

## Trap Line and Trap Grid as Methods of Estimation of Population Parameters in the Bank Vole Inhabiting Crabapple Island

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Bujalska G., 1989: Trap line and trap grid as methods of estimation of population parameters in the bank vole inhabiting Crabapple Island. *Acta theriol.*, 34, 23: 325—337, [With 3 Tables & 2 Figs.].

An experiment was carried out on a 4 ha, foot-shaped, Crabapple Island: at the most distant places (270 m) two trap lines were set. After 5 days of trapping (the CMR method was used) the lines were replaced by a grid with traps that uniformly covered the entire island area. The grid was used during 7 days. The trap lines revealed 13 individuals, though there were 87 individuals shown by the grid method. The results obtained with the lines misestimated the population structure: immatures were not caught, though there were 32 of them; the sex ratio among mature individuals revealed by the trap lines was 6 males to 7 females, whereas the sex ratio from the grid method was 21 to 34. It was shown that the lines caught mostly males with particularly extended home ranges (of mean value of the maximum range equal to 104.7 m), and among the females only those staying closely to the trap line (24.3 m, on the average) were recorded by the lines. The results obtained were concordant with the previous estimates of home range size. It was pointed out that trap lines are inappropriate for estimation of population parameters because they may provide results influenced by different space utilization by males and females.

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### 1. INTRODUCTION

The assessment of population numbers, that is one of the basic population parameters, can be often biased by the sampling method applied. Moreover, application of various methods, each being a tradition for a given school (*e.g.* live traps, snap traps, lines of traps, square or rectangular grids, density estimation or estimates of numbers trapped per trap-day, *etc.*) makes comparison of various results difficult or even impossible. At present, when mathematical modelling and other subtle methods become a common practice, reliable methods of estimation of field parameters seem to be particularly wanted if a theory is to be proved (or rejected) by its accordance with the empirical data.

Another principal parameter in population studies is the home range size. The home range size appears to be important for the mode of habitat utilization by the animal as well as for the image of relationships between the population numbers and space utilization by the individual. An example of considerations on such relationships can be a paper by Andrzejewski and Babińska-Werka (1986). Their results and the unexpected interpretation associated with them contributed much to my undertaking this topic. Andrzejewski and Babińska-Werka prebaited the voles with oats in two places 600 m mutually distant, during 3 days. Next, they incorporated these places in a snap-trap line of 1200 m. They concluded the following: (1) All the estimates of home range size based on the CMR method are much lower than the real home range size. According to their method the real figures are 35000 square metres (providing the home range is elliptical with the longer range equal to 300 m) or 70000 square metres (on the assumption of circular shape of the home range) and besides, all voles independently of their sex and breeding condition possess equal home ranges. (2) The above mentioned home range size makes evidence, according to these authors, that population density of bank voles ranges from 4.25 to 8.5 individuals per hectare, i.e., in their opinion, all the previous results were overestimated.

Andrzejewski and Babińska-Werka (1986) therefore claim that my results concerning spatial distribution and territoriality of mature females in the population inhabiting Crabapple Island (Bujalska, 1970) are an artifact to which their estimates are a "challenge".

In particular, I intend in this paper to test experimentally the hypothesis of Andrzejewski and Babińska-Werka (1986) as well as my own one concerning the real size of home range and population numbers in the bank voles of Crabapple Island.

## 2. AREA, METHODS AND MATERIAL

Crabapple Island, located in Beldany Lake in North-Eastern Poland, is especially suitable for testing various methods of population estimation, as the entire island area is being trapped, and hence neither the so-called "edge effect" nor the vole migration affect the estimates. Moreover, it has been shown that within a few days each weaned individual is caught at least once, and population density estimated with the "common census method" is in accord with the estimates by Jolly's (1965) method (Bujalska, 1985).

Crabapple Island is covered by a mixed deciduous forest, constituting a typical habitat for the bank vole (Pucek, 1983), and all the forest associations distinguished there by Traczyk (1971) are visited by all categories of trappable voles (Bujalska & Mieszkowska, 1984). The predominant association is *Tilio-Carpinetum* Traczyk,

1962, which together with *Salici-Franguletum* Malc., 1929 covers 93% of the total area of the island.

Between May 29 and June 9, 1988, an experiment was conducted on Crabapple Island aiming at (1) comparison of trapping results obtained with live traps arranged in two lines with those obtained with a grid covering the entire island area, and (2) assessment of the mode of space utilization by the individuals belonging to the distinguished categories. Two phases of the experiment can be distinguished. In the first of them two trap lines (named A and B) each 50

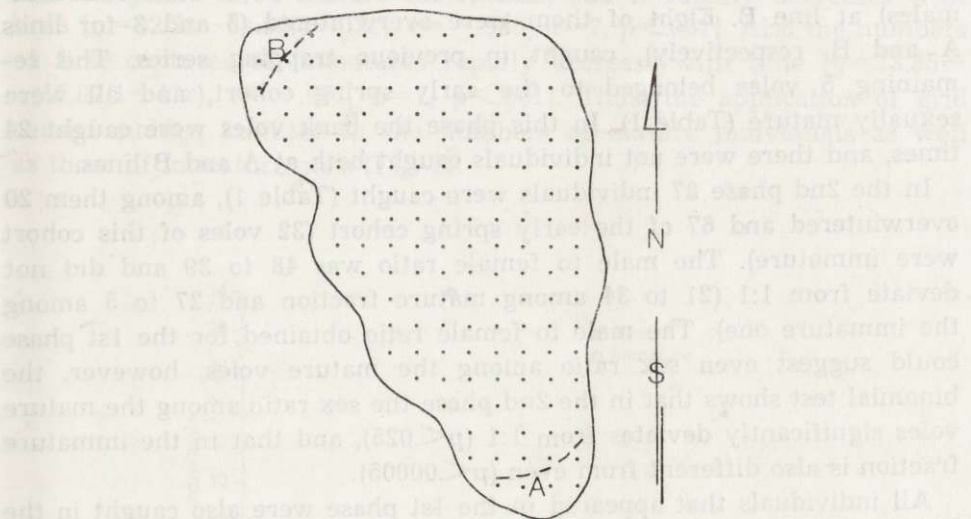


Fig. 1. Distribution of traps during two phases of the experiment conducted on Crabapple Island. Dashed lines denote trap lines A and B. Dots denote positions of trap sites in the grid.

meters long with live traps 1 meter mutually distant were set at the most distant borders of the foot-shaped area of the island (Fig. 1). Line A went through *Tilio-Carpinetum* and line B through *Tilio-Carpinetum* (41 traps) and *Salici-Franguletum* (9 traps). These lines were separated by about 270 meter distance, and between them there were not any trapping devices. It was expected that the population numbers should not exceed 100 voles, and hence the number of live traps would suffice to house most of them at the same trapping occasion. Traps with bait (oats) were made available for rodents in the evening, and since then a 5 day trapping series started. The traps were inspected at 8:00 and 20:00 hours, and the animals caught went through the routine procedure (Bujalska, 1970, 1985) after which they were immediately released at their place of capture. On the 5th day the trap arrangement was changed: they were placed in 159 trap sites mutually distant 15 meters, with 3 traps in each of them (Fig. 1), and the second phase of the experiment ran according to the standard procedures (Bujalska, 1985). It started on June 3, and lasted for 7 days.

It was assumed that during this experiment significant changes in the population

numbers could not occur, neither there were significant changes in the mode of space utilization by the voles. In the latter case it means that the estimates from the grid method are valid for the period in which the lines of traps were in operation.

### 3. RESULTS

In the 1st phase there were 13 bank voles caught (6 males and 7 females): 7 at line A (4 males and 3 females) and 6 (2 males and 4 females) at line B. Eight of them were overwintered (5 and 3 for lines A and B, respectively), caught in previous trapping series. The remaining 5 voles belonged to the early spring cohort, and all were sexually mature (Table 1). In this phase the bank voles were caught 24 times, and there were not individuals caught both at A and B lines.

In the 2nd phase 87 individuals were caught (Table 1), among them 20 overwintered and 67 of the early spring cohort (32 voles of this cohort were immature). The male to female ratio was 48 to 39 and did not deviate from 1:1 (21 to 34 among mature fraction and 27 to 5 among the immature one). The male to female ratio obtained for the 1st phase could suggest even sex ratio among the mature voles, however, the binomial test shows that in the 2nd phase the sex ratio among the mature voles significantly deviates from 1:1 ( $p < .025$ ), and that in the immature fraction is also different from even ( $p < .00005$ ).

All individuals that appeared in the 1st phase were also caught in the 2nd one (they were caught in the 2nd phase 77 times). Trapping success, in terms of numbers of individuals caught per 100 trap inspections, was exactly the same for the 1st and the 2nd phase:  $13/10 = 1.3$  and  $87/66.78 = 1.3$ , respectively. This direct proportionality between the numbers caught and the trapping effort contradicts differences in population size between the 1st and the 2nd phase (as a result of possible recruitment of new voles).

Table 1  
Numbers of individuals caught in the 1st (lines) and the 2nd (grid) phase of the experiment.

Category of individuals	Lines A and B jointly	Grid
Males: mature	6	21
immature	0	27
Females: mature	7	34
immature	0	5
Sum of all	13	87

The following provides a clear indication that the difference in the numbers caught in the 1st and 2nd phases is associated with the method of sampling. The numbers of first captures in consecutive days of the 1st phase do not seem to decrease with advancement of time (correlation coefficient is insignificant) and the mean number of first captures per day equals 2.6, with 95% confidence limits ranging from 0.51 to 4.69 (Fig. 2). The number of caught for the first time in the first day of the 2nd phase is 34 mature individuals, and it rapidly decreases with time [ $y=32.38-38.92(1-1/x)$ ,  $r=-.986$ ,  $n=7$ ,  $p<.001$ ]. Also the numbers of first captures of immatures rapidly decrease with time [ $y=13.35-15.07(1-1/x)$ ,  $r=-.971$ ,  $n=7$ ,  $p<.001$ ]. Thus, the application of grid caused sudden increase in the numbers of mature individuals as well as those of immature ones (Fig. 2).

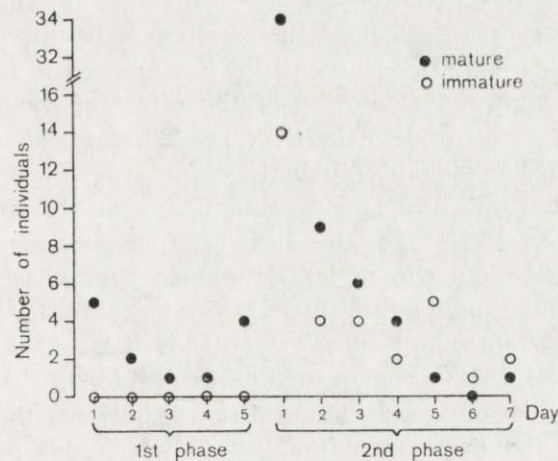


Fig. 2. Time distribution of the first captures in each phase of the experiment.

The change in the arrangement and number of traps due to the shift from line to grid method resulted also in an increase of frequency of captures of the 13 mature voles present in the 1st phase of the experiment. During 5 days of the 1st phase each of them was trapped less frequently than in first 5 days of the 2nd phase: mean=1.85 and 95% confidence limits from 1.26 to 2.44 for the 1st phase, and mean 4.31 and 95% confidence limits from 2.83 to 5.79 for the 2nd phase. These differences seem to be due primarily to the fact that in the line arrangement of traps less of them would occur within the home range of a vole than in the case of grid arrangement. This confirms the opinion

of Bergstedt (1966) that visits to various sections of home range are not equally frequent.

The number of individuals estimated in the 1st phase is equal to 14.9% of that estimated in the 2nd phase, *i.e.*, the line results provided much lower population estimates than the grid results. Of particular interest is, however, misassessment of the population structure due to the line trapping: only 5 individuals of the early spring cohort (*i.e.*, only 7.5%) were caught, and no one of them was sexually immature. Thus, both density and structure of population estimates seem to be heavily biased when trap lines are applied.

An attempt to assess what features of space utilization favour the probability of "being caught" in the trap lines was made. Individual behaviour in space was expressed with indices of home range size, and the home range location relative to the lines was taken into regard. The home range size index is the so-called "maximum range" revealed in the 1st three captures of the individual. The constant "1st three captures" allows one to remove the effect of the number of captures on the maximum range estimate, and concurrently it has allowed to include almost all the individuals into consideration of the effect of the range on the probability of being captured in the line. The estimates of the maximum range can be applied to single individuals.

It can be shown that the males caught in the 1st phase of the experiment, *i.e.*, in the traps arranged in lines, possess significantly larger home ranges than the males present in that phase though unrevealed by the line method (Table 2). Contrary to that among the females caught and uncaught in the 1st phase there is no statistically significant difference in the home range index (Table 2).

Next, the assessment of the minimum distance between the home range of the individual and the trap in the line in which this individual was

Table 2

Components of the mode of space utilisation by the bank voles caught and uncaught at trap lines. In parentheses the number of voles used to estimate the mean value of a variable is given.

Mean	Sex	Caught	Uncaught	U test
Maximum range (metres)	Males	104.7 (6)	44.5 (25)	$p < 0.01$
	Females	20.3 (6)	27.2 (18)	$p > 0.1$
Distance from line (meters)	Males	62.3 (6)	63.1 (25)	$p > 0.4$
	Females	24.3 (7)	90.0 (20)	$p < 0.001$

caught was made. The minimum distance was calculated (in meters) between the trap in the line and the closest trap site visited by the individual in the 2nd phase of the experiment, *i.e.*, when the grid was in use. The 1st three captures of the individual were taken into account. It can be seen that the males caught and uncaught in the 1st phase did not differ as far as their distance from the lines is concerned (Table 2). Contrary to that the females caught in the 1st phase were less distant from the trap lines than those uncaught in this phase (Table 2).

The above makes evidence how the differences in the mode of space utilization by males (differences in size of home ranges between mature and immature males) and females (close proximity to the line at lower variation in home range size) may affect the results of such estimates like population size or sex ratio.

Let us consider quantitative relations between the home range size and the number of individuals caught in the 1st phase. We assume, what emerges from the cited paper by Andrzejewski and Babińska-Werka (1986), that the individual possessing a home range with a trap within it should be caught at least one time within a period of 5 days. We take into account the following 3 variants of calculations, that differ in the assumed home range size.

(1) Let us accept the figures given by Andrzejewski and Babińska-Werka (1986), namely that the home range area equals 35000 square metres and is elliptical with longer range equal to 300 m. Hence, all the individuals present in the 1st phase (*i.e.*, presumably all present in the 2nd one) should be caught and moreover, each of them should be trapped both in line A and B. The results of the 1st phase, however, contradict this expectation: only 13 voles were caught and no one appeared both in line A and B.

(2) Let us assume that the longer range equals 135 m — the figure slightly higher than the mean for 6 voles radio-tracked in winter by Karlsson and Ås (1987) — and the home ranges are ellipses placed parallel to the longer side of the island. The latter is in accord with the results of Mazurkiewicz (1971). Thus, one might expect that each vole would be captured in line A or line B. This does not agree, however, with the empirical results of the 1st phase.

(3) Let us accept, after Bujalska and Grüm (1989), that home ranges of mature males are elliptical, their mean size is 1753 square metres and the longer range is 67 m. The home ranges of mature females, immature males and immature females are circular and their size and diameter are equal to 897 sq. m and 33.8 m, 832 sq. m and 32.5 m, and 737 sq. m and 30.6 m, respectively.

According to Mazurkiewicz (1983), bank voles are distributed at random when the ratio of immatures to matures does not exceed 3.0. The individuals whose home ranges are comprised within a belt of the width equal to that of the line should be caught in it (Andrzejewski & Babińska-Werka, 1986). Hence, one can expect proportionality between the belt area and the number of individuals present within it. The expected numbers of caught are given in Table 3. It can be shown that the difference between the set of the expected and that of the empirical numbers of caught in the 1st phase is insignificant (one-tailed Mann-Whitney U test yields  $p = .243$ ).

Table 3

The expected and the real numbers of individuals caught in the 1st phase of the experiment (see text for explanation).

Category of individuals	Expected number	Observed number
Mature males	8.32	6
Mature females	6.84	7
Immature males	5.26	0
Immature females	0.94	0

Therefore, the latter home range sizes, estimated by the method of Wierzbowska (1972) from the data obtained with the help of grid sampling, seem to explain satisfactorily the presence of only part of the individuals inhabiting the island as well as almost even sex ratio among the voles caught in the 1st phase.

#### 4. DISCUSSION

Two lines each 50 metres long used in the 1st phase resulted in 6 males and 7 females captured. Even sex ratio might suggest that the space utilization by males and females does not differ, and hence their chances to be caught in the linearly arranged traps are similar. However, a more detailed insight into the spacing behaviour evidences that mature males and females differ in this respect. The lines were visited mostly by mature males of particularly high value of the maximum range (that is those moving over rather extended home range area) as compared with the maximum ranges of the remaining, uncaught mature males. In the case of mature females both caught and uncaught individuals had similar mean value of the maximum range, and the decisive factor for visiting



by them these trap lines was the distance of the individual home range from the trap line. In this context the even sex ratio results from high degree of overlap of home ranges in mature males (Bujalska & Grüm, 1989), and from uniform distribution of much smaller and less overlapping home ranges in mature females (Bujalska, 1970, 1973). The sex ratio among the mature individuals revealed by the grid arrangement of 159 trap sites was 21 males to 34 females. The numerical prevalence of mature females over mature males combined with larger mean value of maximum range in the mature males than that in mature females satisfactorily explains even sex ratio estimated by the trap line method. It should be pointed out that there were 27 immature males (revealed by the grid method) of which no one was caught at the trap lines. These males possess home ranges smaller than even those of the mature females (Bujalska & Grüm, 1989). From the above the conclusion can be drawn that individual home range extent, indicated by the estimates of the maximum range, differ among the mature and immature voles as well as between the sexes, and such differences may affect the estimates of population numbers (and also sex ratio) dependently on the method of sampling employed.

In the opinion of Andrzejewski and Babińska-Werka (1986) grids of traps are unsuitable for estimation of home range size in rodents, because these animals are stopped from long distance movements by attractive (bait) traps. These authors estimated the maximum range in the bank voles (mean for each sex and regardless of sexual maturity) as equal to 300 meters, and the home range size as equal to 3.5 or 7 hectares dependently on the elliptic or circular home range model. If this hypothesis were true, then all the voles present in the studied island population should be caught in the 1st phase of the present experiment, as the distance between the lines of traps did not exceed 300 meters. Besides, the voles not stopped by traps in between the lines should be caught in both trap lines. Moreover, when one accepts the "traditional" home range size in the bank voles then the differences between the numbers caught (concerning both entire population and the distinguished elements of its structure) in the lines and the grid can be explained. This is an indirect evidence of the home range size much smaller than that proposed by Andrzejewski and Babińska-Werka. Thus, there is the reason to confirm the previous estimates of home range size (see Bujalska & Grüm, 1989) made for bank voles of Crabapple Island.

Overestimation of home range size in the bank vole by Andrzejewski and Babińska-Werka (1986) is also clear in the light of visual estimates of movements of these animals marked the way allowing to distinguish

them from a long distance (Mironov, 1979). Mironov's estimates in the summer period for males are 527 to 3260 sq. meters and for females the appropriate figures are from 50 to 1323 sq. meters. According to Grüm (1988) home ranges of more than 1 hectare are improbable, because the animal would be unable to get to its border each day, especially in the case of females caring for their young (for which it is essential to be fed and warmed frequently).

Of similar range are the estimates of home range size delivered by Bergstedt (1966), who applied a method of magnetmarking. He was able to trace freely moving voles, and the sizes of home ranges obtained by him are over 2000 sq. m for males, and over 600 sq. m for females. The mean values of the maximal range calculated by myself from Karlsson and Ås (1987), who traced a few males and females with a telenetric equipment, are equal to 125 m, what is closer to the home range sizes usually obtained for the bank vole, than to 300 m of the longer range in Andrzejewski and Babińska-Werka (1986).

Comparison of the effect of various arrangements of trapping devices was the aim of many studies (*e.g.*, Smith *et al.*, 1971, 1975, Flowerdew, 1976 and others). Nowadays, when predictions from models of population strategies provide precisely population numbers and/or structures, adequately precise estimates obtained from natural populations are badly needed as means of theory testing. Of particular importance seems to be estimation of spatial aspects of population organization, like home range size, spacing behaviour, pattern of spatial distribution of individuals *etc.* Such elements may appear to show a certain degree of variation related to seasonal changes, geographical factors or local conditions. Hence, it seems to be too risky to assume that they can be treated as constants to be universally applied.

In spite of that Andrzejewski and Babińska-Werka (1986) insist that, except of their estimate, all other estimates of home range size are invalid, and they use the value of 300 meters long maximum range to assess population density of the bank vole. Namely, they speculate that their trap lines attract these voles from the distance of 300 meters from both sides of the line, and as a consequence all the voles caught at the line during 5 days represent all those present in the area equal to line length times 600 meters. The figures they obtain, *i.e.*, 4.25 to 8.5 per hectare seem to be — in the light of the present results — an example of serious underestimation of population density of the bank vole.

A similar approach to the problem of estimation of population density was presented by Novikov (1949), who assumed that captures of this rodent species in a trap line revealed all animals that were present not

further than 50 meters on both sides of the line. If the approach by Novikov is applied to the trap lines in the 1st phase of the present experiment, then the appropriate estimate of the population numbers is slightly over 100 individuals in the island population of the bank vole (each line can attract voles from the distance of 50 meters only, as the lines were set at the island border).

It seems evident that the approach adopted by Novikov (1949) will only incidentally produce realistic estimates, as they represent calculations based on a constant value, which in fact is a variable ecological parameter.

**Acknowledgement.** I wish to express my gratitude to Dorota Mieszkowska, M. Sc., for her help in conducting the experiment.

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Received 12 December 1988, Accepted 4 March 1989.

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LINIE I SIEĆ PUŁAPEK JAKO METODY OCENY PARAMETRÓW  
POPULACYJNYCH NORNICY RUDEJ ZASIEDLAJĄCEJ WYSPĘ  
DZIKIEJ JABŁONI

Streszczenie

Na 4-ha wyspie Dzikiej Jabłoni przeprowadzono w dniach od 29 maja do 9 czerwca 1988 r. metodą CMR eksperyment, którego celem było porównanie ocen liczebności i niektórych elementów struktury populacji nornicy rudej, *Clethrionomys glareolus* (Schreber, 1780) uzyskanych za pomocą dwóch różnych metod polowu.

W pierwszej fazie eksperymentu, na dwóch najbardziej od siebie oddalonych brzegach wyspy (o 270 m) ustawiono po jednej linii pułapek, tj. po 50 pułapek w 1-metrowych odstępach, (Ryc. 1). Pułapki eksponowane były przez 5 dni. W drugiej fazie eksperymentu linie zastąpiono siecią pułapek rozstawionych w odstępach 15×15 m na całej powierzchni wyspy i eksponowanych w ciągu kolejnych 7 dni.

Porównano wyniki otrzymane przy pomocy obu metod. W pierwszej fazie eksperymentu złowiono 13 osobników, choć jak wykazują wyniki drugiej fazy liczebność populacji wynosiła 87 osobników. Ani jeden osobnik nie złowił się w pułapki obu linii. Osobniki złowione przy pomocy linii pułapek nie odzwierciedlały struktury populacji określonej przy użyciu sieci pułapek. Nie zarejestrowano np. osobników niedojrzałych płciowo, choć było ich 32. Także stosunek liczbowy samców do samic wśród dojrzałych osobników, oceniony w pierwszej fazie eksperymentu na 6:7, był *de facto* jak 21:34 (Tab. 1). Tak więc użycie linii pułapek może po-

wodować poważne niedocenywanie liczebności populacji i deformację oceny jej struktury.

Zbadano, które spośród obecnych w populacji osobników złowiły się w pułapki ustawione w linii. Spośród samców były to te, które posiadały szczególnie duże areale osobnicze (o maksymalnej długości arealu średnio równej 104,7 m), a spośród samic te, które przebywały w pobliżu linii pułapek (w odległości średnio wynoszącej 24,3 m) (Tab. 2). Wyjaśnia to mechanizmy leżące u podstaw "wybiórczego" odłowu osobników w linii pułapek.

Opierając się na dotychczas przyjętych ocenach wielkości i kształtu arealów osobniczych oraz ich rozmieszczeniu wyliczono ile osobników winno się złowić w linii (Tabela 3). Porównano ich oczekiwaną i rzeczywistą liczbę; brak różnic między obu ciągami liczb wskazuje na poprawność dotychczasowych ocen wielkości arealów osobniczych.

Podważono pogląd o znacznym niedocenywaniu wielkości arealów osobniczych i przecenianiu gęstości populacji przy użyciu połowów w sieć pułapek.