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Original Article

Study Concerning the Evolution of Large Game Species within Ecosystems Managed by CASHF from the County of Cluj, Romania

COVRIG Ilie[1], Ioan MESEŞAN[2], Ioan OROIAN*[1], Antonia ODAGIU[1], Petru BURDUHOS[1]

[1]*University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Mănăştur St., no. 3-5, 400372 Cluj - Napoca, Romania*
[2]*County Association of Sportive Hunters and Fishers from the County of Cluj, Romani, 21 Decembrie 1989 Bd., no. 23 – 25, 400105 Cluj – Napoca, Romania*

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Abstract

Sportive hunting is an activity, which benefits of an increasing interest, worldwide. In this context, important regulations are implemented in the field at international level. The present study focuses the evolution of four most abundant game species taken care by the County Association of the Sportive Hunters and Fishers (CASHF) - County of Cluj, Romania, during a two years period. In the mean time, we aimed to emphasize the relationships among the occurrence of the studied game species (roebuck, wild boar, hare and deer). Basic statistics, one-way ANOVA and PCA analysis were implemented for statistical data processing, using STATISTICA v. 6.0 software. Three of four monitored specie, recorded positive very significant differences compared to optimum value (46.23 heads in roebuck, and 24.33 heads in boar, respectively), while deer stocks were also superior compared to optimum value (by 5.79 heads) but difference is statistically not significant. Hare is the single monitored game specie with lower average stocks compared to optimum (by 13.34 heads), statistically not assured at significance threshold of 5%. PCA analysis shows that roebuck stocks are the most important game specie, followed by wild boar, hare, and deer. This hierarchy may be explained by the adaptability of the roebuck and wild boar species to the specific ecosystem conditions, and also to appropriate game management practices. The correlation matrix emphasize the relationships among the monitored game species, good tolerance between hare and deer species, and surviving competition among wild boar and hare.

Keywords: monitoring, roebuck, wild boar, hare, deer, basic statistics, one-way ANOVA, PCA analysis

1. Introduction

The issue concerning hunting is a permanent controversy source worldwide. Some consider that hunting, even practiced for leisure, is a useful tool for environmental management because it contributes, to diminish unwanted species (e.g. pests, animals, etc.) mostly within supervision of authorities [6].

On the other hand, lots of ecologists militate for diminishing sportive hunting activities, by arguments as preservation of ecosystems' integrity, and the "right to live" of all Earth creatures [7]. This context, In this respect we consider that the most valuable approach could be the permanent and real communication between actors – public, ecologists, and hunters. In our opinion, this dialog could bring important contribution to environmental balance by both eliminating the unwanted increase of the number of game species, and mitigation of the attacks against biodiversity.

* Corresponding author.
Tel.: +40 264 596384; Fax: +40 264 592 793
e-mail: neluoroian@yahoo.com

Even fewer people hunt ourdays compared to previous decades, for easy understanding reasons, the public acceptance of sportive hunting practice increases (e.g. in USA, a survey performed in 2006 emphasized a 5% increase in hunting support in a 20 years period, 1995 - 2006, respectively, from 73% 1995 up to 78% in 2006 [7]).

Anyway, the national authorities must be worldwide preoccupied by managing in an appropriate manner the hunting practices, putting them on sustainable and legal basis [8, 10, 11]. In this respect, we note that one of the most important practices in supplying sustainability of game resources is to practice a responsible hunting according to specific designs specifying the exact number of scarified game, in a manner that allow the population to replace itself in an appropriate rate [9, 10].

In the particular case of Romania, sportive hunting is an activity, which benefits of an increasing interest. The management of the game resources is regulated by the Law no. 407/2006 of Hunting and Game Found Protection, and Law of Environmental Protection modified by the stipulations of the Ordinance of Urgency no. 58/2012 concerning the modification of some normative documents in the field of environmental and forest protection [2, 3, 4]. At regional level the county associations of sportive hunters and fishers are the official organisms that manage the game found.

Our study focuses the evolution of four most abundant game species taken care by the County Association of the Sportive Hunters and Fishers from the County of Cluj, Romania, during a two years period. In the mean time, we aimed to emphasize the relationships among the occurrence of the studied game species.

2.Material and Method

The trial was conducted within hunting area divided in 24 hunting founds, managed by the County Association of the Sportive Hunters and Fishers (CASHF) from the County of Cluj, Romania, during two consecutive years, 2012 and 2013, respectively. The evolution of the stocks of the game species with higher frequency and effectives was monitored. They were represented by: roebuck, wild boar, hare and deer, spread within managed hunting founds, in different proportions. Thus, roebuck and wild boar stocks were identified in all 24 locations (fig. 1a and b), while hare stocks occur in 22 locations (fig. 1c), and deer stocks only in 7 locations (fig. 1d). The monitoring activity consisted in daily observations in the field and weekly recordings. Basic statistics was performed for emphasizing the average stocks, and compare their evolution with optimum established.

The significance of differences between recorded stocks and optimum number by specie was calculated using One-way ANOVA test. Principal Component Analysis (PCA) was implemented for the identification of the relationships among the occurrences of the studied game species.

The uncorrelated components, game species, respectively, are extracted by performing the linear transformation of the raw data. In this way, we can find majority of variations from the initial dataset in the most important principal component (PC). The PC emphasize the hierarchy of the components based on their importance and are extracted in an order that reflects this importance. In this case, we used the correlation matrix within the PCA analysis because our variables (game stocks) have different variances (tables 1 and 2). In order to emphasize the variation of each principal component we used the eigenvalues, and eigenvectors. The eigenvalues can be mathematically expressed using the representation of a correlation matrix:

$$\sum_{j=1}^{p} \lambda_j a_j a_j = \begin{vmatrix} 1 & r12 & r13 \\ r21 & 1 & r23 \\ r32 & r31 & 1 \end{vmatrix}$$

The eigenvalues vary according to PC position in hierarchy (larger for the most important principal component and smaller for the less important principal component). Always the sum of eigenvalues is equal to the number of the analyzed components, and the amount corresponding to each component reported to the sum of eigenvalues represents its share. The importance of eigenvalues in PC analysis consists in its limitative role in retaining the first PC components.

The eigenvalues greater than one account for greater variance compared to original variable in standardized data, and illustrates the greater importance of the concerned components. The eigenvectors allow the calculation of the uncorrelated principal components. So, each principal component is given by the formula

$$PC_1 = \sum_{1}^{p} a_{1j} X_j$$

where:

PC – principal component

a_{1j} – linear coefficient (eigenvector)

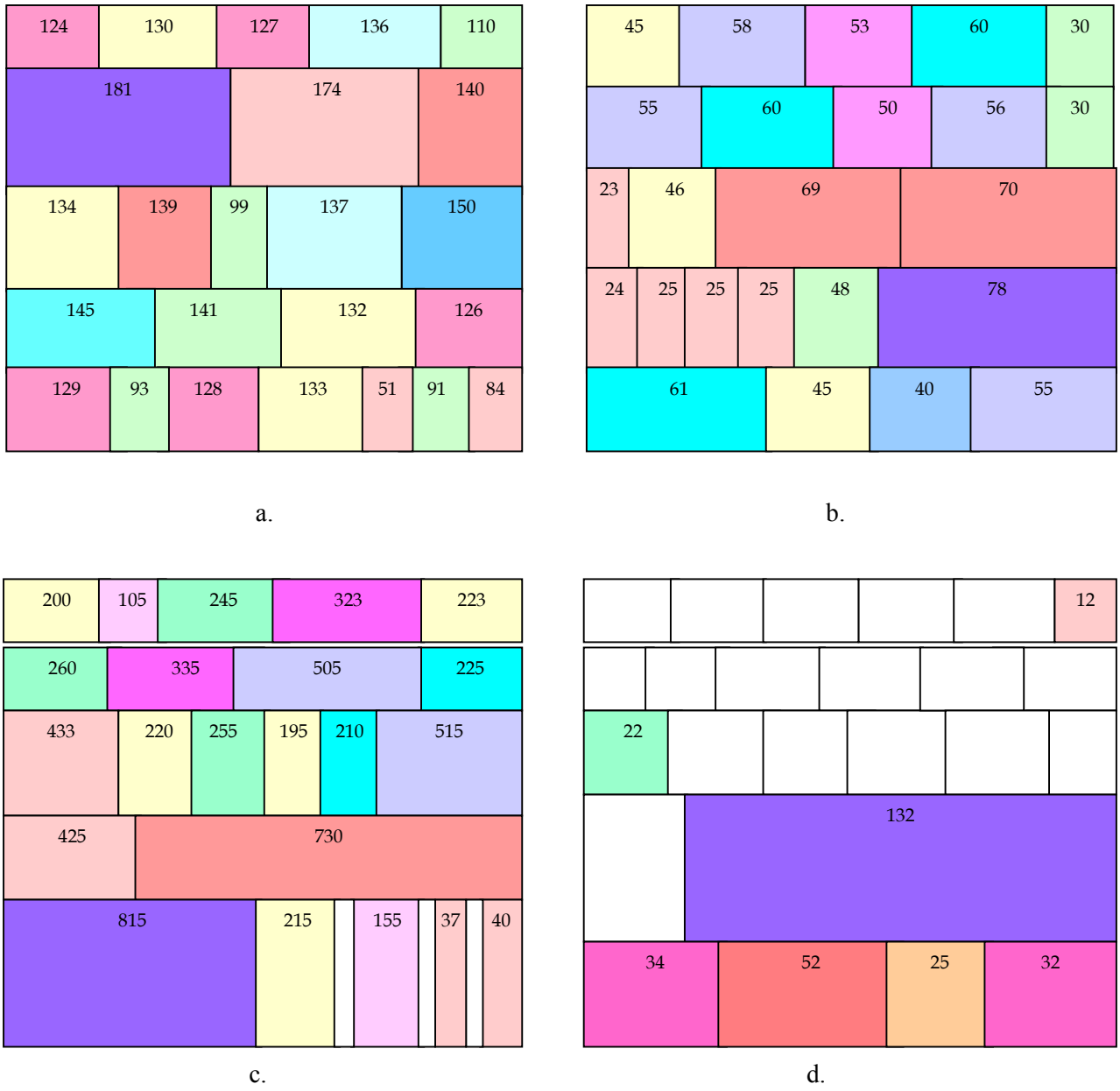

Figure 1. The occurrence of game stocks in hunting founds locations. a. Spreading of roebuck stocks. b. Spreading of wild boar stocks. a. Spreading of hare stocks. a. Spreading of deer stocks.

PCA analysis is very useful when linearity of studied variables is demonstrated. STATISTICA v. 6.0 software was used for raw data processing.

3.Results and Discussions

The evolution of the game stocks within monitored hunting area, demonstrates the presence of roebuck and wild boar stocks in all locations, while hare stocks are present in 22 locations, and deer stocks only in 7 locations (table 1).

The most important average effective (table 1) was recorded in hare stocks (304.88 heads) even occurrence was not reported in all locations of the monitored area. It was followed by average roebuck stocks (126.19 heads), average wild boar stocks (46.96 heads) and deer stocks (44.07 stocks). High variance values recorded in hare and deer stocks occurrence may be determined by the sensitivity of this species that could be affected by a wider spectrum of variance sources, compared with roebuck and wild boar species, which are recognized as resistant to environmental pressures (table 1). The high value of the variances in almost all cases, may be explained by large differences, among monitored locations,

concerning geographical and climatic conditions affecting the targeted species. Another important factor to consider may be frequency of sportive hunting practices that could differ from a location to another. The values of Skewness and Kurtosis show the distribution of data close to normal (table 1).

Table 1. Basic statistics concerning the main game stocks from hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Specie Statistical parameter	Roebuck	Wild boar	Hare	Deer
n	48	48	44	14
Mean, $\overline{X}_S$	126.19	46.96	304.88	44.07
Standard error of average $s_{\overline{X}}$	4.05	2.37	30.31	10.61
Standard deviation s_d	28.06	16.39	198.75	39.71
Variance	787.52	268.59	39501.77	1576.69
Minimum	48	20	25	12
Maximum	190	85	830	136
Skewness	0.58	0.02	1.12	1.77
Kurtosis	1.22	0.84	0.92	2.31

If compare the recorded monitored game stocks with the optimum number established by the management of the hunting area according to present legislation [3, 4], except hare stocks, the real effective is higher compared to optimum number (table 2). In this case, too, the very high value of the variances, in all cases, may be explained by large differences, among monitored locations, concerning geographical and climatic conditions affecting the targeted species. For roebuck, wild boar and deer stocks, this state of art is due to the managerial policy of the game fund (e.g. supplying food in critical periods, responsible culling and hunting practices), but also to deficient hunting abilities as shooting imprecision. The lower number of hare stocks compared to optimal established number may be the result of deficiencies in activity of releasing hare hunting authorizations not enough adapted to zonal conditions that do not support such amplitude.

Concerning the roebuck stocks occurrence, higher values were recorded in 2013 compared to 2012, in 9 of the total of 24 locations (6, 10, 12, 13, 15, 16, 17, 21, and 22), but in overall, in all monitored areas during both experimental years, they are higher compared to optimum value (fig. 2). Positive very significant difference, of 46.23 heads ($p < 0.001$) was reported between recorded stocks and optimum value, in advantage of existing stocks (table 3).

Table 2. Basic statistics concerning the optimum number of main game stocks from hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Specie Statistical parameter	Roebuck	Wild boar	Hare	Deer
Mean, $\overline{X}$	48 79.96	48 22.63	44 318.22	14 38.29
Standard error of average $s_{\overline{X}}$	7.23	3.01	43.15	15.21
Standard deviation s_d	35.41	14.73	183.09	40.24
Variance	1253.52	216.85	33520.42	1619.24
Minimum	14	2	180	12
Maximum	140	58	800	126
Skewness	0.18	0.31	1.72	2.25
Kurtosis	1.02	0.11	2.24	5.33

The evolution of wild boar stocks occurrence, demonstrate the existence of higher stocks in 2013 compared to 2012, in more than a half of locations, 14 of the total of 24 (2, 3, 4, 5, 7, 9, 12, 13, 14, 19, 20, 21, 22 and 24), but in overall, similar with evolution recorded for roebuck stocks, in all monitored areas during both experimental years, they are higher compared to optimum value (fig. 3). Positive very significant difference, of 24.33 heads ($p < 0.001$) was reported between recorded stocks and optimum value, in advantage of existing stocks (table 3).

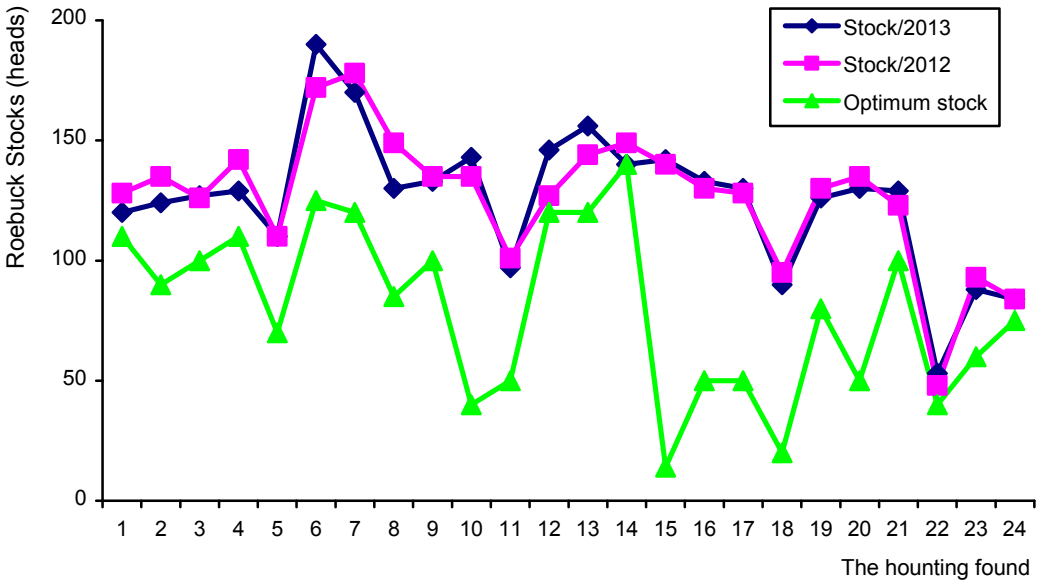

Figure 2. The evolution of the roebuck stocks compared to optimum stock in 2012 and 2013 within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

The hare stocks occurrence is, in almost all locations, higher compared to optimum values during the entire experimental two years (2012 and 2013) period (fig. 4). The optimum values specification lacks in some locations (2, 5, 20, 21, 22, 23, and 24) where even hare stocks occurrence was reported, they are not nominated (fig. 4). In 2013 only in 5 locations (14, 17, 18, 23, and 24) the stocks were superior to those recorded in 2012.

Negative not significant difference, of – 13.34 heads ($p > 0.05$) was reported between recorded stocks and optimum value, in advantage of optimum nominated hare stocks (table 3).

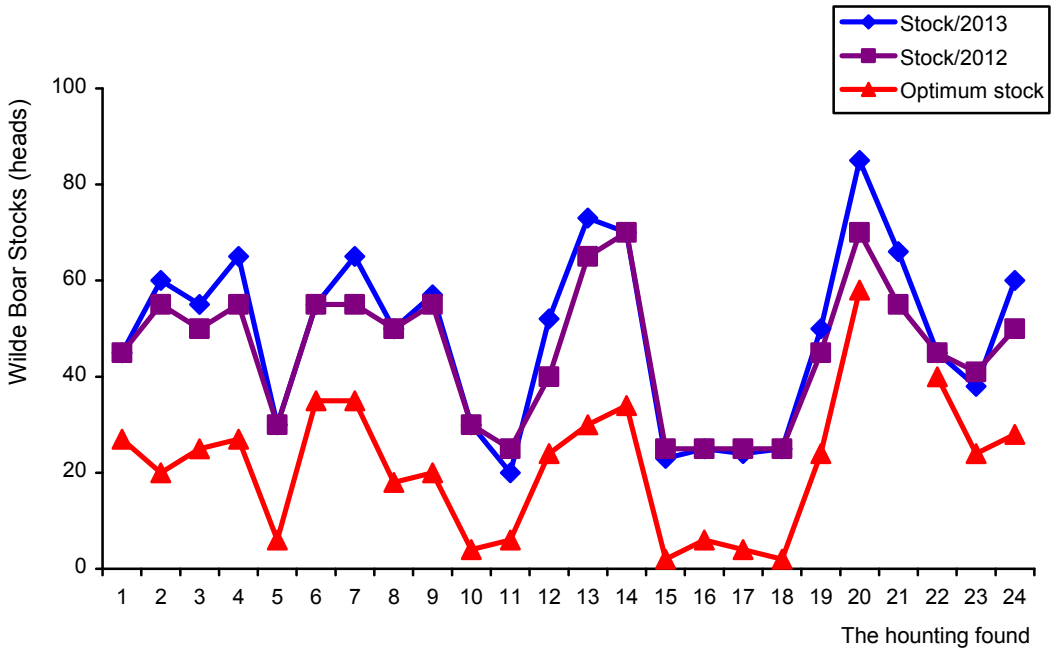

Figure 3. The evolution of the wild boar stocks compared to optimum stock in 2012 and 2013 within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

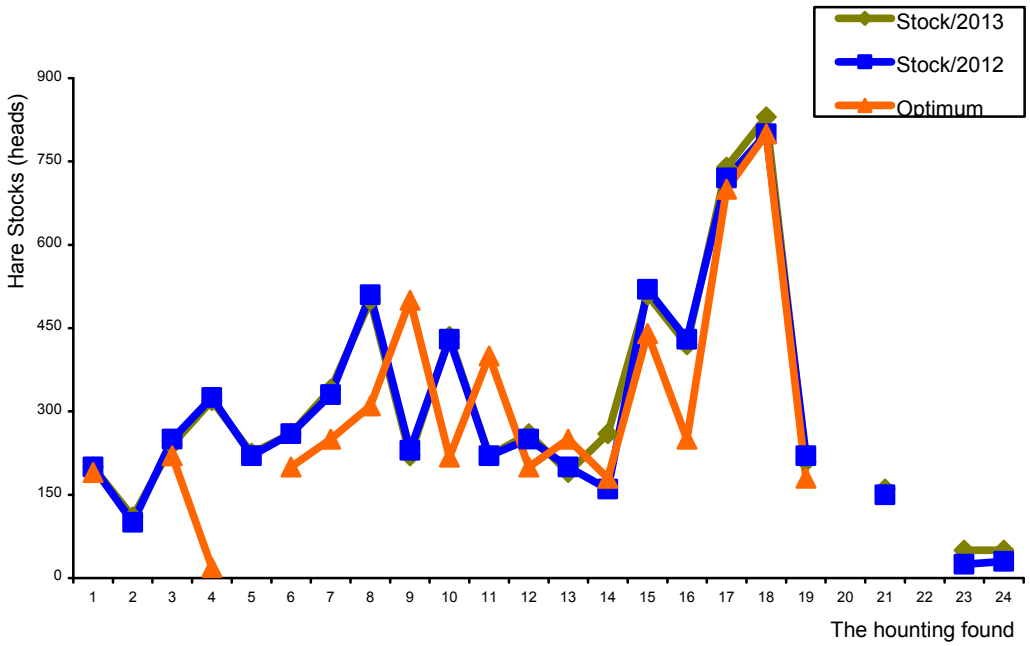

Figure 4. The evolution of the hare stocks compared to optimum stock in 2012 and 2013 within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Fewer locations (7), compared to the other analyzed mammalian game species (24 for roebuck and wild boar, or 22 for hare), were specific for deer hunting. The deer stocks occurrence in 2013 is, in 2 locations of 7, higher compared to 2012 (fig. 5). The optimum values are lower, in majority of locations (except 20 and 23) compared to recorded stocks (fig. 5). Positive not significant difference, of 5.79 heads ($p > 0.05$) was reported between recorded stocks and optimum value in advantage of recorded deer stocks (table 3).

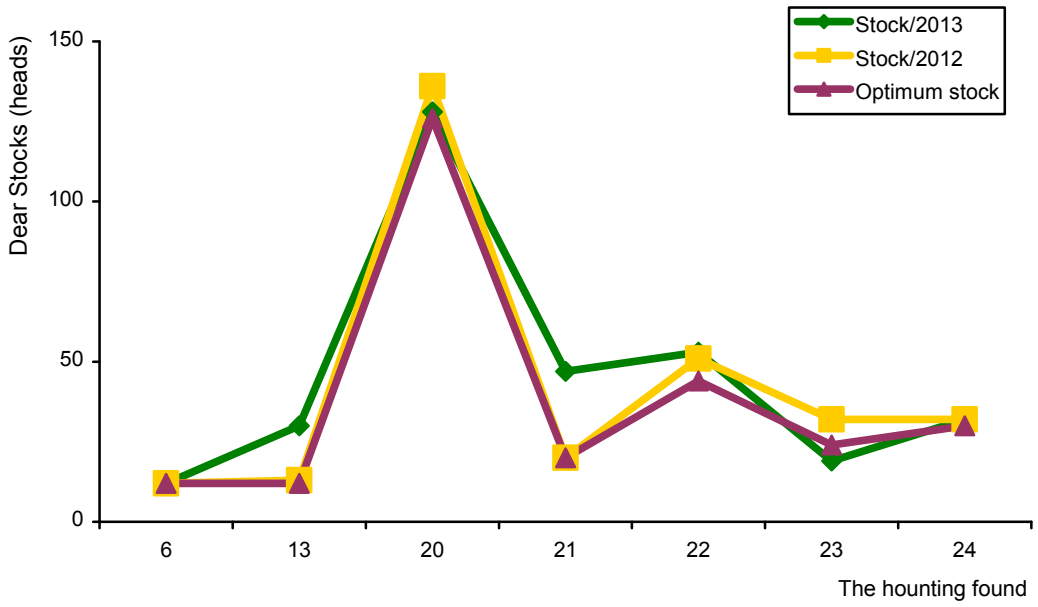

Figure 5. The evolution of the deer stocks compared to optimum stock in 2012 and 2013 within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Table 3. The significance of differences between the main game stocks and their optimum number within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Specie Statistical parameter	Roebuck	Wild boar	Hare	Deer
Difference $\overline{X}_S$ - $\overline{X}_O$	46.23***	24.33***	-13.34^{ns}	5.79^{ns}
DF	70	70	56	19
t	6.02	6.13	- 0.24	0.3134
p	0.0001	0.0001	0.8077	0.7573

^{ns} - p > 0.05; *** - p < 0.001

As showing in fig. 6, the occurrence of the monitored game species is not linearly related. Even though, according to literature PCA analysis could be performed, taking into account that in real situations the linearity is seldom recorded [5]. According to eigenvalues, which are greater than 1 (table 4) for two game species, wild boar, and roebuck, respectively, the PCA plot includes only two axes (fig. 5).

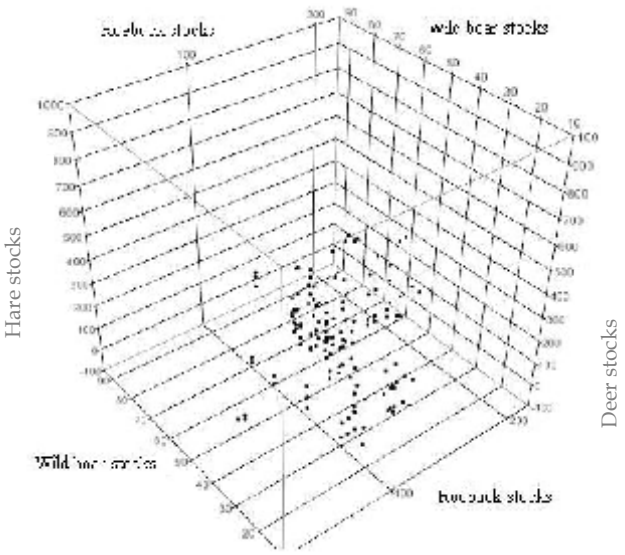

Figure 6. The dependence between the monitored game specie stocks by entire monitored period, years 2012 and 2013, within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Table 4. The eigenvalues correspondent to PCA analysis

Issue	The eigenvalues
Roebuck	2.1272
Wild boar	1.0774
Hare	0.6030
Deer	0.1924

In order to identify the contribution of each analyzed game species to the axis, we analyze the eigenvectors values (table 5).

The axis 1 is highly positively related with occurrence of wild boar and deer stocks (26.94% occurrence of roebuck stocks, vs. 4.81% occurrence of deer stocks), and weekly positively with roebuck and deer stocks, while axis 2 is highly positively related to roebuck and hare stocks occurrence (53.18% occurrence of roebuck stocks, vs. 15.08% occurrence of hare stocks), weekly positively related with wild boar stocks occurrence and negatively weekly related with deer stocks occurrence (tables 4 and 5).

Analyzing the PCA plot (fig. 7) we note that wild boar spreading is opposite with deer spreading. This is confirmed by the eigenvalues associated with them (table 4) ranked in an order demonstrating that the most important component of the analysis is the roebuck, even the average stocks is not in such amount as hare (table 1), and the less important is deer.

So, it is legitimate the question what makes the roebuck the most important specie form a location shared with other three game species, as hare, which is superior in stocks (table 1).

Table 5. The eigenvectors values correspondent to PCA analysis

Stocks	PCA 1	PCA 2	PCA 3	PCA 4
Roebuck	- 0.2797	0.8611	0.0025	- 0.4246
Wild boar	- 0.5565	0.0284	0.7112	0.4287
Hare	0.5478	0.5063	0.0071	0.6659
Deer	0.5584	- 0.0369	0.7031	- 0.4387

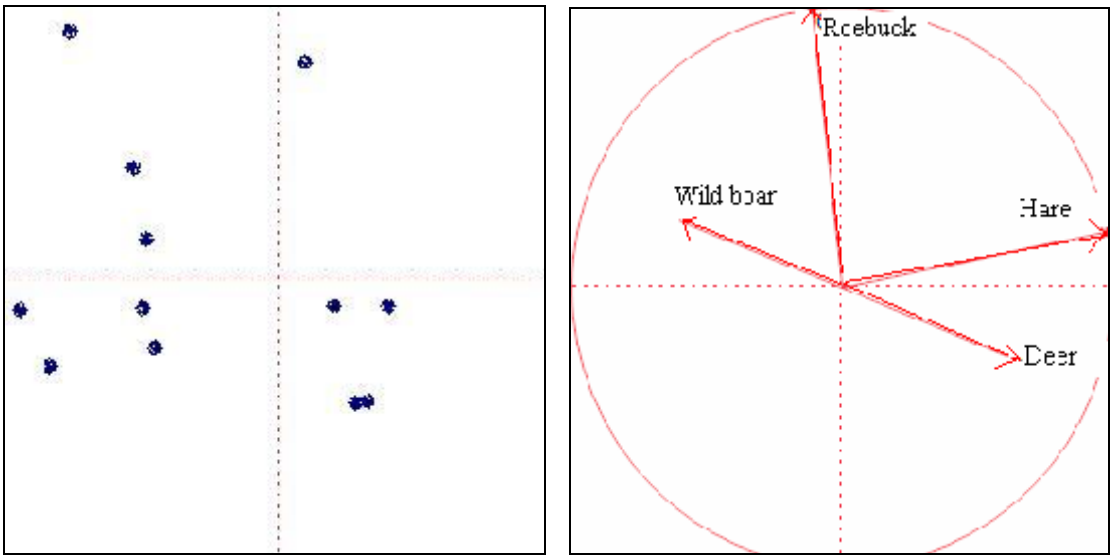

Figure 7. The Bi-Plot display of PCA analysis conducted for game species stocks by entire monitored period, years 2012 and 2013, within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

The answer is connected to roebuck specific traits that allow specie a high capacity of environmental adaptation and good mobility.

The correlation matrix between the occurrences of the main game stocks within monitored hunting area emphasize a positive average correlation (r = 0.5774) among less important game species, from occurrence point of view, hare stocks and deer stocks, respectively (table 6). In the mean time, the principal components, according to PCA analysis conducted in this study, roebuck and wild boar occurrences, according to he value of the coefficient of correlation, r = 0.3437, are positive weekly correlated (table 6).

These results demonstrate the lack of a noticeable interaction between occurrences of monitored large mammal game species (r = 0.3237) roebuck and wild boar, respectively, while the average to strong negative correlation between wild boar and hare emphasizes the competition between these species concerning food supplies, and also the vulnerability of hare cubs against wild boar attacks.

Table 6. The correlation matrix between the occurrences of the main game stocks within hunting area managed by the Association of the Sportive Hunters and Fishers from the County of Cluj, Romania

Issue	Roebuck	Wild boar	Hare	Deer
Roebuck	1.0000	0.3237	0.0893	0.3297
Wild boar		1.0000	- 0.5751	- 0.3970
Hare			1.0000	0.5774
Deer				1.0000

4.Conclusions

The evolution of the game stocks within studied area demonstrates a good managerial practice.

For three of four monitored specie, the effective was higher compared to optimum. Positive very significant differences (46.23 heads, and 24.33 heads, respectively) were recorded among roebuck and wild boar effectives compared to optimum value, while deer stocks were also superior compared to optimum value, (by 5.79 heads) but difference is statistically not significant.

Hare is the single monitored game specie with lower average stocks compared to optimum (by 13.34 heads), statistically not assured at significance threshold of 5%.

PCA analysis shows that roebuck stocks are the most important game specie, followed by wild boar, hare, and deer. This hierarchy may be explained by the adaptability of the roebuck and wild boar species to the specific ecosystem conditions, and also to appropriate game management practices.

The correlation matrix emphasize the relationships among the monitored game species,

good tolerance between hare and deer species, and surviving competition among wild boar and hare.

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