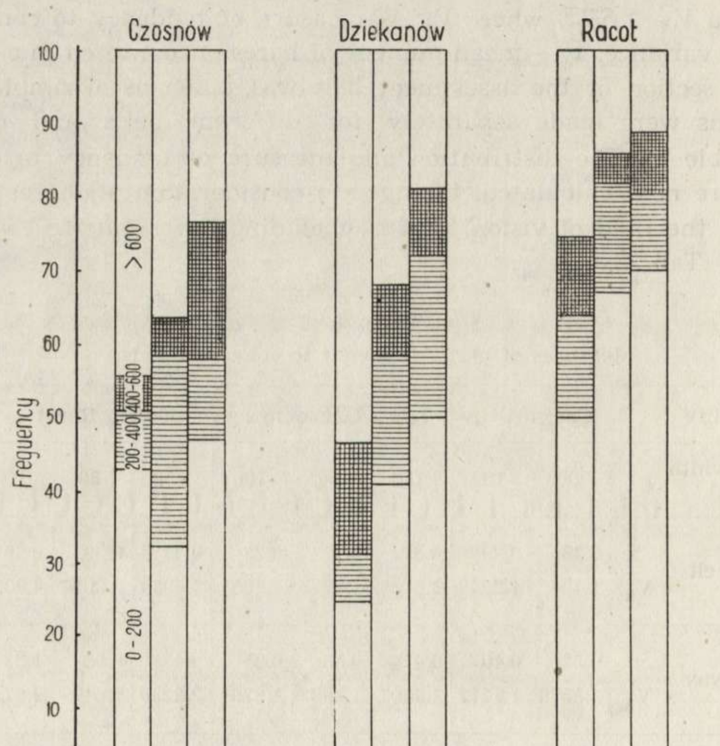

Fig. 6. Distribution of distances between hares.

The distribution of distances between hares and distribution of the number of hares encountered in samples and calculated measures of tendency to concentrations indicate that the hares' tendency to form concentrations increases with an increase in density.

4.5. Number of Hares Outside the Assessment Belt

In order to ascertain the effect of the width of the assessment belt on the number of hares starting up outside the belt, calculation was made of the ratio of the number of these hares to the number of hares, starting up inside the belt. Analysis was made of 1097 in the belt and 401 hares put up outside the belt (Tab. 5).

Analysis of results for all the areas reveals a decrease in the number of hares starting up outside the belt together with an increase in the width of the assessment belt. The decrease in numbers of these hares is not necessarily rectilinear, and its extent and character appears to depend on density (Tab. 5).

Table 5.

Ratio of number of hares encountered outside the assessment belt to number of hares in the belt.

Belt width (m.)	Czosnów	Dziekanów	Racot
50	0.3958	0.452	1.367
100	0.3709	0.2281	0.2865
150	0.2277	0.1818	0.3829

5. DISCUSSION

Increase in the width of an assessment belt usually results in putting up a larger number of hares. Statistical analysis proved that the number of hares put up from a 150 m belt does not significantly differ from the number put up from a 100 m belt (with the exception of the area with minimum density of hares (Tab. 1 and 3).

Assuming that a large number of samples eliminates the error caused by random distribution of hares in the assessment belt of a given sample, the non-significant difference between the mean result of assessment along a 100 m and 150 m belt must be due to an error committed by the assessor. Some of the hares starting up outside the assessment belt may be erroneously counted as hares within the belt, or some of the hares put up from the belt may be overlooked by the assessor. If this second errror played an important part in the case of the 150 m belt, lowering its results in relation to the 100 m belt, analogically assessment on a 100 m belt would also lower the number of hares in relation to a 50 m belt. This is not however observed, and simultaneously another argument against this possibility is the fact that the situation of hares stating up in relation to the boundaries of the belt is determined simultaneously by assessor and the end beaters. As Pielowski (1966) shows, the end beaters are more liable to make this mistake than the assessor, and in consequence the fact of such an eror occurring is less likely.

The difficulty of correctly defining the boundaries of the assessment belt increases as the distance at which the hares start up increases, since in accordance with the principles of perspective the width of this belt, as seen by an assessor gazing forwards, appears to narrow towards the horizon. The assessor most often fails to take this fact into consideration at all in the case of near hares or estimates the width of the belt incorrectly at a considerable distance in front of the line of beaters, judging the boundaries of the assessment belt by the end beaters, and committing an error arising from subjective widening of the belt where, according to the principles of perspective, it does not correspond to the actual width. Beaters also tend to judge the width of the belt by the observation points situated opposite them on the horizon, whereas the real width of the path is far less at that distance.

The error differs depending on the width of the belt. The narrower the belt, the nearer the horizon, defined in this case by the distance at which, in accordance with the principles of perspective, the boundaries of the assessment belt converge. Therefore the relation of supplementary triangles [2]) to the triangle formed in perspective by the assessment belt, is the greater, the narrower the width of the belt. This relation is confirmed by considering a section of the assessment belt about 300 m long, *i. e.* the maximum distance at which, according to assessment records, hares start up. Hares which are in fact outside the assessment belt and are counted as within the belt as the result of optical error, exaggerate the results of assessment and the density of hares calculated from them. Erroneous counting of a uniform number of hares regardless of the width of the belt is possible. The ratio of hares mistakenly counted as being within the belt to hares actually put up within the boundaries of the belt is, however, different. The greatest error is committed with the narrowest width of the belt, as each incorrectly counted hare causes relatively greater over-estimation of assessment than when a wide belt is used.

The extent of the error also depends on the radius of the beaters' putting up the hares. Pielowski (1966) and Jezierski (1968) found that hares occur in concentrations, and this is confirmed by the results presented in section 4.5. of the present study.

The size of the concentrations, in the sense of area occupied, may

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[2]) Area in which hares are incorrectly considered as hares inside the belt.

differ. Increase in measure of tendency to concentration with increase in the width of the assessment belt (Tab. 4) and particularly when harres starting up outside the belt are included, shows that a narrow assessment belt does not cover whole concentrations. Even in the case of a wider belt part of the concentration remains outside the boundaries of the belt.

Putting up hares present in the assessment belt simultaneously puts up hares outside the belt, if they belong to the concentration. This fact increases the possibility of the assessor making an error, particularly in the case of a narrow belt, when relatively the most hares remain outside the belt.

When a narrow assessment belt is used the fact that hares occur in concentrations and that such concentrations start up as a whole causes a large number of hares to be put up outside the belt. When a wide belt is used a smaller percentage of the concentration remains outside the boundaries of the belt, thus reducing the possibility of committing an error.

The timidity of hares may also contribute to errors in assessment. An estimate of the hares' timidity has a tendency to decrease with increase in the width of the belt, or possibly is so defined by the assessor. If more hares do in fact start up when assessing on a 50 m belt at a greater distance, then the possibility of making an error by counting hares as belonging to the belt would be greater, as shown by the fact that optical error occurs at a considerable distance in front of the line of beaters.

It is possible that timidity does not depend on the width of the belt, but that there is only a tendency for the assessor to judge it as greater when the belt is narrow. It is probable that the assessor defines the distance of a started hare by a certain measure of distance such as formed by the width of the assessment belt, *i. e.* the distance from the assessor of the end beater. The assessor would therefore commit greater errors when assessing on a narrow belt.

Analysis of assessment results shows that greater error is committed using 50 and 100 m belts, and the least with 150 m belts. A uniformly great error may occur during assessment by either 50 or 100 m belt, but the width of the 100 m belt is twice greater than the 50 m belt and in the event these differences differ significantly. Additional analysis of an area with very low density of hares would seem to suggest that the lesser the density, the greater the assessment error using a 50 m belt. The straight line of regression drawn for the Dziekanów area exhibits the same tendency. The decrease in numbers causes exaggeration of results by a 50 m belt in relation to 100 and 150 belts.

It should be anticipated that where the mean results of assessment differ significant when calculated per 100 ha there will be no statistically significant differences and conversely, where there were no significant differences between mean values, that these means will now differ significantly. If this does not occur in the case of all the mean results of assessment this means that belts of different widths do not provide proportional results.

Calculation per 100 ha of assessment results from different areas shows that the 100 m belt gives the highest estimate of the numbers of hares, then the 50 m and 150 m belts. Additional analysis of assessment results from area C (minimum density) does not confirm this, but quite the opposite, the increase in width of belt causes a gradual lowering of the index of numbers.

Statistical analysis of the above results proves that the 50 m and 100 m belts give higher results, which is in agreement with the conclusions reached by analysis of assessment results not calculated per 100 ha. For area B these differences, although not statistically significant, also point to over-estimation of numbers by a 100 m belt. Additional analysis of an area with considerable density confirms the conclusions reached on the basis of analysis of the whole of the material. In area C (minimum density) the 50 m belt assesses highest, and the 100 m belt non-significantly higher than the 150 m belt.

The straight line of regression also shows that the 100 m belt assesses highest, which is in agreement with the results of numerical analyses. Referring to the first part of the discussion of results it would seem that these conclusions were correct. The error committed during assessment by means of 50 and 100 m belts exaggerates the results of assessment in relation to the 150 m belt, and probably also in relation to the actual numbers.

Analysis of comparisons of mean results of assessment by the 50/100 m, 50/150 and 100/150 m belts with 50, 100 and 150 m belts according to diagram (Fig. 2) suggests that the presence of additional beaters outside the assessment belt of the second assessor (the beaters forming a certain kind of measure of distance) makes it easier for that assessor correctly to judge the boundaries of the assessment belt and to count the hares. Differences between belts 50, 100 and 150 m are not due to fortuitous distribution of hares over the area of the assessment belts but to the width of the belt only.

With minimum density (when erroneous counting of even a small number of hares seriously over-estimates results) this error would appear greater where the width of the belt is smaller, and in consequence the area smaller to which the additional, erroneously included hares are referred. With larger numbers this error would appear less important. The absolute error of assessment (*i. e.* the number of hares incorrectly counted as in the belt) is not smaller, but its relative value is smaller in relation to the result of assessment, which is in direct proportion to numbers. Widening of the belt therefore reduces the error, the smaller the numbers of hares, the greater the reduction.

The data presented in this study appear to indicate that assessment by belts gives different results, assessing the density of hares differently in a given time depending on the width of the assessment belt used. Over-estimation of numbers is in principle reduced with an increase in width of assessment belt (not necessarily in a straight line). The 50 m belt is too narrow to determine numbers as it distinctly exaggerates the results of assessment, and in consequence the index of density of hares in a given area.

The fact that hares occur in concentrations and that such concentrations start up as a whole, and hence the number of hares outside the belt depends on the latter's width, contributes to incorrect assessment.

Error in assessment, *i. e.* the reciprocal ratio of density indices obtained from assessment by belts of different width, most probably alters depending on the density of hares in a given area.

Analysis of results of assessment also shows that carrying out one assessment does not give the correct numbers of hares, since the variability of results of assessment is very great, regardless of the width of belt used. This is illustrated by the extent of the arror in mean value (Tab. 1 and 2). It would appear that it is only by carrying out assessments several times and by using the widest belt, that it is possible to give an approximate estimate of the numbers of hares in a given area, particularly when the density of the hares is great.

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OCENA ZAGĘSZCZENIA ZAJĘCY W ZALEŻNOŚCI OD SZEROKOŚCI PASA TAKSACYJNEGO

Streszczenie

Szacowano zagęszczenie zajęcy w kilku terenach, stosując pasy taksacyjne o szerokości 50, 100 i 150 m. Tereny badań różniły się zagęszczeniem zajęcy (Ryc. 1). Przeprowadzono analizę średnich wyników taksacji z pasów o różnej szerokości oraz korelacji pomiędzy odpowiednimi wynikami taksacji (Rys. 2). Wyniki taksacji przeanalizowano powtórnie w przeliczeniu na 100 ha. Porównano także oceny zmiany zagęszczenia na pasach o różnej szerokości, rozkład przestrzenny oraz płochliwość zajęcy.

Stwierdzono, że wyniki taksacji wzrastają w miarę zwiększania szerokości pasa taksacyjnego. Jednakże zwiększanie powierzchni objętej taksacją nie powoduje odpowiedniego wzrostu liczby wypłaszanych zajęcy (Tabele 1 i 3). Ocena zagęszcze-

nia zajęcy zależy od stosowanej szerokości pasa taksacyjnego. Zawyżanie oceny liczebności w zasadzie zmniejsza się wraz ze wzrostem szerokości pasa (niekoniecznie prostoliniowo). Pas 50 m jest za wąski dla określania liczebności ponieważ wyraźnie zawyża wskaźnik zagęszczenia zajęcy na danym terenie (Tabele 2 i 3). Zagęszczenie zajęcy wpływa na wielkość błędu taksacji. Spadek zagęszczenia powoduje wzrost tego błędu (Tabele 1—4 i Ryc. 3 i 4).

Różnice wskaźników zagęszczenia otrzymywanych przy pomocy taksacji pasami o różnej szerokości wypływają najprawdopodobniej z błędu optycznego popełnianego przez taksatora. Istnieje tendencja do zaliczania zajęcy do pasa taksacyjnego pomimo, że znajdują się one w rzeczywistości poza jego granicami. Wynika to z faktu, że taksator najczęściej nie zdaje sobie sprawy jak dalece zgodnie z zasadami perspektywy zwęża się pas taksacyjny w dużej odległości przed linią nagonki. Te dodatkowe błędnie zaliczane zające zawyżają wyniki taksacji i obliczane stąd zagęszczenie zajęcy.

Na powstawanie błędu taksacji ma pływ skupiskowe występowanie zajęcy (Tabela 4, Ryc. 6) i podrywanie się skupień jako całości. Szczególnie w wypadku taksacji pasem o małej szerokości, kiedy stosunkowo najwięcej zajęcy pozostaje poza granicami pasa taksacyjnego (Tabela 5) fakt ten zwiększa możliwość popełnienia błędu przez taksatora.

Płochliwość zajęcy (mierzona odległością płoszenia się przed linią nagonki) spada w miarę wzrostu szerokości pasa taksacyjnego (Ryc. 5). Przypuszczalnie nie jest to jednak wynik rzeczywistego spadku płochliwości, lecz subiektywnego błędu oceny taksującego wskazującego także na sposób powstawiania błędu taksacji.

Zmienność wyników taksacji jest bardzo duża jak na to wskazuje wielkość błędów średniej (Tabele 1 i 2).