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## COMPARISON OF CA, P AND MG CONCENTRATION CHANGES IN THE SERUM OF FALLOW DEER (*DAMA DAMA*) HINDS AND STAGS DURING THE PERIOD OF ANTLER GROWTH IN STAGS

## PORÓWNANIE ZMIAN STĘŻENIA CA, P I MG W SUROWICY SAMIC I SAMCÓW DANIELA EUROPEJSKIEGO (*DAMA DAMA*) W OKRESIE WZROSTU POROŻA U SAMCÓW

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**Strzeszczenie.** Określono dynamikę zmian stężeń Ca, P i Mg w surowicy samic i samców daniela europejskiego w okresie wzrostu poroża u samców oraz rozważono zasadność wprowadzenia w badanym okresie programu suplementacji mineralnej w zależności od płci zwierząt. Badania wykonano na dojrzałych samicach (n = 8) i samcach (n = 8) daniela europejskiego. Określono stężenie Ca, P i Mg w próbkach surowicy pobieranej w odstępach miesięcznych w okresie od kwietnia do września. U samic dynamika zmian stężenia badanych minerałów nie wykazywała znacznych zmian, charakteryzując się systematycznym wzrostem stężenia przez cały czas doświadczenia. U samców zaobserwowano podobny profil stężenia w większości badań, z wyjątkiem wyraźnego spadku stężenia Ca, P i Mg we wrześniu. Wyniki sugerują, że pokarm pastwiskowy pobierany wiosną i latem wystarcza, by zapewnić możliwość stałego uzupełniania zapotrzebowania na wapń, fosfor i magnez. Ze względu na wykazaną różnicę w dynamice zmian stężenia badanych minerałów w końcowym okresie badań zasadne jest rozważenie zwiększenia intensywności suplementacji mineralnej u samców.

**Słowa kluczowe:** daniel europejski, hodowla fermowa, minerały, poroże.  
**Key words:** antler, fallow deer, farming, minerals.

### INTRODUCTION

The financial benefits coming from the possibility to obtain high-quality venison, leather and antlers contribute to the rising interest in cervid farming in Poland and in the EU and make the cervid farming an interesting alternative for cattle breeding (Borys et al. 2012). This branch of animal production is still developing, which explains the current lack of complex farming programs, based on the scientific experience. This justifies the studies on the biology of cervids. To ensure the profitability of cervid farming, the proper nutrition is essential, including the optimal and balanced doses of fodder (van Soest 1994). Spring and summer are the periods of the elevated demand on nutrients due to gestation and lactation in hinds (Gallego et al. 2006) and antler growth in stags, which is important in efforts leading to the reproductive success (Karpowicz 2012). The antler is one of the quickest-growing animal tissues which is developed and cast every year, and this means a huge energetic effort for

the stag (Landete-Castillejos et al. 2012). The period of late summer and early autumn is the time of antler mineralization, which requires the mobilization of calcium, phosphorus and magnesium reserves, crucial for this process. The demand on these minerals is so big, that only the diet is not sufficient to satisfy it and therefore the minerals are also mobilized from the skeleton, resulting in a temporary osteoporosis (Estevez et al. 2009). On the other hand this effort is not pointless because well-developed antler is an advantage in harem fights and establishing the social position in a herd, which leads to the reproductive success. Another aspect worth noticing is the trade value of the antlers which are considered either as hunting trophies or a material for furniture or jewelry production. In the first case the quality of an antler is assessed with special scales, which determine their value on the market. In the second case, the less attractive antlers are sold to producers or craftsmen as a substrate to produce decors.

The determination how the mineral economy in the period of antler growth is shaped will allow to determine the moments of higher demand and in the consequence may help to adjust the diet composition to current needs of a stag. Moreover it is worth to consider if there are any sex-dependent differences in Ca, P and Mg management which may extort the different pathways of mineral supplementation for females and males. Therefore the aims of this study were: to determine the dynamics of calcium, phosphorus and magnesium concentration changes in the serum of fallow deer females and males during the period of antler growth in males; to consider the validity of introducing the sex-dependent mineral supplementation programs in the aforementioned period.

## MATERIAL AND METHODS

The study was performed on adult fallow deer (*Dama dama*) females (n = 8) and males (n = 8) maintained in the farm conditions in the Western Poland. The animals were kept in the 1–2 ha casements separated with fence, with an *ad libitum* fresh water access. During the whole experiment the animals ate the pasture feed and no mineral supplementation was used.

The experimental material was blood from the jugular vein (10 ml). Serum obtained after centrifugation (10 min, 4000 rpm) was stored in –20°C until the laboratory analyzes. The samples were collected once a month, from April to September, which is the period of 8 months corresponding to the period of antler growth in fallow deer stags (Szuwart et al. 1998).

In the examined serum the concentrations of calcium ions, inorganic phosphorus and magnesium ions were measured spectrophotometrically, using the Alpha Diagnostics kits (Warsaw, Poland) and the Epoll-20 unit (Poll LTD, Warsaw, Poland). The results were statistically analyzed using the repeated-measure analysis of variance and correlation factor tools provided by the Statistica 10 software (Statsoft, Krakow, Poland). The significance statistical differences were evaluated by  $p < 0.01$  and  $p < 0.001$  significance levels.

The experiment has been approved by the Local Ethics Committee.

## RESULTS

### Calcium

Figure 1 demonstrates the changes in the concentration of calcium in the examined hinds and stags. In females, the period from April to July was characterized by constant mean concentration of  $71.25 \pm 8.89 \mu\text{g/ml}$ . In the following two months the mean concentration increased to  $87.25 \pm 13.15 \mu\text{g/ml}$  and was significantly ( $p < 0.001$ ) higher than in the previous

months. In males, during the April-August period, the concentrations were similar (mean  $77.60 \pm 6.30 \mu\text{g/ml}$ ) but in the last month of the study a significant ( $p < 0.001$ ) decrease of concentration was observed ( $64.48 \pm 15.40 \mu\text{g/ml}$ ).

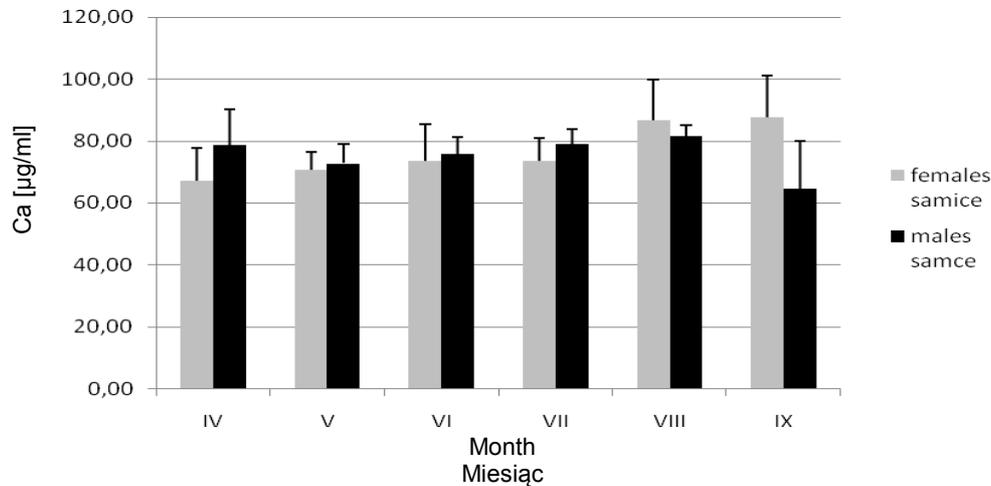


Fig. 1. Concentration of calcium (Ca) in the serum of fallow deer females and males in the following months of the stags antler growth period

Ryc. 1. Stężenie wapnia (Ca) w surowicy samic i samców daniela w kolejnych miesiącach okresu wzrostu poroża u samców

### Phosphorus

Changes in the concentration of phosphorus in the studied hinds and stags are shown on Fig. 2. In the females, no significant differences were shown between the concentrations noted in the following months of the study. The mean concentration during the whole experiment was  $63.27 \pm 10.48 \mu\text{g/ml}$ . In the males, concentrations observed from April to August did not differ significantly and was at the mean level of  $56.89 \pm 9.45 \mu\text{g/ml}$ . In the last month of the study a significant ( $p < 0.001$ ) decrease in the concentration of phosphorus was noted, reaching the  $38.63 \pm 7.30 \mu\text{g/ml}$ .

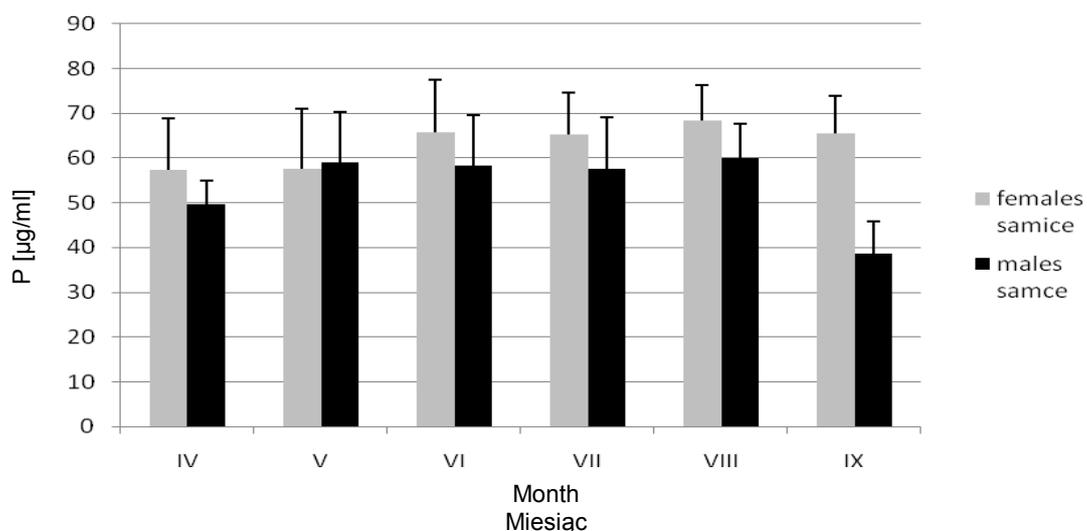


Fig. 2. Concentration of phosphorus (P) in the serum of fallow deer females and males in the following months of the stags antler growth period

Ryc. 2. Stężenie fosforu (P) w surowicy samic i samców daniela w kolejnych miesiącach okresu wzrostu poroża u samców

## Magnesium

Changes in the serum concentration of magnesium in examined females and males are shown on Fig. 3. In case of the females, the period from April to July was characterized by constant mean level of  $16.05 \pm 1.20 \mu\text{g/ml}$ . In August and September a gradual increase of concentrations was observed, which mean level was significantly ( $p < 0.001$ ) higher than in the previous months. In males, the mean concentration in the two first months of the experiment was  $14.76 \pm 1.76 \mu\text{g/ml}$ . From June to August an increase to the maximal concentration ( $20.28 \pm 1.75 \mu\text{g/ml}$ ) was noted but in the last month a rapid decrease of magnesium concentration to  $15.79 \pm 2.89 \mu\text{g/ml}$  was observed, which was significantly ( $p < 0.001$ ) lower than in the previous month.

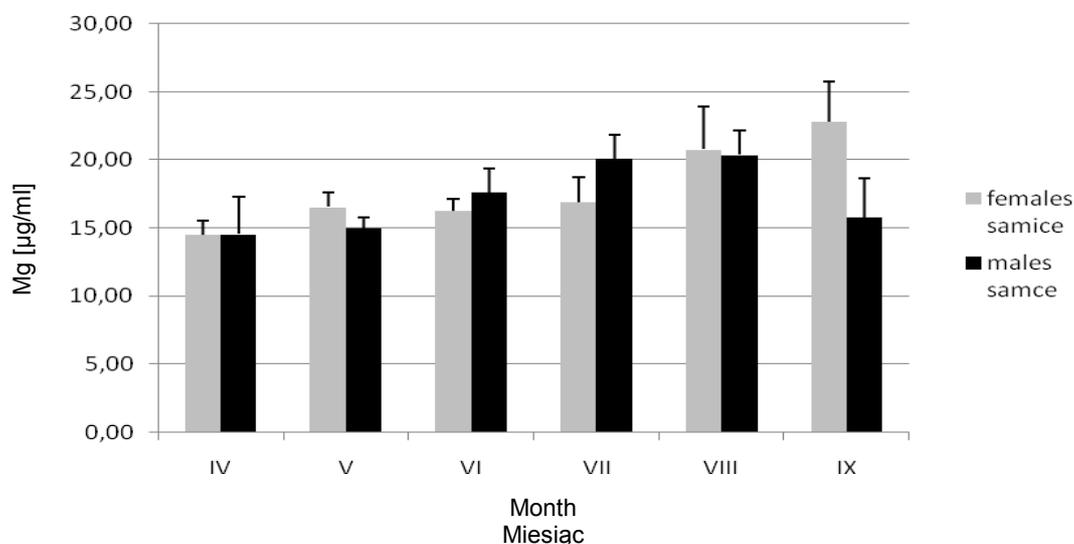


Fig. 3. Concentration of magnesium (Mg) in the serum of fallow deer females and males in the following months of the stags antler growth period

Ryc. 3. Stężenie magnezu (Mg) w surowicy samic i samców daniela w kolejnych miesiącach okresu wzrostu poroża u samców

In case of the examined hinds, the significant correlation was observed between the concentrations of calcium and magnesium, while in the stags all the minerals were significantly correlated. Values of the correlation factors are shown in Table 1.

Table 1. Values of the correlation factors between the studied parameters in fallow deer hinds and stags evaluated by the significance levels of  $p < 0.001$  and  $p < 0.01$

Tabela 1. Wartości współczynników korelacji pomiędzy badanymi parametrami u samic i samców daniela, obliczone przy poziomach istotności  $p < 0.001$  oraz  $p < 0.01$

Hinds	Mg	Ca	P	Stags	Mg	Ca	P
Mg	1,0000	<b>0,4396</b> <b>p = 0,002</b>	0,2228 p = 0,128	Mg	1,0000	<b>0,5107</b> <b>p = 0,000</b>	<b>0,4132</b> <b>p = 0,006</b>
Ca	<b>0,4396</b> <b>p = 0,002</b>	1,0000	0,2420 p = 0,098	Ca	<b>0,5107</b> <b>p = 0,000</b>	1,0000	<b>0,4915</b> <b>p = 0,001</b>
P	0,2228 p = 0,128	0,2420 p = 0,098	1,0000	P	<b>0,4132</b> <b>p = 0,006</b>	<b>0,4915</b> <b>p = 0,001</b>	1,0000

Significant correlations are indicated in bold – Istotne korelacje wyróżniono pogrubioną czcionką.

## DISCUSSION

The zone of temperate climate is characterized by the clearly marked weather differences between each season (Farmer et al. 2003). This results in noticeable changes in the metabolic processes, which are particularly clear in species which show a strongly pronounced seasonality, including the fallow deer (Perelberg et al. 2003). In case of examined fallow deer females we have shown that the concentrations of calcium, phosphorus and magnesium are characterized by an increasing tendency throughout the whole study and reaches the highest values in the final months of the experiment. In case of the males, a similar tendency is observed in all three macroelements, but interestingly the dynamics of minerals concentration changes in comparison to females in September, showing a rapid decrease.

The regular growth of the minerals concentration in the whole study in hinds and in the most of the months in stags presumably results from the food abundance, which translates into the mineral availability. In the temperate climate zone the spring months are the time of initiation of the plant vegetation, most of which constitute the base of fallow deer diet (Bogdaszewska and Bogdaszewski 2012). This period of abundance allows the animals to recover after winter, when the organism is forced to use its energetic and mineral reserves, due to the deficient plant availability (Pettorelli et al. 2005). Therefore we may suppose that the increasing tendency in the concentration of calcium, phosphorus and magnesium is a reflection of refilling the mineral reserve, depleted in winter. It is more important that good physical condition is necessary for reproduction season, which in fallow deer takes place in autumn (Murphy 2012). The strategy of mating in cervids differs according to the sex. In females the main effort related to the offspring birth concerns mainly the gestation and extends to the period of lactation (Goldman 2002; Gallego et al. 2006). In turn in males the most demanding period covers the time of harem fights and female conceptions (Fričová et al. 2008). These differences particularly explain the interesting decrease in the concentration of all three macroelements, observed in males in September. It may be supposed that the observed differences result from the process of antler mineralization in stags. The data show that in adult males of fallow deer, the antler is being built from April to August while its cleaning and mineralization begins in September (Szuwart et al. 1998). This process is closely related to the reproductive cycle of a male and may be directly identified with the seasonal change in photoperiod, which in turn affects the steroidogenic activity of gonads (Bubenik 2006). From spring to early summer the gradual increase in the concentration of this hormone stimulates the growth of antler while in autumn, when it reaches the highest concentration, it initiates the process of transferring the minerals to the growing antler (Gaspar-López et al. 2010; Savanth and Saseendran 2012). Many reports indicate the role of food availability which has a huge influence on the intensity of antler growth and is pronounced, among other factors, through the accessibility of calcium, phosphorus and magnesium (Pis et al. 1994; Stachowicz 2010; Borys et al. 2012). The rapid decrease we have noted in the concentrations of these minerals suggests a disturbance in the balance of stags mineral economy. What is worth noticing is the fact that the demand on calcium, phosphorus and magnesium in the end of studied period is so big, that requires a temporal mobilization of mineral pool deposited in the skeleton (Klevezal 1996). For this reason we

may suppose that the September concentration decrease is an illustration of a radical change in the mineral metabolism in stags, whereas in the females we examined no changes occur at all because there is no antler. The inorganic composition of antler includes about 48% of calcium phosphate, 5% of calcium carbonate and 2% of magnesium carbonate, which explains the concentration decrease of all three studied minerals (Nowicka et al. 2005). Also the positive and significant correlations we observed between all the minerals in males, but only in Ca and Mg in females emphasize the differences between mineral metabolism in both sexes. Moreover we suppose that the correlations in concentrations of all the minerals in males demonstrate that each of them is necessary for the growth of antler. As far as the aforementioned low percentage of magnesium salts does not suggest that magnesium plays such a big role in the growth of antler. However it is worth noticing that in case of severe calcium deficiency, this mineral may be replaced by magnesium, due to the bivalent character of cations of these elements (Ergün et al. 2002).

## RECAPITULATION

The results of this study demonstrate the differences in the metabolism of calcium, phosphorus and magnesium between the females and males of fallow deer. Basing on them we may presume that the pasture fodder which animals retrieve in spring and summer is sufficient to ensure the progressive growth in the availability of studied macroelements in both sexes. However, regarding the effort stags have to bear to obtain the reproductive success, it is worth to consider the application of a special mineral supplementation program aiming at satisfying the large mineral demand in the period of antler growth in the males. Between many ways to supplement the cervids, using the salt blocks seems to be the most popular way of providing the necessary element income in Polish deer farming. What favors the salt blocks, is their relatively low price (10–20 PLN) and the fact that there are salt block composed specifically for the cervid mineral needs, so they may be considered in application of the supplementations program for stags.

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**Abstract.** In the study we decided to determine the dynamics of Ca, P and Mg concentration changes in the serum of fallow deer females and males in the period of antler growth in males and consider the validity of introducing the sex-dependent mineral supplementation programs in the aforementioned period. The study was performed on adult fallow deer hinds (n = 8) and stags (n = 8). The concentrations of Ca, P and Mg were measured in the serum samples, which were collected monthly from April to September. In the hinds the dynamic of mineral concentration changes does not show any significant variations and is characterized by a stable and constant growth through the experiment. In the males a similar profile of concentrations is observed through the most of the study except a considerable difference in September, when a rapid decrease in the level of all three minerals was noted. The results suggest that the pasture feed consumed in spring and summer is sufficient to ensure the constant complementation of calcium, phosphorus and magnesium reserve however in the period of antler mineralization in males, the intensification of mineral supplementation for stags may be considerable.

